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MASTER'S THESIS

THE SHORT-TERM EFFECT OF ECONOMIC RELEASES ON THE EXCHANGE RATE MOVEMENTS

Ljubljana, November 2014 MATEJ OJSTERŠEK

AUTHORSHIP STATEMENT

The undersigned Matej Ojsteršek, a student at the University of Ljubljana, Faculty of Economics, (hereafter: FELU), declare that I am the author of the master's thesis entitled The short-term effect of economic releases on the exchange rate movements, written under supervision of doc. dr. Vasja Rant.

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INTRODUCTION

How is news about fundamentals reflected in the foreign exchange market? The topic behind this question is a central issue in financial economics – to understand the determination of prices. Researchers began examining the effects of economic releases[1] on exchange rate movements in the early 1980s. However, their studies have often been quite contradictory. Ever since Meese and Rogoff (1983) failed to connect foreign exchange prices and fundamentals, researchers have been strongly motivated to suggest otherwise.

Indeed, a remarkably comprehensive literature on the topic has emerged. In earlier research, several authors examined the response of exchange rates to macroeconomic announcements using monthly or semi-annual data, which precluded the assumption that announcement effects are the only factor affecting the exchange rates (Hakkio & Pearce, 1985). While there has long been a general consensus that fundamental data matters in the long run (Mark, 1995), only recently has the emergence of more sophisticated computers allowed researchers to gather high-frequency data and document the effects of these fundamentals also in the short run (Neely & Dey, 2010).

Researchers are now no longer limited by monthly or weekly data, but can rather use minute-by-minute or even tick-by-tick data to estimate the extreme short-term announcement's effect on the exchange rates. Using a high-frequency dataset consisting of real-time exchange rate quotations and macroeconomic announcements data from 2008 to 2014, I also study the near-instantaneous reactions of foreign exchange market to macroeconomic news releases, allowing me to assume that the exchange rate movements that happen immediately after the news release are mainly driven by the release itself. If I used less frequent data, such an assumption would be questionable.

The premise behind my research investigates how markets absorb new information. When a macroeconomic announcement is released and it is different from its forecasted value, the market receives new information about the fundamental value of currencies. In an efficient market, this new fundamental value should be reflected by the change in the exchange rate. If the released announcement is the same as expected, no new information is provided and the result of the announcement should have already been incorporated into the exchange rate[2].

To study this empirically I follow Balduzzi, Elton and Green (2001) in constructing the regression model and standardizing news surprises. In particular, **I study the 1-minute response of the euro/dollar exchange rate to the various U.S. and European economic**

[1] Throughout this master's thesis I use the terms (macro)economic releases, (macro)economic announcements, releases/announcements and (macro)economic reports interchangeably.

[2] I refer to the difference between the announced and forecasted value of macroeconomic release as »news surprise«.

releases in the period from 2008 to 2014. I find that news surprises over these macroeconomic fundamentals do have significant effects on the movement of the euro/dollar exchange rate. In this way, this thesis relates to previous work and confirms earlier findings.

However, this master's thesis **differentiates itself from previous work** in at least three ways. These include the determination of patterns in how foreign exchange markets react to news surprises, my focus on the extreme short-term 1-minute responses, and the time period considered in the thesis. Let me discuss them briefly in turn.

First, this study determines not only whether certain news surprises produce a significant response on the foreign exchange market but also whether there are any patterns in the response. I perform four different tests to assess the following financial phenomena: asymmetric response, nonlinearity, business cycle and liquidity.

Asymmetric response refers to the differences in price movements that result from good to bad news. If the asymmetric response were present in the market, then the news effect would vary with the sign of the surprise. In other words, markets would react differently to good versus bad news.

Nonlinearity refers to the fact that the prices react differently depending on the magnitude of the news surprise. If the markets are linear, then the reaction of the price fluctuation should be the same for each marginal unit of surprise, no matter the size of the surprise. On the other hand, nonlinear markets should react more strongly to either »big« or »small« surprises.

In the most general terms, **business cycle** refers to the periods of expansion and periods of recession in a country's economic activity. It is therefore reasonable to believe that also the exchange rates react to news surprises differently depending on the state of the business cycle.

Liquidity is a measure of trading activity. If a market is characterized by a high level of trading activity and is therefore (perfectly) liquid, news surprises should be incorporated in the foreign exchange rate almost immediately. In a less liquid market, trading activity is lower and therefore news surprises take longer to be incorporated into the market.

Second, I look at the extreme short-term 1-minute exchange rate responses to news surprises. Many of the recent studies look at 5-minute or 10-minute reactions; however, survey results by Cheung and Chinn (2001) suggest that the foreign exchange rate prices adjust within the first minute of the macroeconomic announcement release. Also, the emergence of powerful algorithms used in trading can dissect the new information from the market automatically and instantly, which should also be reflected in rapid responses.

Third, I use the most recent data available, ranging from January 2008 to August 2014. As far as my knowledge goes, no studies have yet used such recent data to evaluate the impact of news surprises on exchange rate movements. This makes the results from this thesis more relevant for further studies, as financial markets have developed greatly over the last few years.

In the most general sense, my results confirm prior related studies. Several researchers have discovered significant correlations between news surprises and exchange rate movements and in this way my results provide confirmation and elaboration of previous findings. However, my results can also be viewed as an expansion of these previous findings as I use the most recent data, evaluate extreme short-term exchange rate responses and perform various tests of financial phenomena.

This master's thesis proceeds as follows. In chapter 1, I cover the importance of economic releases for the exchange rate movements and the most highly watched U.S. and European macroeconomic announcements. Chapter 2 provides an overview of the existing relevant literature on the topic. Chapter 3 describes the methodology utilized in my research and chapter 4 provides the overall and test results of the study. In chapter 5, I provide suggestions for further research.

1 FOREIGN EXCHANGE MARKETS AND ECONOMIC RELEASES

The study of the effects of economic releases on the exchange rate movements is closely correlated with the efficient market hypothesis (hereinafter: EMH). If the markets were efficient, then there would be no possible way of a steady profit by trading on publicly available information (Neely & Weller, 2011). However, as the literature has shown, foreign exchange markets are not fully efficient. Successful traders can exploit macroeconomic announcement releases and generate profits by investing in this market. This chapter covers three topics. First, I cover the studies on the foreign exchange market efficiency. Then, I talk about the importance of economic releases and conclude with the overview of the most important U.S. and European macroeconomic announcements.

1.1 Efficiency of the foreign exchange market

There has been an on-going debate in the literature about the efficiency of financial markets, including foreign exchange market. Samuelson (1965) was one of the first researchers to study efficient markets. His view was that only by taking a disproportionate level of risk, investors and traders could generate extra profits. Fama's (1970) definition of efficient market hypothesis states that in an efficient market, prices always fully reflect available information. Therefore, EMH is also referred to as informational efficiency (Hallwood & MacDonald, 1994).

Ever since Fama's (1970) semi-strong efficient market hypothesis researchers have been motivated to connect exchange rates to economic announcements. For example, Jensen (1978) argues that in an efficient market, there is no possibility to generate steady profits by using the available information. Also, in efficient markets, investors continuously gather information from the market and trade on this information so the prices should react instantly to any potential surprise components of economic announcements. If the prices did not react instantly, this would mean that a profit opportunity exists even though there should be no such opportunities in efficient markets (Neely & Dey, 2010). To prove that foreign exchange markets are not efficient, researchers have used forecasts of macroeconomic announcements and high-frequency exchange rate data to determine the reaction of prices.

At this point, I should note that there are common misconceptions about the EMH. First, EMH does not mean that exchange rates and macroeconomic news are not related (Neely, 1997). Also, it does not mean that exchange rates move randomly around their fundamental value, as Murphy (1999) suggests. Rather, EMH means that the markets are always trying to provide a best guess to the value of exchange rates and that it is impossible to predict future price fluctuations (Neely, 1997).

The existing literature on foreign exchange market efficiency is both comprehensive and contradictory. Several studies have found support for the efficiency of foreign exchange markets. For example, Fama (1970), Hakkio and Rush (1989), Wu and Chen (1998), Nguyen (2004) and Lee and Sodoikhuu (2012) all test for efficiency using different econometric methods and find evidence of foreign exchange markets efficiency.

On the other hand, researchers have been able to successfully apply trading rules on the foreign exchange market, generating profits, and as a consequence, proving that EMH does not hold true for the foreign exchange market. For example, Sweeney (1986), Engel and Hamilton (1990), Levich and Thomas (1993), Neely, Weller and Dittmar (1997) and more recently Osler (2000) and Zivot (2000) all argue that foreign exchange markets are not efficient. Foreign exchange markets absorb and adjust to the new information slowly, instead of instantly reflecting the new information in exchange rates (Eichenbaum & Evans, 1995).

How is one to interpret such inconclusive and contradictory evidence? First, let us look at the framework of EMH. Shostak (1997) argues that EMH does not make sense because it implies that all market participants behave rationally at all times. Grossman and Stiglitz (1980) identify a concept called »paradox of efficient markets«, which assumes that investors can surely generate excessive returns on the foreign exchange market because otherwise they would not spend so much time and money to analyze and gather information about the market. Cambell, Lo and MacKinlay (1996) introduce a similar logic and suggest that instead of evaluating market efficiency, the degree of inefficiency should rather be assessed.

Another view of why the foreign exchange market is not totally efficient is due to the lack of knowledge of the majority of market participants. Even if all the information is available for all the investors at the same time, some investors do not know how to react to this information and therefore create an opportunity for other investors to make a profit based on the lack of skill to make a correct decision by the unskilled investors (Dryckman & Morse, 1986).

Also, Hafeez (2007) finds that only 24-49% of the participants in the foreign exchange market are profit-seeking. Others use the foreign exchange market for hedging or liquidity purposes and do not focus merely on profit maximizing. This also presents an opportunity to make excess returns for those investors who are looking to generate profit on the market.

Furthermore, central bank intervention is a common practice in the foreign exchange market. Central banks often engage in participating in the market in order to manage inflation and unemployment. This kind of intervention is not always intended to maximize profit, but for macroeconomic and political motives instead, which means that central banks are willing to incur losses in some cases. These losses provide an opportunity for skilled investors to make money, providing another example of inapplicability of EMH on the foreign exchange market (Neely & Weller, 2011).

Additionally, Neely (1997) argues that if the foreign exchange markets were efficient, there should be no apparent trends seen in charts of exchange rate prices. Some proponents of EMH negate this view by arguing that even completely random price changes might shape trends (Malkiel, 1990). However, in efficient markets, these types of trends happen by chance and might change its direction at any moment, so it is impossible for investors to generate steady profits by exploiting them (Neely, 1997).

Speculation is also a very big part of the foreign exchange market. An example of the market inefficiency by using speculation would be the case of George Soros when he »broke the Pound«. Soros (2003) argues that the currency moves are often exaggerated due to speculation.

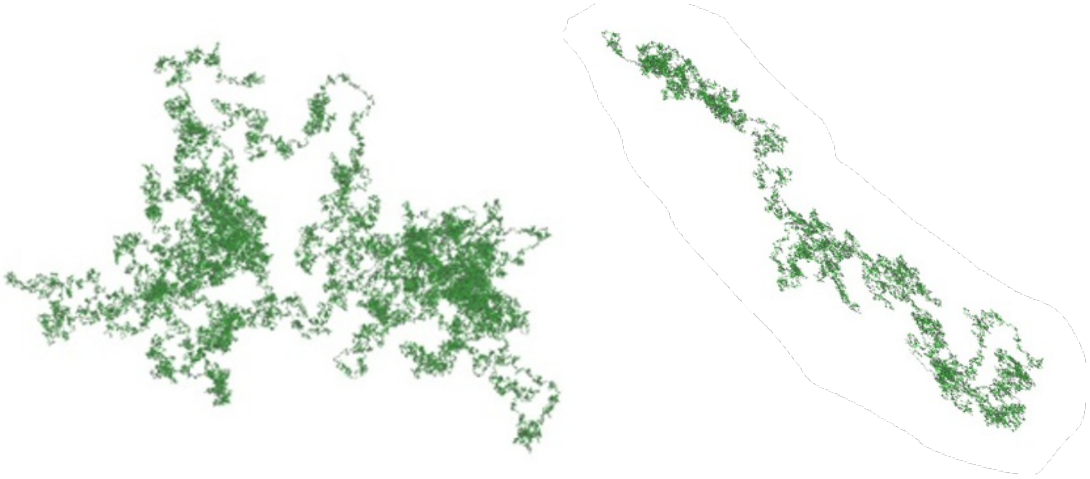
EMH is closely correlated with random walk theory. The random walk theory states that the market prices wander in a purely random and unpredictable way (Yao & Tan, 2000). Malkiel (2003) explains how random walk theory and efficient markets interact. He states that if the information is immediately reflected in stock prices (as is the case with the efficient markets), then future price changes will reflect only future news and will not depend on today's price changes. Because the news is always unpredictable, also future prices cannot be predicted and are considered as totally random.

A method called random walk visualization produces an interesting picture of the foreign exchange market (Figure 1). On the left side of Figure 1, we can see how pure randomness

looks like. The picture is produced by the following method. For every tick (the minimum upward or downward movement in the price) there is a 50% chance of going up and 50% chance of going down and on the next tick, there is a 50% chance of going left and 50% chance of going right. If the random walk theory was valid also for the foreign exchange market, the random walk visualization method would produce a picture similar to pure randomness. The picture on the right side of Figure 1 was generated by moving up or right for rises in price and down or left for falls in price, while alternating horizontal and vertical movements. As we can see, the foreign exchange market is far from pure randomness.

Figure 1. Random walk visualization

(A) Pure randomness (B) Foreign exchange market



Source: Dukascopy, *Forex is Not a Random Walk*, n.d.

All of the above research shows us that we can question the applicability of EMH in the foreign exchange market. Although the foreign exchange market is highly efficient, there is a possibility to earn stable profits from investments in this market, using both fundamental and technical trading analysis. As I focus on fundamental analysis in my thesis, I cover the importance of economic announcement releases next.

1.2 Importance of economic announcement releases

There is a general consensus in the literature that economic announcement releases play an important role in the foreign exchange market and significantly affect exchange rate returns and volatility. Neely and Dey (2010) argue that by studying the effects of economic releases on the exchange rates, researchers can determine which releases affect exchange rates most significantly, how markets react to policy changes, the speed of market reaction to new information and also the incorporation of the new information into the exchange rates.

Usually, markets tend to respond only to the unexpected or surprise component of these economic releases. The reaction to the announcement seems to be stronger if its surprise content is higher. Investors often use economic releases to test the market efficiency hypothesis by looking at the news surprise and the corresponding price changes or, to test the rational expectations theory[3] by looking at the market realizations and market expectations. The correlation between monetary policy and foreign exchange markets has always motivated research on the impact of economic releases (Andritzky, Bannister, & Tamirisa, 2007).

Macroeconomic announcement effects seem to be different across financial markets and also depend on the type of announcement. For example, Aggarwal and Schirm (1998) show that the impact of trade balance news appears to differ across foreign exchange market, U.S. stock market and bond market, and that this difference depends on the sign and size of the surprise component in the announcement. Most significant effects on the U.S. Treasury bond market come from the nonfarm payroll, inflation and retail sales data (Kim, McKenzie, & Faff, 2004).

Also, foreign exchange markets react to many types of economic releases (Chang & Taylor, 2003). However, the exact type of economic releases that have significant effects on the foreign exchange market seems to differ among studies. The general consensus among the studies is that U.S. nonfarm payroll employment, interest rates and output data appear to have a consistently large and stable effect on the foreign exchange market. Among the Non-U.S. announcements, German monetary announcements are also influential. Kim et al. (2004) find that trade balance, GDP and nonfarm payrolls affect the foreign exchange market. Bartolini, Goldberg and Sacarny (2008) use euro/dollar 30-minute and daily data to show that only GDP advance, nonfarm payroll and private sector manufacturing significantly affect the exchange rates. Lahaye, Laurent and Neely (2010) argue that federal funds rate and nonfarm payroll data produce significant responses. Neely and Dey (2010) provide an explanation for this inconsistency in results – effects of macroeconomic releases can be unstable because they are not structural, i.e. they are not independent of market expectations and other policy changes.

The order of an announcement release is important too. Doukas (1985) shows that U.S. money supply releases generate more significant responses than Canadian money supply releases, because U.S. releases come out 50 minutes earlier. Andersen, Bollerslev, Diebold and Vega (2003) also prove that announcement timing matters. If we sort economic releases into various categories that are based on the type of the indicator, i.e. GDP advance, GDP preliminary and GDP final reports all fall into the same category, the most significant effects tend to come from those releases that are released earlier. Similarly,

[3] The rational expectations theory was developed by Muth (1961). The hypothesis assumes that economic agents who need to guess future prices make their best guess based on all the available information and that, on average, their forecast will be correct. This implies that markets tend to respond only to the unexpected component of economic releases.

Ehrmann and Fratzscher (2005) prove that U.S. macroeconomic news are more important than German and euro area news and attribute this difference in the effect to the fact that U.S. announcements are released earlier compared to corresponding European announcements.

Not only the type and order of the economic releases matter, there is also proof of asymmetric response between good and bad news. In particular, Andersen et al. (2003) find that negative news surprises tend to have larger effect on exchange rates than positive surprises. Fatum, Hutchinson and Wu (2012) come to the similar conclusion. Of the earlier studies, Sheehan and Wohar (1995) test for asymmetry of information and show that prices are only affected by negative surprises and not positive surprises. Sultan (1994) also finds some evidence of asymmetry in the foreign exchange market.

The speed of price adjustment to the macroeconomic surprises has been researched quite heavily. Most of the literature has reached an agreement that the exchange rates adjust very rapidly to the news events, producing the so-called price discontinuities or »jumps« in prices. However, there is a difference between reactions on scheduled and unscheduled news releases. For example, Ederington and Lee (1995) confirm these quick »jumps« in prices, which begin in the first 10 seconds after the economic release and finish in 40 seconds after the release. Andersen et al. (2003) and Lahaye et al. (2010) come to the similar conclusions. Contrary, Almeida, Goodhart and Payne (1998) detect that the prices react differently to U.S. and German economic releases. In particular, the reaction to the unscheduled German releases was much slower than the reaction to the scheduled U.S. releases.

The significance of individual economic releases shifts over time and is closely correlated with the central banks' reaction function to specific releases. The market agents are often looking at the macroeconomic news through the eyes of the central bank to determine which news would make the central banks increase or decrease the interest rates, which are very closely correlated to the exchange rates. This shift is proven by both Cheung and Chinn (2001) and Lien (2009). Cheung and Chinn (2001) examine the importance of individual macroeconomic announcements in 1992 and 1997. While the interest rate has been very important in both years, their most interesting conclusion involves the trade deficit. In 1992, trade deficit was considered the most important macroeconomic announcement that affects the exchange rates. In 1997, however, it has lost most of its significance on the market. Similarly, money supply and GDP have decreased in importance, while unemployment and inflation have increased in importance. Similar, but more recent findings are those from Lien (2009), who searches for top market-moving indicators in years 2004 and 2007. While nonfarm payrolls and interest rates remained at the top in both years, causing the biggest average changes in exchange rates, trade balance, ISM manufacturing and foreign purchases U.S. Treasuries indicators have fallen out of the top 10 indicators in 2007, making room for new and existing home sales and durable goods orders. In some way, such a shift can be explained intuitively. It makes sense that the

market and the central banks will shift their attention to different macroeconomic data depending on the state of the economy. For example, in times when an economy faces large trade deficits, investors will look at trade balance more carefully. Similarly, when the unemployment rate in an economy is high, data on new job creation is more relevant (Lien, 2009).

1.3 Main U.S. and European economic releases

The studies have given unequal attention to connecting the U.S. economic releases to the foreign exchange movements, compares to economic releases from other economies. Neely and Dey (2010) argue that there are two main reasons for this. First, U.S. economic release data and exchange rate data are most easily obtainable. Second, in contrast to announcements from many other economies, U.S. releases are scheduled in advance and so the market participants always know what announcements to expect at what time of the day.

Prior to adoption of the euro, the study of European releases was mostly limited to German announcements and the German Mark. Moreover, due to the unavailability of other data, earlier studies were confined only to the research of German trade balance and GDP announcements. Only recently have the researchers included more European announcements in their studies. They are, however, still in minority compared to the study of U.S. releases.

Most of the main economic releases out of Europe are remarkably similar to those from the United States, with some minor differences in calculation methods or reporting. For example, the EU retail sales report is viewed in the same way as the U.S. retail sales report – as a measure of sales on a retail level. Similarly, consumer price index is used as a measure of inflation in both economies. The same logic holds true for most of the macroeconomic announcements.

The key difference between U.S. and European releases, however, can be found in reports from individual European countries. European markets tend to pay attention not only to the Eurozone-wide announcements that are issued by the European Central Bank (hereinafter: ECB), but also to the national announcements from the individual European countries. Mainly, the most important national announcements come from the largest economies, like Germany or France. In many cases, the national releases produce even larger exchange rate movements than the releases that cover the entire region as they are viewed as the leading indicators of Eurozone-wide data. For example, if the German GDP falls, this may suggest that the GDP of other Eurozone countries is set to fall, too.

Another difference between the United States and the Eurozone is in the role of the central banks. In the United States, the Federal Reserve Board or the Fed is the monetary policy

authority. The goals of the Fed are twofold – it has an objective or mandate of both sustainable economic growth and price stability. In order to meet its objectives, the Fed has to limit inflation and unemployment to achieve balanced growth. There are two main mechanisms for the Fed to achieve this. First, the Fed can purchase government securities from the open market, signalling future policy changes. In general, an increase in Fed purchases of government securities decreases interest rates, while selling of government securities by the Fed boosts interest rates. Second, the Fed can directly influence the federal funds target rate, which is the interest rate for borrowing that the Fed offers to its member banks. If the Fed wants to restrain inflation, the rate is increased. If the Fed wants to promote growth and consumption, the rate is decreased. Market participants closely watch changes in the federal funds rate, as they usually indicate large policy changes, which in turn produce significant consequences not only for foreign exchange markets but also for bond and stock markets (Lien, 2009).

On the other hand, the ECB is the governing body of the European Union and is in charge of determining the monetary policy of the countries that are a part of the European Monetary Union (hereinafter: EMU). The primary objective or mandate for the ECB is only one – to maintain price stability within the Eurozone. The most important element of the ECB statement is therefore the inflation outlook. The ECB refinancing rate represents the price that banks pay to borrow funds from the ECB. Therefore, in order to keep inflation at appropriate levels, the ECB is predisposed to keep the refinancing rate high. Market participants closely watch how the ECB changes its refinancing rate as the changes usually have significant consequences for the euro (Lien, 2009).

The most important U.S. and European economic releases with corresponding short descriptions are covered in Table 1. Releases belong into four categories – labour market reports, consumer-level data reports, business-level data reports and structural data reports. Those releases that are specific to the United States or Europe are marked with U.S. or EU in parentheses. It is important to note that most of the releases are so called lagging indicators, as they relate to past economic activity. For example, the unemployment rate measures the actual number of unemployed workers in the previous month. Similarly, GDP measures usually measure the GDP from the previous quarter. On the other hand, monetary policy announcements, such as the FOMC minutes or the ECB press conference after the refinancing rate announcement, are leading indicators, as they forecast the short-term interest rates based on latest announcements, forecasts and other information. As such, market participants always closely watch them.

Table 1. Most important U.S. and European economic releases

Announcement	Short description
Unemployment rate	Unemployed workers – those seeking work but never employed during the period – as a percentage of the labour force.
Nonfarm payrolls (U.S.)	Change in number of employed people during the previous month, excluding the farming industry; as well as trends in hiring payments and sectors.
Average hourly earnings	Average hourly wage of production and nonsupervisory workers on private nonfarm payrolls by industry sector and selected industry detail.
Initial unemployment claims	Number of first-time filings of jobless claims, seasonally adjusted.
Employment cost index	Total compensation for civilian workers.
Consumer confidence index (CCI), University of Michigan consumer sentiment (both U.S.)	Mood of consumers with respect to present and future economic conditions.
ZEW survey (EU)	Growth expectations over the next six months for Germany and for whole Eurozone.
IFO survey (EU)	Corporate sentiment survey on how business is expected to develop over the next six months.
Gfk survey (EU)	Monthly measure of consumer confidence.
Personal income	Income received by individuals.
Personal spending	Amount spent by consumers on goods and services.
Retail sales	An advance estimate of the value of sales at the retail level, based on a sample of both small and large firms.
Durable goods orders	Value of new purchase orders placed with domestic manufacturers for goods with a life expectancy of more than three years, such as automobiles, computers and appliances.
Existing home sales	Annualized number of existing residential buildings that were sold during the previous month.
New home sales	Annualized number of new residential buildings that were sold during the previous month.
Housing starts	Annualized number of new residential buildings that began construction during the previous month.
ISM Index (U.S.)	A national manufacturing index based on a survey of purchasing executives at roughly 300 industrial companies. Signals expansion when the index value is above 50 and contraction when below.
Industrial production	Output of industrial firms.
Beige book (U.S.)	Overviews of the economy by Federal Reserve district.

table continues

continued

Announcement	Short description
Consumer price index – CPI	The normalized price paid by urban consumers for a representative basket of goods and services using a fixed-weight index. The core CPI excludes prices of food and energy.
Producer price index – PPI	Price level of output from domestic producers.
Personal consumption expenditure index – PCE (U.S.)	Price level of consumers when purchasing goods and services, a Fisher index. The core PCE excludes prices of food and energy.
GDP advance	Initial estimate of GDP; total value of all goods and services produced by the economy.
GDP preliminary	Revision to estimate of GDP advance; total value of all goods and services produced by the economy.
GDP final	Final estimate of GDP; total value of all goods and services produced by the economy, revising the preliminary.
Trade balance	Value of exported less imported goods and services.
Current account balance	Balance of trade + net factor payments + net transfer payments.
Government budget and deficit forecasts	A review of the state of the economy and budget, and related forecasts on future outlook.
FOMC minutes (U.S.)	A detailed record of the Committee's interest rate meeting held about two weeks earlier. The minutes provide detailed insights regarding the FOMC's stance on monetary policy, so traders carefully comb them for clues regarding future interest rate shifts.
Target federal funds rate (U.S.)	FOMC sets the target interest rate at each of its meetings.
ECB refinancing rate	Level of borrowing that the ECB offers to the central banks of its member states.
M3	Measure of money supply that includes notes and coins and bank deposits.

Source: C. J. Neely & S. R. Dey, *A Survey of Announcement Effects on Foreign Exchange Returns*, 2010, p. 420-423; K. Lien, *Day Trading and Swing Trading the Currency Market*, 2009, p. 230-233.

2 LITERATURE REVIEW

Extensive literature exists to explain the impact of economic releases on the foreign exchange market. Although numerous studies have suggested significant and substantial exchange rate responses to news surprises, some studies, particularly older studies, claim otherwise, stating that the effect of the announcements is unimportant. With the emergence of high-frequency data, the literature has in general reached an agreement that fundamental announcements and prices in the foreign exchange market are correlated. In this section I

describe the most visible studies, which will serve as a reference for my study. First, I make an overview of early studies, then the recent studies using high-frequency data and at the end, the studies on Non-U.S. economic releases and the exchange rates.

2.1 Early studies of announcement effects on exchange rate movements

Researchers have been trying to understand the effects of various economic releases on the exchange rates since the early 1980s. The motivation behind these studies is a central issue in financial economics – to understand the determination of prices. In efficient markets, exchange rates respond to news surprises of economic releases almost instantly, providing a unique opportunity to assess how the prices are determined. The response of the exchange rates on these economic releases therefore informs us how markets form future releases (Neely & Dey, 2010).

Due to the unavailability of high-frequency data, the early studies use monthly, weekly or daily data in order to assess the effects of news on the market. Unfortunately, this approach precludes the assumption that announcement effects are the only factor affecting the exchange rates, meaning that many other factors and announcements could have easily been the catalyst for exchange rate movements, other than the studied announcement (Hakkio & Pearce, 1985).

One of the first researchers to use daily data of the foreign exchange market was Cornell (1982), who finds that the surprise component of the money supply economic release coincides with an interest rate increase, which consequently appreciates the U.S. dollar. He argues that dollar appreciation should not occur if interest rates rose only because of higher inflationary expectations. Similarly, Engel and Frankel (1984) use daily data to evaluate how money supply shocks affect the foreign exchange rate, but offer an alternative explanation as to why interest rates rise when money supply is greater than expected. A rise in money supply is only a temporary policy that the Fed will eventually invert. When the Fed lowers the money supply levels, lower inflation and consequently rise in interest rates are expected. Due to this expectation, today's real interest rate is raised, foreign capital flows into an economy and consequently the U.S. dollar appreciates. It is worth noting that even though these two studies use daily foreign exchange data, it is highly possible that other intraday effects and releases have significant effects on the exchange rate, other than money supply.

Early studies of news effects on exchange rate movements focus on money supply announcements because from 1979 to 1982 the Fed changed its method to pursue its monetary policy goals by targeting the quantity of money, particularly nonborrowed reserves (Neely & Dey, 2010). A change in the quantity of money was believed to be superior in controlling inflation, which was very high in that period. Indeed, from 1979 to 1982, fluctuations in M1 drastically increased fluctuations in the federal funds rate

fluctuations, which allowed for a better control of inflationary outlook. Starting in late 1982, the Fed started targeting the price of money and not the quantity of money, which meant that the Fed was buying and selling securities in open market operations in order to meet the federal funds target rate. With this shift in the Fed's monetary policy, researchers began to focus also on other economic releases. In this respect, Meese and Rogoff (1983) try to find a correlation of foreign exchange rates to many different macroeconomic announcements. However, they fail to do so, stating that prices and fundamentals are largely disconnected. Moreover, they argue that exchange rate movements are best described by a random walk model if we look at the period that is shorter than one year. Their study, however, has strongly motivated researchers to suggest otherwise and to use various exchange rate modeling techniques to connect currencies to economic release surprises (Neely & Dey, 2010).

Later research follows that of Meese and Rogoff (1983) in trying to determine the reaction of exchange rates to a wider set of economic releases. For example, Hardouvelis (1988) finds that not only money supply news, but also trade balance, inflation and business cycle news significantly affect the foreign exchange market. Sheehan and Wohar (1995) estimate whether money supply releases retained significant effects on exchange rates compared to the results from 1985 and find that the impact has become slightly less important. This coincides with Federal Open Market Committee (FOMC[4]) switching to targeting the price of money instead of quantity of money in the period when their research was conducted. Also, Sheehan and Wohar (1995) test for asymmetry of information and find that only negative surprises produce significant responses in the foreign exchange market. Hakkio and Pearce (1985), on the other hand, test for news surprise reactions on several economic releases, but find that only money supply announcements are systematically related to exchange rates, while inflation and real activity data have no significant impact on the exchange rates.

2.2 High-frequency data studies of news effects on exchange rate movements

The advent of high-frequency data and more computer power has spurred further research on the impact of economic release surprises on exchange rate movements. The biggest advantage of high-frequency data is that it allows researchers to study the impact of economic releases in a short time frame around. Therefore they can isolate the effect of a single release and assume it is the only factor affecting the exchange rates (Neely & Dey, 2010).

[4] Federal Open Market Committee or FOMC is the Federal Reserve committee, whose mandate is to set interest rates and make key decisions about the growth of the United States money supply.

Using high-frequency 5-minute dollar/Deutsche Mark data, Ederington and Lee (1993) show that the majority of intraday exchange rate movements happen because of news surprises. Moreover, the biggest move happens in the first minute after the release and volatility is elevated for the next 15 minutes and somewhat higher than average for the next few hours. Ederington and Lee (1994) use the same approach for the dollar/yen exchange rate and reach similar conclusions. Ederington and Lee (1995) use even more frequent data, 10-second and tick-by-tick data to confirm quick jumps in prices, which begin in the first 10 seconds after the release and finish in 40 seconds after the release. They find that in some cases prices tend to produce knee-jerk reactions one minute after the release, but they are corrected in the next few minutes. Also, while volatility remains above average moments before the announcements, no information leakage is found. This rise in volatility can therefore be attributed to speculation. Interestingly, while using hourly data, Tanner (1997) suggests that markets react to trade balance releases rather quickly (in the first half an hour after the release), but fail to do so with the inflation announcements, where the market takes up to five hours to fully absorb the new information.

The more recent high-frequency data studies on the impact of economic releases in the foreign exchange market typically follow the methodology developed by Balduzzi et al. (2001), who first calculate news surprises by subtracting market expectation from the announced market realization and then standardize these surprises. At the end, exchange rates are simply regressed on these announcement surprises.

Using such methodology, Andersen et al. (2003) examine the effect of announcement surprises from 1992 to 1998. They use 5-minute exchange rate returns and show that the reaction to the news surprises is quick and that it produces so called »jumps« in prices. Furthermore, they argue that the announcement timing matters. After sorting various economic releases into categories based on type of the release, the most significant effects tend to come from those releases that are released earlier. Finally, proof of asymmetric response is found in their study. In particular, the impact on the exchange rates differs depending on the sign of the news surprise – negative surprises often generate more significant responses than positive surprises.

A different approach was used by Cheung and Chinn (2001), who use survey analysis to determine the impact of news surprises on exchange rates instead of performing the typical methodological approach by modeling and then estimating the responses. Their approach involves a set of questions that attempts to give a direct answer on the actual behaviour of foreign exchange market participants, their experiences and future outlooks of the market. Also, they attempt to assess how the relative importance of economic releases shifts over time and what are the reasons for these potential changes. Their survey includes 142 completed questionnaires. For most releases, the exchange rate response is very quick – it happens within the first few minutes after the announcement. This coincides with the empirical findings of Andersen et al. (2003), who show that most of the variables have statistically significant coefficients at the 5-minute time horizon. In particular, market

participants believe that for all the variables except for the money supply, the bulk of the adjustment of the exchange rate happens within one minute. Moreover, except for the money supply, about one third of the respondents state that the market absorbs the new information within the first 10 seconds after the release. Furthermore, they assess which economic releases are the most important in terms of the exchange rate impact. Based on their survey, the most important announcements are the interest rate and the unemployment. On the other hand, the money supply and the GDP rank as the least important. It is interesting to note that these two releases are ranked at the bottom also in terms of the speed of the adjustment. Cheung and Chinn (2001) argue that this adjustment is slowest exactly because of the fact that these releases are viewed as unimportant. Also, the relative importance of economic releases shifts over time. The interest rates, however, seem to have a consistent role in exchange rate determination. Additionally, market participants believe that in the short run, i.e. intraday, currency prices do not move because of the changes in fundamental values. 59% of the respondents state that prices move because of new fundamental values in the medium run (six months or less) and this number rises to 88% in the long run (six months or more). The biggest reason for these deviations is excess speculation. A very interesting finding comes from the question on what factors, if not fundamentals, force exchange rate movements in the short run. According to market participants' response, either over-reaction to economic release surprises, bandwagon effects or speculation act as most important factors in the exchange rate movements.

Also, Lien (2009) performs an analysis on how various economic releases affect the exchange rates in 2004 and in 2007. She looks at how the euro/dollar currency pair reacts to economic releases 20 and 60 minutes after the release. U.S. nonfarm payroll announcement is found to be the indicator that moves the market the most in both years. However, the importance of other individual announcements shifted over this time period. Interestingly, these findings coincide closely with findings of Cheung and Chinn (2001) from 1992 and 1997. Lien (2009) also finds that the importance of individual releases shifts from the first 20 minutes after the announcement to the end of the trading day, with U.S. nonfarm payroll announcement being the most market-moving indicator in both cases.

Other notable studies on the topic include Goodhart, Hall, Henry and Pesaran (1993), who study high-frequency data of the dollar/pound exchange rate and U.S. trade balance and U.K. interest rate releases. They find that both releases have a significant impact on the exchange rate and that the reaction is very quick. In a similar way, Almeida, Goodhart and Payne (1998) also prove systematic short-lived effects of economic releases by studying three year high-frequency data of Deutsche Mark/U.S. dollar exchange rate. Dominguez (1999) shows that the most important move happens in the first 10 seconds after the economic releases and that central bank intervention around these releases increases their impact.

On the other hand, some empirical studies suggest that exchange rates and fundamental data are not connected. As stated above, Meese and Rogoff's (1983) study is one of the first that fails to connect prices and fundamentals. Frankel and Rose (1995) argue that in the short run, exchange rates are characterized by a random walk and that unexpected big changes in exchange rates happen either because of changes in intangible fundamentals or speculative bubbles and other non-fundamental factors. Mark (1995) and Mark and Sul (1998) show that news surprises affect exchange rates only at long horizons, while in short horizons, there is a disconnect between the two. Evans and Lyons (2002) use a different approach and evaluate the importance of order flow on the exchange rate movement. They find that order flow produces significant short-term effects in the exchange rates. However, they are not successful in linking these effects to the economic releases. Evans and Lyons' (2005) research shows that news surprises from economic releases have a prolonged impact on exchange rates, rather than currency market reacting to surprises instantaneously.

2.3 Studies of Non-U.S. announcement effects on exchange rate movements

Several papers study the effects of Non-U.S. economic releases on the exchange rate movements. In general, most studies find that market reaction depends on how central banks are expected to respond to the news surprises (Neely & Dey, 2010). For example, Doukas (1985) finds that exchange rates are more responsive to U.S. rather than Canadian money supply releases. He speculates that this is due to U.S. releases being released prior to analogous Canadian releases and because Bank of Canada is believed to be closely monitoring the Fed's policy changes. Ito and Roley's (1987) results indicate that the U.S. dollar is inclined to appreciate in the U.S. trading session and depreciate in the European trading session and that U.S. money supply economic release produces a more significant impact than Japanese money supply release on the dollar/yen exchange rate. Almeida et al. (1998) prove that German releases have less significant impact than U.S. releases, stating that this is because the German announcements are unscheduled compared to the scheduled U.S. announcements.

In the late 1990s, several important economic events happened that had an immediate impact on the studies of the economic releases. First, the Bank of England gained independence in setting the monetary policy for the United Kingdom in 1998. Second, also in 1998, the ECB was established, taking over the monetary policy for the members of the EMU. Third, investors and traders began to put much more emphasis on central banks' communication to the public, which in turn encouraged central banks to explain their policy changes and actions in much greater detail (Neely & Dey, 2010). All these changes immediately renewed the attention on economic releases.

For example, Galati and Ho (2003) show that economic news surprises generate a significant impact on the euro/dollar exchange rate. Moreover, their results suggest that the biggest exchange rate changes came from the bad news of the euro area. They interpret this result by saying that in 1999, investors became overly concerned about the future prospects of the euro currency. Cagliesi and Tivegna (2005) use twice-daily data to find that exchange rate changes in the U.S. trading session respond much more significantly to the U.S. economic releases and that scheduled announcements also have a stronger impact in the U.S. trading session than in European trading session. Mostly, this holds true for the U.S. nonfarm payroll release. As many authors before them, they also discovered that in the European trading session currency prices are mostly affected by unscheduled news surprises. Conrad and Lamla (2010) focus on the ECB's communication during and after the interest rate release. They find that the most important part for the exchange rate movements is the press conference and the later question-and-answer session. Furthermore, during the press conference, the most significant movements are recorded when the ECB talks about future development of prices and interest rates, rather than about economic activity and money supply choices. Melvin, Saborowski, Sager and Taylor (2010) investigate the effects of decisions regarding the UK interest rate that is set by the Bank of England Monetary Policy Committee. Using intraday, 5-minute return data, they find that interest rate announcements do not affect return but have a significant impact on volatility.

3 METHODOLOGY

In this chapter, I describe my methodological approach to determining the short-term effect of economic releases in the foreign exchange market. First, I describe the research question and the data used in the study and later continue with the regression model and tests used to reveal the impacts and patterns of various macroeconomic effects on the exchange rates. I conclude with limitations of this study.

3.1 Research question

In a broader sense, I investigate how markets absorb new information. Specifically, I try to determine how announcements of macroeconomic fundamentals are reflected in the foreign exchange market. The premise behind my research is fairly simple and straightforward. When a macroeconomic announcement is released and it is different from its forecasted value, the market receives new information about the fundamental value of currencies. In an efficient market, this new fundamental value should be reflected by the change in the exchange rate. If the released announcement is the same as expected, no new information is provided and the result of the announcement should have already been incorporated into the exchange rate.

To study this empirically, I construct a regression model to examine the foreign exchange rate response to certain macroeconomic fundamentals that denote a nation's economic health. In particular, I study the 1-minute response of the euro/dollar exchange rate to the various U.S. and European economic releases in the period from 2008 to 2014. Let me elaborate on the decision to utilize this specific data in my study.

First, I study the 1-minute response of exchange rates to economic releases. In order to determine the change in price due to the specific announcement, I needed to choose a narrow enough window around the announcement to exclude or at least minimize the possible effects of other factors besides that specific announcement. If I manage to do this, I can assume that the specific announcement is the only new piece information on the market or in other words, that immediate exchange rate movements are dominated by this specific announcement. Many other researchers who study the topic incorporate the logic behind this. Ederington and Lee (1993), Ederington and Lee (1995), Almeida et al. (1998), Andersen et al. (2003), Bartolini et al. (2008), Lahaye et al. (2010) and many others (see Chapter 2 for details) all use high-frequency data around the macroeconomic announcements. Even though many of these studies use 5-minute or 10-minute responses, I believe that it is sensible to test also for 1-minute responses. There are two main reasons behind this choice. First, as Cheung and Chinn (2001) point out in the results of their survey analysis, the exchange rates react to news surprises very quickly – for most surprises it is within ten minutes. Moreover, more than two thirds of the respondents believe that the response happens within the first minute. Second, the emergence of powerful algorithmic trading in recent years can dissect new information from the market automatically and instantly and that should be reflected also in the time of the surprise to take effect. The assumption that the released macroeconomic announcement is the only driver behind the exchange rate movement in such a narrow interval is the central assumption of my research and the basic premise behind my empirical model and further testing.

The decision behind the choice of the euro/dollar currency pair is simple. Euro/dollar currency pair is the most liquid one and it is widely perceived that it reacts most purely to the U.S. and European announcement releases (Lien, 2009). Other currency pairs were omitted mostly because the availability and reliability of free high-frequency data for other currency pairs is far inferior to the euro/dollar. Also, as I study the effects of U.S. and European economic releases, this currency pair is the natural choice for my study.

In my thesis, I look at the 12 macroeconomic announcements that encompass the U.S. and European most watched economic indicators[5], which represent six different general macroeconomic announcement categories. In each of the six announcement categories, I study the most important U.S. and European releases. The 12 releases are as follows (Table 2).

[5] Per former research (see Chapter 2) and per conventional wisdom

Table 2. U.S. and European economic releases used in the study

Category	Announcement	Source	Frequency
Employment	Nonfarm payroll employment	U.S.	Monthly
	German unemployment rate	EU	Monthly
Growth	U.S. GDP advance	U.S.	Quarterly
	German preliminary GDP	EU	Quarterly
Inflation	U.S. core CPI	U.S	Monthly
	German preliminary CPI	EU	Monthly
Net exports	U.S. trade balance	U.S	Monthly
	German trade balance	EU	Monthly
Interest rate	U.S. federal funds rate	U.S	Six weeks
	ECB main refinancing rate	EU	Monthly
Sales	U.S. retail sales	U.S	Monthly
	EU retail sales	EU	Monthly

The reason behind the choice of both U.S. and European indicators is twofold. First, as Neely and Dey (2010) point out, the research literature has given unequal attention to connecting U.S. economic releases to the foreign exchange movements, compared to economic releases from other economies. My goal is therefore to determine whether other (namely European) announcements also have a significant impact on the exchange rates. Second, the period I study, i.e. from 2008 to 2014, is a period when Europe has suffered greatly due to the financial crisis. This is also the period when the interest rate were lowered drastically all over the world and when market participants were uncertain about future monetary policy prospects, which made any changes to the interest rates extremely difficult to predict (Evans & Speight, 2010). Market participants have devoted lots of attention to the ECB, its decisions and communication strategies as well as to other European announcements for which they believe the ECB is watching closely (Conrad & Lamla, 2010).

The choice behind the specific U.S. announcements is fairly straightforward. I choose such announcements that represent different announcement categories, that have been studied in the past and that are highly watched by the market. The choice of specific European announcements, however, was not that simple. First of all, the European announcements should represent the same categories as the U.S. announcements. However, the aggregated numbers from the EU announcements are not always the best choice. For example, the EU unemployment rate measures the unemployment across all of the EU countries. However, the market does not put much attention to this number, because the unemployment rate of specific EU countries, like Germany or France, is released prior to the EU number. Usually the market considers the German unemployment rate as the important number to watch and by the time the EU unemployment rate comes out, the market would have already priced in this announcement. The same holds true for the EU GDP q/q, EU CPI and the EU trade balance. The same logic goes for the preliminary versus final numbers of the

announcements. The preliminary numbers are released earlier and the market tends to price in the surprise before the actual final numbers are released, causing much smaller reactions to the final numbers.

Lastly, I should elaborate on the choice of the study period, i.e. the period from January 2008 to August 2014. This period is unique in a way that it includes the period right before the global financial recession, the period during the financial crisis when central banks all over the world were lowering interest rates and the period of slow, but steady recovery. As far as I was able to research, my thesis is the first to consider such recent financial data. This makes the results from this thesis more relevant for further studies, as financial markets have developed greatly over the last few years.

Using the above described methodology I follow many authors in determining the impact of economic releases on the exchange rate movements, but distinct my thesis from previous research by using the 1-minute most recent data that was, as far as my knowledge goes, never used before. However, I want to distinguish this thesis from previous work also by expanding the scope of its research question. In addition to estimating the overall impact of news surprises, I also look into various patterns of these surprises and how they affect the exchange rates.

I perform four different tests to assess the following:

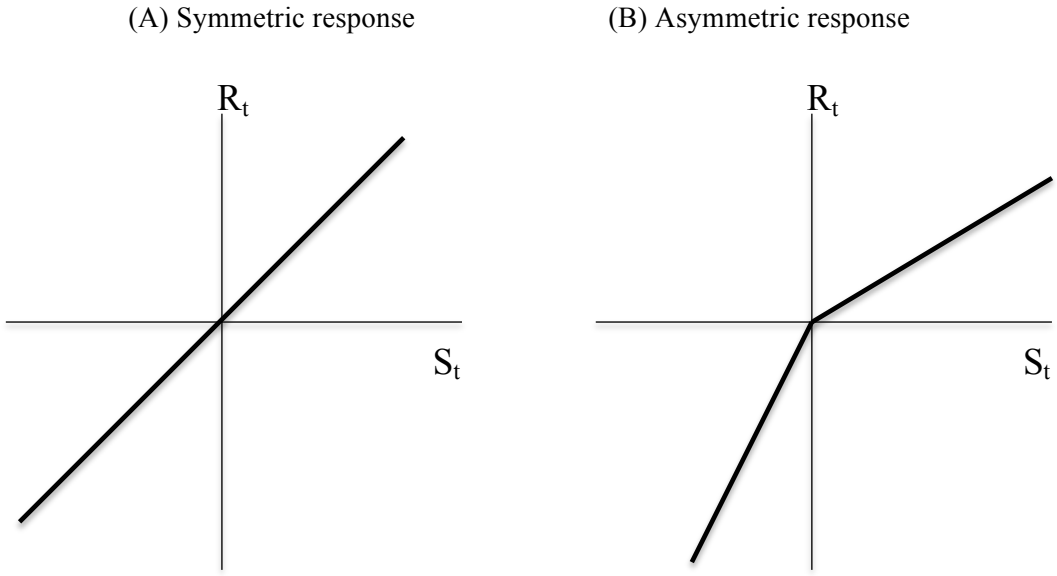
- Asymmetric response;
- Nonlinearity;
- Business cycle;
- Liquidity.

Asymmetric response refers to the differences in price movements that result from good to bad news. If the asymmetric response were present in the market, then the news effect would vary with the sign of the surprise. In other words, markets would react differently to good versus bad news. Figure 2 represents a hypothetical graphical representation of asymmetric response.

Out of the four tests I perform, asymmetric response has been studied most heavily. Perhaps the most important finding for my research is the study by Conrad, Cornell and Landsman (2002) who perform the asymmetry study on the reaction of stock prices to earnings announcements and find that the strongest reactions happened when bad surprises occurred in good times. Since my sample period from 2008-2014 happens entirely in »bad« times, I expect that I should not find much of an asymmetric response in my study. Other researchers, such as Sheehan and Wohar (1995), Sultan (1994), Andersen et al. (2003) and Fatum et al. (2012) have come to the same conclusion – that markets react to news asymmetrically, i.e. that bad news has more significant effect on exchange rates than

good news. On the other hand, some studies have not been able to confirm the asymmetry to news responses (Pearce & Solakoglu, 2007).

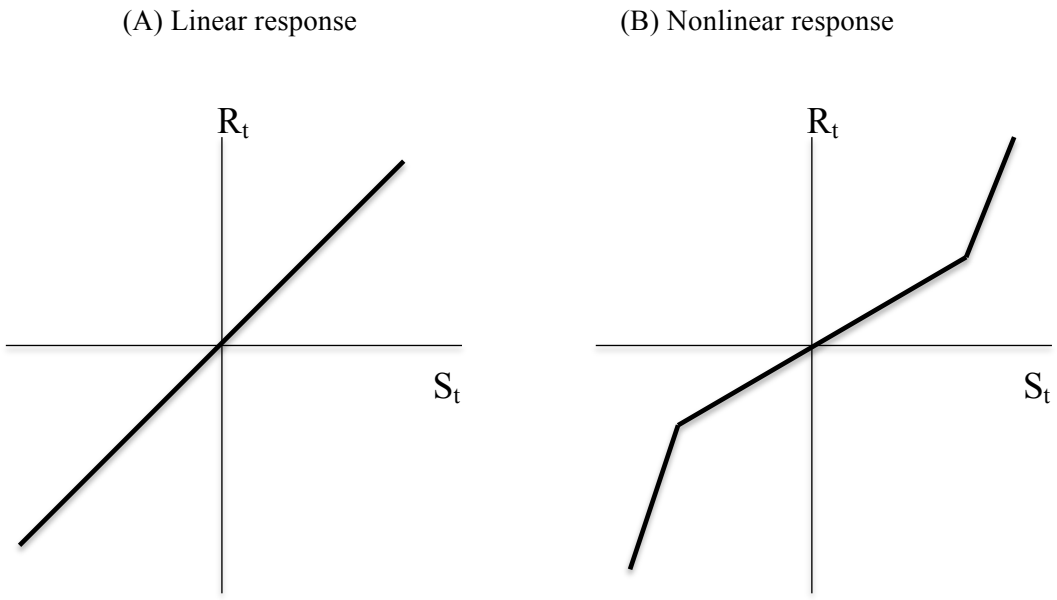
Figure 2. Hypothetical graphical representation of asymmetric response



Note. S_t represents the news surprise and R_t represents the return on exchange rate.

Nonlinearity refers to the fact that the prices react differently depending on the magnitude of the news surprise. If the markets are linear, then the reaction of the price fluctuation should be the same for each marginal unit of surprise, no matter the size of the surprise. Nonlinear markets on the other hand should respond more strongly to either »small« or »big« surprises. Figure 3 represents a hypothetical graphical representation of nonlinearity.

Figure 3. Hypothetical graphical representation of nonlinearity



Note. S_t represents the news surprise and R_t represents the return on exchange rate.

As far as my knowledge goes, nonlinearity has not been studied as much as asymmetric response and even those findings were mixed. Aggarwal and Schirm (1998) find evidence of nonlinear responses in exchange rates after U.S. trade balance news surprises in the period from 1985 to 1993. Interestingly, they find that surprises that are smaller in size (in absolute values) generate larger responses than bigger surprises (in absolute values). On the other hand, Pearce and Solakoglu (2007) find only evidence of linearity in their study of news surprises from January 1999 to April 2004.

In the most general terms, **business cycle** refers to changes in economic activity that an economy experiences over a period of time. A business cycle is defined by periods of growing economy or expansion periods and contracting economy or recession periods. Expansions are measured from the trough of the previous business cycle to the peak of the current cycle, while recessions are measured from the peak to the trough. During a typical business cycle, market participants behave differently throughout the expansion and recession periods. During expansion periods, consumer spending is growing, interest rates generally rise, markets go up etc. During recession periods, consumer spending falls, unemployment rises, interest rates fall and markets go down etc. It is therefore reasonable to believe that also the exchange rates react to news surprises differently depending on the state of the business cycle.

Hardouvelis (1988) is one of the first to show that foreign exchange markets respond significantly to business cycle news. Andersen, Bollerslev, Diebold and Vega (2007) study the response of various stock, bond and foreign exchange markets to economic news surprises in different states of the business cycle and show that exchange rates respond differently in periods of expansion or contraction. Specifically, as many authors before them, they find that exchange rates react most rapidly and significantly on bad news in expansion periods. Pearce and Solakoglu (2007) also find some evidence that the impact of economic release surprises depends on the state of the business cycle. Fatum et al. (2012) come to the similar conclusions.

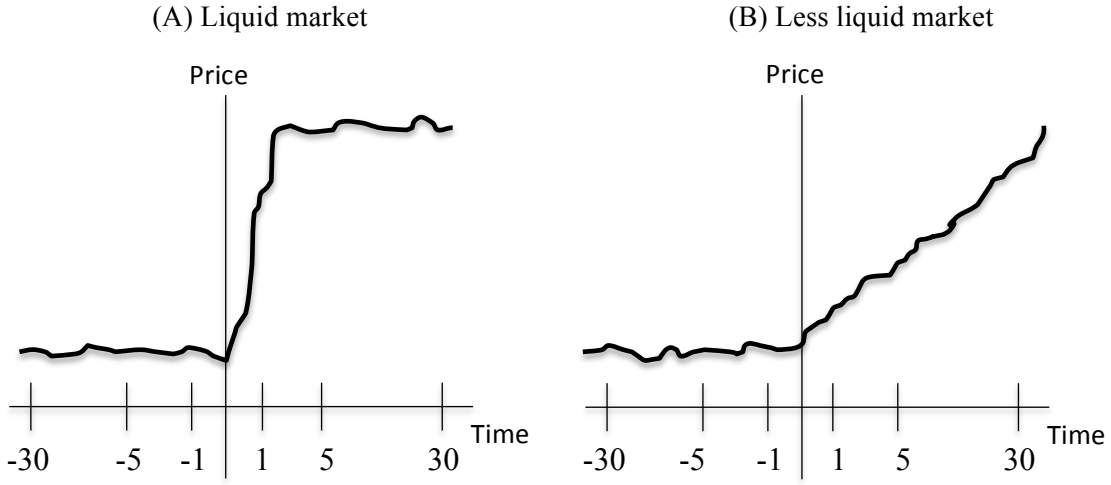
The official periods of expansion and recession are determined by the National Bureau of Economic Research (hereinafter: NBER) in the United States and by the Centre for Economic Policy Research (hereinafter: CEPR) in the EU and the Euro area. It is important to note that there is no clear-cut official definition of recession by both of these institutions. As a good rule of thumb, many economists define recession as two consecutive quarters of decline in a country's real (inflation adjusted) GDP. However, this definition has its drawbacks and NBER and CEPR both use a broader definition of recession and consider many other factors – apart from GDP – such as sales, income, employment, and industrial production, to define the business cycle (Kose & Claessens, 2009). In this regard, NBER (n.d.) has determined that the last recession period in the U.S. started in December 2007 (Q4/2007) and ended in June 2009 (Q2/2009). Since then, the United States has been in a period of (slow) recovery. On the other hand, the EU recession periods have been much more complicated. CEPR (2014) has determined that the euro area

has been in recession period from the first quarter of 2008 (Q1/2008) to the second quarter of 2009 (Q2/2009). This period coincides with that of the United States. However, the euro area has entered another period of recession in the third quarter of 2011 (Q3/2011) and even though it experienced a longer period of weak growth since early 2013, the CEPR has precluded from officially stating that the recession period that started in Q3 2011 has ended. Officially, as per CEPR, the euro area is currently still in recession period, albeit calling the period after 2013 a longer break in the recession.

The fact that the U.S. and euro area recession periods do not coincide perfectly presents a challenge for my study. Typically, economic studies use official declarations of recession as a benchmark to distinguish between good and bad times. However, as I study the foreign exchange markets, I believe it is insufficient to only look at one economy's business cycle fluctuations. Since the foreign exchange rate always represents the price of exchange of one currency for another currency, I believe I should consider both, the U.S. and euro area business cycles when determining the recession and expansion periods. Ideally, these business cycles would of course coincide. However, in the case of the two economies in the period from 2008 to 2014, this is not true. After the second quarter of 2009, when both economies exited the recession period, the euro area entered a new one in the third quarter of 2011. This undermines the purpose of business cycle test, because one economy was expanding while the other was receding. After much consideration, I ultimately decided to test the impact of macroeconomic news specific to business cycle in a period from Q1 2008 to Q3 2011. The benchmark date, or the date when the cycles switch, is the end of Q2 2009. This decision does shrink my observation period but leaves me with two periods where the cycles coincide for both economies. Also, the subsample size of both cycles is comparable, making the test more reliable.

In the most general terms, **liquidity** refers to the degree to which an asset or security can be bought or sold in the market without affecting the asset's price. Liquidity is characterized by a high level of trading activity. I take a slightly different approach to defining liquidity. If a market is characterized by a high level of trading activity and is therefore (perfectly) liquid, it should incorporate news surprises into the exchange rates almost immediately. In a less liquid market, the trading activity is lower and the news surprises take longer to be incorporated in the market. If I observe the response to news surprises over various intervals of time, I can therefore determine the liquidity of the market. This assumption is at the core of determining how quickly the market absorbs the effect of the news surprise and underlies the entire approach to testing for liquidity. Figure 4 represents a hypothetical graphical representation of liquidity. As we can see, a liquid market absorbs the effect of the announcement release at time $t = 0$ almost instantly, in one minute. In comparison, a less liquid market absorbs the new information slowly, the appreciation of the price continues until 30 minutes after the announcement ($t = 30$).

Figure 4. Hypothetical graphical representation of liquidity



Note. The announcement occurs at time $t = 0$.

In sum, I study the effects of various economic releases on the exchange rate movements. I perform an overall test, where I regress the short-term return of exchange rates on the surprise (actual value – expected value) in announcement. In this way I follow and contribute to many studies that have been done in the past. However, this thesis differentiates itself from its predecessors in many ways. In particular, I use the 1-minute return data instead of the commonly used 5-minute or 10-minute return. The time period I consider, from 2008 to 2014 has, as far as my knowledge goes, never been considered before. Also, I perform four tests to determine different patterns of the response. In particular, I perform asymmetric response, nonlinearity, business cycle and liquidity tests. In the next section I describe the data used in my study.

3.2 Data

This section describes the data set used in my study: the Histdata 1-minute euro/dollar exchange rate data and the Action Economics Ltd. forecast news data.

3.2.1 Exchange rate data

I use the 1-minute euro/dollar exchange rate data that was obtained on Histdata.com website. The sample period runs from January 1, 2008, through August 31, 2014. The exchange rate data is based on the tick bid price and is based on the Eastern Standard Time (EST). The time zone of the exchange rate data is important because it differs from the time zone of the macroeconomic announcements data, which was available in Greenwich Mean Time (GMT). To make both datasets comparable, I transformed the EST exchange rate data to the corresponding GMT time zone, also taking into account the daylight saving time (DST) where necessary.

In order to calculate the 1-minute return of the euro/dollar exchange rate around announcement releases, I divided the closing price at the minute of the announcement release with the opening price at the minute of announcement release. This approach allowed me to compare prices exactly one minute after the release and at the moment of the release.

The 1-minute euro/dollar sample from January 1, 2008, to August 31, 2014 consisted of 2,395,842 high-frequency observations. The data was faulty at some parts and I was not able to obtain the exchange rate for every minute of trading in the studied period. However, only in four instances was the data faulty at the time of the chosen announcements. These include January 4, 2008, U.S. nonfarm payroll release and May 27, 2009, June 26, 2009, and January 27, 2010, German preliminary CPI releases. After keeping the data when announcements were made and excluding the missing data I was left with 826 observations.

3.2.2 Macroeconomic announcements data

I use the economic forecast data from EconoDay. EconoDay offers historic economic data and analysis and is considered one of the most respectable companies in its field. Other well-known market analysis companies, such as Bloomberg, also use their economic calendar. EconoDay's forecast methods are based on surveying money managers few days prior to the actual announcements and then reporting the forecasts from the survey. The exact number of respondents in the EconoDay survey varies from one economic release to another, depending on how interesting the release is to market participants. For the most highly watched announcements, such as unemployment data, EconoDay often surveys 50 respondents or more. Also, the time between the participants' response and the time of the actual announcement differs significantly depending on the importance of the release – for most important releases the lag is only a few days, while for the less important releases, the lag can amount to a few weeks.

In the literature, the most commonly used macroeconomic announcements data is the Money Market Services (MMS) data. For example, Hakkio and Pearce (1985), Ito and Roley (1987), Hardouvelis (1988), Balduzzi et al. (2001), Andersen et al. (2003), Lahaye et al. (2010)[6] and Evans and Speight (2010)[7] all use MMS data in their studies. However, the MMS data is no longer available. More recent studies, such as Bartolini et al. (2008) and Cai, Joo and Zhang (2009) use EconoDay/Bloomberg data.

EconoDay publishes both median and average values for each forecast. In order to avoid the potential bias from outliers I use the median value as the official market expectation. I

[6] Their sample period is from January 1987 to October 2004

[7] Their sample period is from January 2002 to July 2003

have to note, however, that even though the use of median instead of average values of the market expectations does eliminate the potential bias from outliers, the median value also has its potential shortcomings, especially in the case of a big variance in the forecast data from the respondents. I cover this issue in detail in chapter 5.

In addition to forecast data, EconoDay also published the actual announcement data and its revised value. Economic indicators may be announced and then revised in subsequent announcements. The first reported value at the time of the announcement may only be a preliminary number that is made prior to processing all the data collected for the indicator and using estimation techniques that infer the value from partial data. When the remaining data are carefully tabulated and analyzed, revised indicators are released (Stengel & Chaffe-Stengel, 2011). As I study the immediate reaction to the news surprises that is published at the exact time of the announcement, I use the first reported announced value.

The timing within the announcement day is scheduled, with the exact time of the release known in advance. Most often the scheduled times are at 8:30 U.S. Eastern Time (12:30 or 13:30 GMT), secondarily at 10:00 U.S. Eastern Time (14:00 or 15:00 GMT) for the news in my study. The time of the U.S. federal funds rate has varied, but has remained constant since March 2013 at 14:00 Eastern Time (18:00 or 19:00 GMT). The European data release time is much more various among releases, ranging from 7:00 GMT to 12:45 GMT. The EconoDay data has also provided me with the information whether the releases have been leaked prior to the scheduled announcement or have been postponed. This happened often especially with the federal funds rate announcements. I take this into consideration in my analysis and adjust my data accordingly.

Typically, macroeconomic announcements are released monthly. However, out of the announcements I study, the U.S. GDP advance and the German preliminary GDP are released quarterly. The U.S. federal funds rate is released every six weeks. After synchronizing the time of the 12 announcements with the corresponding exchange rate data, I was left with 826 observations. For each monthly announcement I had between 76 and 81 observations, for the both quarterly announcements I had 27 observations and for the U.S. federal funds rate I had 55 observations.

I took considerable caution to make sure that the 12 macroeconomic announcements do not overlap at the same time. This is of critical importance because it validates the main assumption that the macroeconomic announcement is the only driver behind the exchange rate movement. In all of the 826 observations the overlap between the announcements did not happen. However, there were instances where one of the announcements was released at the same time as other related announcements that I did not include in the study. For example, the month over month U.S. core CPI that I used in my study is always released concurrently with the month over month U.S. headline CPI and the year over year headline and core values. The U.S. nonfarm payroll announcement is always released concurrently with the U.S. unemployment rate release. Even though those other releases may have an

influence on the exchange rate, the market typically tends to focus on just one of these related releases, especially in the extreme short-term time frame. I therefore assume that my central assumption still holds true even in case of these overlaps.

At this point it is worth noting some of the shortcomings of the Econoday survey data. First, there is the aforementioned lag between the time of the survey and the actual time of the announcement. When the lag is significant, it is possible that the EconoDay forecasts do not represent all relevant information that is available at the time of the announcement Most notably, Bartolini et al. (2008) have pointed out that one of the biggest problems of measuring market expectations is that the respondents are more likely to give conservative estimates of the forecasts. They name three main reasons for this problem.

First, the measure of news that the literature adopts, i.e. the difference between the actual value of the economic release and its expected value, relies exclusively on survey data. Even though that this kind of information gathering might provide the best available assessment of market expectations, the data captured might still have errors. One reason for this error is the possibility that the expectations from the survey do not capture all the information. During the time between the participants' response and the date of the announcement, there can be a great deal of new information that could affect the announcement forecast. The new information could take into account other announcement releases, policy statements or other economic developments. In this respect, the forecasted announcement no longer reflects the true value based on the information on the market, meaning that the implications from news surprises could be much larger than the estimations suggest (Bartolini et al., 2008).

Second, announcement forecasts are in many cases derived from a relatively small sample of respondents. As noted earlier, this happens especially often with the releases that are not considered important by the market. Cai et al. (2009) study the impact of news surprises on exchange rates in the emerging markets and state that for many of these markets, only five respondents or less may provide forecast estimates, making the median forecast value much less reliable. On the other hand, 50 respondents or more provide estimates for the most highly watched indicators in the most liquid foreign exchange markets.

Third, many of the individuals that participate in the surveys are often not the ones with direct responsibility of managing their companies' trading activities and may therefore not be motivated enough (in monetary terms) to give their most considered estimations of future economic releases. In this respect, Ito's (1990) wishful expectations theory[8] and Lamont's (2002) study on forecasters' biased opinions on their expectations due to the wish that their names or affiliations are explicitly listed come into consideration.

[8] Ito (1990) defines wishful expectations as skewing the forecasts in a way that their realizations would benefit their companies.

3.3 Estimation of exchange rate response to news

3.3.1 Estimation of the overall response

I follow Balduzzi et al. (2001), Andersen et al. (2003) and Cai et al. (2009) in methodological approach to evaluating the impact of different economic releases on foreign exchange prices.

First, let F_i represent the median value of the EconoDay forecast survey and A_i the released (actual or realized) value for the announcement *i*. I measure the news surprise in announcement *i* as:

$$E_i = A_i - F_i \tag{1}$$

Because economic releases are measured in different units, I standardize the news surprises to easily compare them across all variables. I use the sample standard deviation as the measure of standardization. The standardized news surprise of the announcement *i* at time *t* is therefore:

$$S_{i,t} = \frac{E_{i,t}}{\sigma_i} \tag{2}$$

Where σ_i is the sample standard deviation of $A_i - F_i$. Therefore, when regressing exchange rate return on news surprises, the regression coefficient represents the change in return of a one standard deviation change in the surprise. As the standard deviation σ_i is constant across all observations for a given announcement *i*, the standardization affects neither the significance of the estimates or the fit of the regressions (Balduzzi et al., 2011). The standardization is therefore only used to compare the size of regression coefficients of news surprises across different announcements.

I calculate the euro/dollar exchange rate return as the percentage change of the exchange rate one minute after the announcement:

$$R_t = ln\,(P_{t+1}) - \ln\,(P_t) \tag{3}$$

Where,

- P_{t+1} is the foreign exchange rate (or price) one minute after time *t*
- P_t is the foreign exchange rate (or price) at the time of the announcement *t*

To analyze the effect of macroeconomic news surprises on euro/dollar exchange rate, I regress the exchange rate return on *i* announcement surprises. I estimate a set of bivariate regression models with OLS:

$$R_t = \alpha + \beta_{i,t} S_{i,t} + \varepsilon_{i,t} \quad (4)$$

Where,

- R_t is the 1-minute percentage return after the announcement at time *t*
- $\beta_{i,t}$ is the sensitivity of the price to the announcement for announcement *i* at time *t*
- $S_{i,t}$ is the standardized surprise in the announcement *i* at time *t*
- ε_t is the error term that represents factors other than selected announcements that affect the exchange rate

In this model, $\beta_{i,t}$ captures the overall effect of the surprise on the 1-minute return of the euro/dollar exchange rate.

3.3.2 Estimation of differentiated responses

One of the key contributions of this thesis is to determine any patterns in how foreign exchange markets respond to news surprises, depending on the sign of the news surprise, its magnitude, the state of the business cycle and the liquidity of the particular currency pair. The basic approach to these tests has been done in three steps.

First, I divide the surprises into subsets that are mutually exclusive. For example, in the asymmetric response test, I divide the surprises into one subset that includes all positive surprises (actual value is bigger than expected) and the other subset that includes all negative surprises. For the nonlinearity test I choose the median of the absolute value of surprises as the benchmark to distinguish between big and small surprises (in absolute terms). The business cycle test includes the recession data subset (from January 2008 to June 2009) and expansion data subset (from July 2009 to July 2011). For the liquidity test I compare all surprises on different time frames – 1-minute, 5-minute and 30-minute returns.

Second, after determining the corresponding subsets I remove all the data that does not belong in either of the two subsets. This is the case only with the asymmetry test, where I had to remove all the surprises that had a zero surprise (actual value is the same as the expected value) because a zero surprise is neither positive nor negative. The zero surprises were not that common, ranging from one to six such cases for each economic release, expect in the case of German Preliminary CPI, where I found 23 such observations. After removing them, I was still left with 56 observations and able to perform the asymmetric response test. In three instances, however, I was not able to perform the tests. First is the U.S. core CPI asymmetry test, where all the positive subset observations had the same

value (constant 0.10% positive surprise in particular), rendering my regression model useless. Second and third instances were the U.S. federal funds rate and ECB refinancing rate where the vast majority of surprises equalled zero. There were only three non-zero surprises in the case of U.S. federal funds rate and seven non-zero surprises in the case of ECB refinancing rate, rendering not only the asymmetry test, but also nonlinearity and business cycle test useless. In all other cases I was able to perform all four tests.

Third, I run a multivariate regression with both subsets separately as independent variables in order to get two coefficients that determine the effect. If I can show that the difference between those coefficients is statistically significant, I can say that the studied phenomenon exists in the market. Table 3 represents how I determined the subsets of the surprises for each testing category.

Table 3. Test descriptions

Differentiated response	**Condition #1**	**Condition #2**
Asymmetric response	Positive ($S_t > 0$)	Negative ($S_t < 0$)
Nonlinearity[9]	Large (S_t > median $\|S_t\|$)	Small (S_t <= median $\|S_t\|$)
Business cycle	Recession (t > January 2008 & t < July 2009)	Expansion (t > July 2009 & t < July 2011)
Liquidity	$R_t = \ln(P_{t+1}) - \ln(P_t)$	$R_t = \ln(P_{t+5}) - \ln(P_t)$ $R_t = \ln(P_{t+30}) - \ln(P_t)$

3.3.2.1 Asymmetry testing, nonlinearity testing and business cycle testing

For each of the first three tests, I perform a multivariate regression with two independent variables. The basic model is therefore:

$$R_t = \alpha + \beta_1 S_t + \beta_2 D_t + \beta_3 (S_t D_t) + \varepsilon_t \quad (5)$$

Where,

$$D_t = \begin{cases} 0 \; if \; Condition \; \#1 = true \\ 1 \; if \; Condition \; \#2 = true \end{cases}$$

The above regression equation simplifies to:

$R_t = \alpha + \beta_1 S_t + \varepsilon_t$ When Condition #1 = true

[9] For nonlinearity testing, I use the median of the absolute value of the news surprises because I am interested only in size, not in the sign of the news surprise. If the absolute value were not taken, then the nonlinearity test would closely resemble the asymmetric response test if we assume the normal distribution of surprises.

And:

$R_t = (\alpha + \beta_2) + (\beta_1 + \beta_3)S_t + \varepsilon_t$ When Condition #2 = true

Which can also be written as:

$R_t = \gamma + \delta S_t + \varepsilon_t$

Where,

$\gamma = \alpha + \beta_2$
$\delta = \beta_1 + \beta_3$

β_1 measures the ***total*** marginal effect of surprises on euro/dollar exchange rate return under baseline condition #1, δ measures the ***total*** marginal effect of surprises on euro/dollar exchange rate return under alternative condition #2, while β_3 is the ***additional*** marginal effect of surprises due to alternative condition #2, on top of the effect under condition #1. A proof of significantly differentiated euro/dollar exchange rate response to positive/negative, large/small, recession/expansion announcement surprises therefore requires testing the hypothesis that regression coefficients β_1 and δ are different, which can be formally written as:

$$H_0: \delta - \beta_1 = 0$$
$$H_1: \delta - \beta_1 \neq 0$$

This test simplifies to:

$$H_0: \beta_3 = 0$$
$$H_1: \beta_3 \neq 0$$

The proof therefore boils down to testing the significance of the β_3 coefficient.

Regression constants under both conditions (α and γ) in principle also have an interpretation. They can be interpreted as measuring the average exchange rate response to accurate announcement forecasts (lack of surprise), which, if markets are at least semi-efficient, should be low and insignificant. However, exclusion of observations with zero surprise from the analysis (in the case of asymmetric test) as well as practical shortcomings in the measurement of announcement surprises (discussed in chapter 3.2.2) may possibly render interpretation of regression constants biased and useless.

3.3.2.2 Liquidity testing

Unlike the first three tests, which required adjustments to the independent variable of the regression model (with the inclusion of an additional dummy variable), the liquidity test requires adjustments to the dependent variable. Specifically, I look at returns at 5-minute and 1-minute intervals after the announcement and 30-minute and 1-minute intervals after the announcement. In order to test for liquidity, I first construct two models:

Model A: Condition #1

$$R_{1minute} = \alpha_1 + \beta_1 S_t + \varepsilon_{t1}$$ [10]

Where I calculated $R_{1minute}$ as follows:

$$R_{1minute} = \ln(P_{t+1}) - \ln(P_t)$$

Model B: Condition #2

$$R_{5minute} = \alpha_2 + \beta_2 S_t + \varepsilon_{t2}$$
$$R_{30minute} = \alpha_3 + \beta_3 S_t + \varepsilon_{t3}$$

Where $R_{5minute}$ and $R_{30minute}$ are defined as:

$$R_{5minute} = \ln(P_{t+5}) - \ln(P_t)$$
$$R_{30minute} = \ln(P_{t+30}) - \ln(P_t)$$

The more liquid the market, less time it needs for new information to be incorporated into the exchange rate. Therefore, when performing the liquidity test, I have to test whether β_1 and β_2 (or β_1 and β_3) are different. To do that, I make the following two-sided hypothesis test for the 5-minute liquidity test:

$$H_0: \beta_2 - \beta_1 = 0$$
$$H_1: \beta_2 - \beta_1 \neq 0$$

And the following two-sided hypothesis test for the 30-minute liquidity test:

$$H_0: \beta_3 - \beta_1 = 0$$
$$H_1: \beta_3 - \beta_1 \neq 0$$

The hypothesis above does not assume any specific direction or particular relationship between β_1 and β_2. It only tells whether the effects of the same announcement are different

[10] This is the same as equation (4)

over different periods of time. A less liquid market would therefore cause the β_2 (or β_3) to be greater (the appreciation/depreciation of exchange rates continues) or less (the appreciation/depreciation of exchange rates reverses) than β_1.

To solve this test I transform the regression into the following:

Model C: 5-minute liquidity test

$$R_{5minute} - R_{1minute} = \alpha_2 + \beta_2 S_t + \varepsilon_{t2} - \alpha_1 - \beta_1 S_t - \varepsilon_{t1}$$
$$R_{5minute} - R_{1minute} = (\alpha_2 - \alpha_1) + (\beta_2 - \beta_1) S_t + (\varepsilon_{t2} - \varepsilon_{t1})$$

Therefore:

$$R_3 = \alpha_3 + \beta_3 S_t + \varepsilon_{t3} \quad (6)$$

Where:

$$\alpha_3 = \alpha_2 - \alpha_1$$
$$\varepsilon_3 = \varepsilon_2 - \varepsilon_1$$
$$\beta_3 = \beta_2 - \beta_1$$
$$R_3 = R_{5minute} - R_{1minute}$$

Therefore, the above hypothesis test simplifies to:

$$H_0: \beta_3 = 0$$
$$H_1: \beta_3 \neq 0$$

Model D: 30-minute liquidity test

$$R_{30minute} - R_{1minute} = \alpha_3 + \beta_3 S_t + \varepsilon_{t3} - \alpha_1 - \beta_1 S_t - \varepsilon_{t1}$$
$$R_{30minute} - R_{1minute} = (\alpha_3 - \alpha_1) + (\beta_3 - \beta_1) S_t + (\varepsilon_{t3} - \varepsilon_{t1})$$

Therefore:

$$R_4 = \alpha_4 + \beta_4 S_t + \varepsilon_{t4} \quad (7)$$

Where:

$$\alpha_4 = \alpha_3 - \alpha_1$$
$$\varepsilon_4 = \varepsilon_3 - \varepsilon_1$$
$$\beta_4 = \beta_3 - \beta_1$$
$$R_4 = R_{30minute} - R_{1minute}$$

Therefore, the above hypothesis test simplifies to:

$$H_0: \beta_4 = 0$$
$$H_1: \beta_4 \neq 0$$

β_3 (or β_4) captures the additional marginal effect of the surprise between the 1 minute and 5 (30) minutes after the announcement happens. To determine whether β_1 and β_2 (or β_3) are significantly different I can therefore look at the statistical significance of t-statistic of β_3 (or β_4) and conclude whether the liquidity exists in the market.

3.4 Limitations

I was able to identify three main limitations to this study.

First, the exchange rate data was faulty at some parts and I was not able to obtain the exchange rates for every minute of trading in the studied period. Even though the data was faulty at the time of the chosen economic release in only four instances, this prevented me from testing how the exchange rate moves from minute to minute after the announcement, which would allow me to identify possible knee-jerk reactions to the news surprises in more detail than merely with the 5-minute and 30-minute liquidity tests.

Second, the shortcomings of the EconoDay data, which I already covered in chapter 3.2.2, may have possible effects on the outcome of the response to the news surprises. Namely, the lag between the respondents submitting their survey results and the actual time of the macroeconomic announcement release, the relatively small amount of respondents for the less important releases and the fact that some individuals that participate in the surveys not be motivated enough (in monetary terms) to provide their most considered estimations of future economic releases could significantly affect the actual response to the news. Also, the dispersion of the survey results reduces the reliability of the median value of the survey forecasts in some cases, which may also have an influence on the actual exchange rate responses.

Third limitation regards the number of announcements that are released at the same time. In some cases, multiple related announcements are released concurrently. In theses cases I take the assumption that just the most highly watched announcement affects the exchange rate[11], although this might not always be the case.

The suggestions for further research that encompass also these limitations to my study are described in detail in chapter 5.

[11] The most highly watched announcements are assumed based on former research (see chapter 2) and on conventional wisdom

4 EMPIRICAL FINDINGS

In this chapter I provide the empirical findings using the regression model described in chapter 3. First, I provide an explanation of the overall results and then continue with the results for each of the four tests I performed.

4.1 Overall results

The empirical findings for the overall 1-minute response of euro/dollar exchange rate to 12 U.S. and European economic releases can be found in Table 4. Before covering the results in detail, let me first explain how the results should be interpreted. In its most basic explanation, the β_1 coefficient expresses a change in the dependent variable as a result of a one-unit change in the independent variable (i.e., the marginal effect of change in the independent variable on the dependent variable). In our case, β_1 therefore measures relative price changes of the exchange between the euro and the U.S. dollar that result from the macroeconomic surprise. Since I used a standardized measure of macroeconomic surprises, the coefficient β_1 measures the change in the 1-minute return of the euro/dollar as a result of a one standard deviation surprise in the macroeconomic announcement. For example, if $\beta_1 = 0.300$, then a one standard deviation surprise in the macroeconomic announcement leads to a 0.300% appreciation of the euro/dollar currency pair.

A very important perspective on β_1 must be explained at this point. I use euro/dollar (and not dollar/euro) exchange rate to measure the effects of the announcements. In foreign exchange market terms, this means that the euro is the base currency and the dollar is the quote currency. The euro/dollar exchange rate tells us how much of the quote currency (dollar) is needed to get one unit of the base currency (euro)[12]. As already explained, β_1 measures how the euro/dollar exchange rate moves due to the change in news surprises. If $\beta_1 > 0$, then the euro appreciates against the dollar, while if $\beta_1 < 0$, then the euro depreciates against the dollar in response to a one standard deviation news surprise. Appreciation of the euro means that more dollars will be needed to buy one unit of euro (euro is becoming relatively stronger against the dollar). In contrast, depreciation of the euro means that less dollar will be needed to buy one unit of euro (euro is becoming relatively weaker against the dollar).

The sign of β_1 regression coefficients for the U.S. macroeconomic releases and the European releases largely corresponds to expectations. Note that for all the U.S. releases β_1 is negative. This is logical, because positive U.S. surprises (for example, higher nonfarm payroll employment than expected) should result in appreciation of the dollar. When the dollar appreciates, euro depreciates, resulting in a lower euro/dollar exchange rate, which

[12] Many international finance textbooks often record the base and quote currency in opposite order – where the dollar would be the base currency and the euro the quote currency

translates to a negative β_1 coefficient. As we can see, this is the case for all the U.S. announcements. For the European announcements, the effects should be the opposite. Because positive European announcement surprises (for example higher retail sales than expected) should appreciate the euro, β_1 should be positive. As we can see, this is the case with all the European announcements except the German unemployment rate. This can be explained intuitively. If the actual German unemployment rate number is larger than expected (a »positive« news surprise according to the terminology of this study), the euro should depreciate, because higher than expected unemployment rate is obviously bad news for the European economy. If euro depreciates, β_1 should be negative.

Another explanation is needed for the results about the inflation (U.S. Core CPI and German Preliminary CPI). The results from Table 4 imply that a positive surprise in inflation (i.e. larger actual inflation than expected) is good news. While a negative surprise in inflation (i.e. smaller actual inflation than expected) is certainly bad news, since it implies the economy is weakening, a positive surprise in inflation is not necessarily good news. Higher inflation than expected is good news only if it is accompanied by a growing economy and increased consumer spending due to the relatively higher rise in wages than in prices. On the other hand, if the higher inflation than expected is a result of higher production costs or lower return on investments (in real terms), it is considered as bad. Since my sample period consists of recession times coupled with a slow recovery, I believe a higher inflation was considered as good news, because the market believed it represented a potential growth in the economy.

The results in Table 4 contain a number of noteworthy findings. For example, a significant influence on the exchange rate is found with many of the economic releases. Out of the 12 U.S. and European macroeconomic announcements surprises I study, 7 were shown to significantly affect the euro/dollar exchange rate within the first minute of the announcement. Out of the U.S. releases these are the nonfarm payroll employment, core CPI and federal funds rate. Out of the European releases German unemployment rate, German preliminary GDP, ECB refinancing rate and EU retail sales affect the euro/dollar significantly. These findings are in accordance with many studies that showed the significant relationship between macroeconomic surprises and the exchange rate returns. However, most of these studies use 5-minute or less frequent data to prove this phenomenon. The results of my analysis do, however, clearly show that the foreign exchange markets incorporate new information extremely quickly, in a matter of a minute, maybe even in a matter of seconds. It is very reassuring that my findings are entirely in line with those of Cheung and Chinn (2001), obtained by surveying traders, who say that the news information is incorporated into the exchange rate almost instantaneously after the news announcement.

Table 4. Estimate of a regression model for the euro/dollar exchange rate

Announcement	α	β_1	R^2	**No. obs.**
U.S. nonfarm payroll	-0.043 (-0.516)	-0.201** (-2.424)	0.070	80
U.S. GDP advance	-0.001 (-0.011)	-0.054 (-0.669)	0.018	27
U.S. core CPI	0.024 (1.130)	-0.080*** (-3.783)	0.155	80
U.S. trade balance	0.026 (0.974)	-0.028 (-1.032)	0.013	80
U.S. federal funds rate	0.113 (0.791)	-0.229* (-1.626)	0.048	55
U.S. retail sales	-0.029 (-1.033)	-0.014 (-0.499)	0.003	80
German unemployment rate	-0.015 (-1.309)	-0.033*** (-2.851)	0.094	80
German preliminary GDP	-0.050 (-1.405)	0.225*** (6.303)	0.614	27
German preliminary CPI	0.011 (0.874)	0.018 (1.400)	0.026	76
German trade balance	-0.007 (-0.619)	0.009 (0.846)	0.009	80
ECB refinancing rate	0.052 (0.969)	0.097* (1.806)	0.040	81
EU retail sales	0.013 (0.846)	0.035** (2.370)	0.067	80

Note. I estimate the regression model (4), $R_t = \alpha + \beta_{i,t} S_{i,t} + \varepsilon_{i,t}$

Corresponding t-values are in parentheses.

* statistically significant at 10% level

** statistically significant at 5% level

*** statistically significant at 1% level

A closer inspection of the data shows that β_1 has a relatively large impact on the exchange rate in some cases. For example, a one standard deviation German preliminary GDP surprise appreciates (if positive) or depreciates (if negative) the euro against the dollar by 0.225%. Also, the determination coefficient for the German preliminary GDP is rather large, showing us that 61.4% of the total variation in 1-minute return of the euro/dollar exchange rate can be explained by the linear relationship between the surprise and the 1-minute return (as described by the regression equation). U.S. federal funds rate surprise causes an even bigger move; one standard deviation surprise appreciates (if positive) or depreciates (if negative) the dollar against the euro by 0.229 %. This is a relatively big move, especially when considering it happened within the first minute of the announcement release. For comparison, the average daily range of the euro/dollar (range

from high to low) during 2009-2013 has been 1.02%[13]. Interestingly, German preliminary GDP does not give significant results in the study from Andersen et al. (2003). Also, Lien (2009) argues that the (U.S.) GDP does not significantly influence the foreign exchange market significantly because it is released less frequently than most of the other data (quarterly versus monthly) and because many of the components that the GDP is comprised of are already known in advance of the release. One of the possible explanations for such a strong German GDP effect in this study is perhaps in the fact that Germany has always been viewed as the cornerstone of the EU, the country that is the most stable and the last to fall into the financial and debt problems. Since the global financial crisis and European debt crisis were so severe, perhaps investors have dedicated much more attention to the growth of the German economy than they would normally, as they anticipated that if German economy doesn't grow, neither will the rest of the EU. A relatively large impact of some macroeconomic announcements found in my study is even more interesting when compared to the impact from the study by Andersen et al. (2003), who find many significant releases but the overall effect (in terms of β_1) is much smaller. The largest average impact Andersen et al. (2003) register is $\beta_1 = 0.138$ for the U.S. trade balance report.

The fact that both U.S. and German employment reports are significant coincides with almost every other study. In some way, this is logical, because an economy that experiences high unemployment rates (as was the case in the last several years) will see unemployment data as more important than, for example, trade balance data, which should be more important when an economy experiences large trade balance deficits. This is also the view that Cheung and Chinn (2001) and Lien (2009) express. Also, both interest rate decisions affect the exchange rate almost instantly.

At this point, I have to note, however, that the insignificant results from the overall regression do not necessarily mean that the other types of surprises from other tests are also not important. Such is the case, for example, with the U.S. trade balance announcements. Notice that the overall effect of all U.S. trade balance announcements is insignificant, with a t-statistic of -1.032. However, notice also that in Table 7, which shows the effects of a business cycle test, the effect of the recession period is, in fact, significant with a t-statistic of -2.604. Similar observations can be seen across all four tests, including the positive and negative, big and small and recession and expansion period surprises.

I can explain this phenomenon. Let us again consider the U.S. trade balance. The recession and expansion periods differ from each other with $\beta_1 = -0.144$ for the recession period and $\boldsymbol{\delta} = -0.015$ for the expansion period. The combined regression of both subsets $\beta_1 = -0.028$ averages the individual effects of the subsets. Because the recession and expansion period

[13] I calculated this by first averaging the average daily pip range of the euro/dollar from 2009-2013, obtained at Hantecfx.com (Hantexfx, n.d.) and then dividing the number with the average euro/dollar exchange rate from 2009-2013, obtained at Oanda.com (Oanda, n.d.).

effects differ so vastly, the β_1 coefficient becomes a poor estimator for all news surprises, which results in insignificant values for the overall regression. Therefore, the individual effects of different subsets can still be significant even though the overall effect is not.

The situation can also be, of course, the opposite. There are certain surprises that have a significant overall effect but lose their significance once they are divided into subsets. For example, consider German unemployment rate, where the overall β_1 = -0.033 is significant with a t-statistic of -2.851. However, in the Table 5, where the surprises are divided into positive and negative subsets, neither of the subsets significantly affects the exchange rate. This phenomenon can also be explained. The effects of both positive and negative subsets are relatively close to each other (β_1 = -0.037 and $\boldsymbol{\delta}$ = -0.033) and both are insignificant. However, when we combine these two effects that are similar, the resulting β_1 = -0.033 becomes a good estimator for all surprises while effectively doubling the number of observations that are estimated by the overall regression. Having explained these various possible scenarios, let us look into the four subset tests more thoroughly.

4.2 Asymmetric response results

Asymmetric response measures whether there is a significant difference on the return between the positive surprises and negative surprises. In other words, do bad news cause a different response as good news.

Table 5 represents the results of the asymmetric response test. Throughout the all 12 announcements, there is no sign of an asymmetric response in the euro/dollar exchange rate that would result from good and bad news. Although there are some significant coefficients of β_1 and δ, the insignificance of β_3, which measures the t-statistic of the difference between β_1 and δ negates that there is any asymmetric response in the market.

The news surprises of U.S. Federal funds rate and ECB refinancing rate were mostly zero (central banks do not change interest rates often and this is what the market expects), which resulted in only three and seven relevant observations (observations where the surprise did not equal zero). Therefore I have excluded these two announcements from this test. Also, as mentioned earlier, I was unable to perform the asymmetric response test for the U.S. core CPI announcement, because all the positive subset observations had the same value (constant 0.10% positive surprise in particular), rendering my regression model useless.

Table 5. Estimate of regression model for euro/dollar asymmetric response test

Announcement	α	β_1	γ	δ	β_3	**No. obs.**
U.S. nonfarm payroll	-0.290 (-1.418)	-0.053 (-0.230)	0.286 (1.657)	0.067 (0.425)	0.119 (0.429)	79
U.S. GDP advance	0.000 (-0.001)	-0.051 (-0.199)	-0.048 (-0.489)	-0.089 (-0.939)	-0.038 (-0.152)	24
U.S. core CPI	/	/	/	/	/	/
U.S. trade balance	0.040 (0.557)	-0.064 (-0.713)	0.051 (1.580)	-0.004 (-0.130)	0.060 (0.722)	80
U.S. federal funds rate	/	/	/	/	/	/
U.S. retail sales	-0.082 (-1.395)	0.021 (0.300)	0.025 (0.472)	0.020 (0.438)	-0.001 (-0.007)	77
German unemployment rate	-0.012 (-0.251)	-0.037 (-0.716)	-0.016 (-0.892)	-0.033 (-1.992)	0.004 (0.089)	79
German preliminary GDP	0.010 (0.113)	0.170** (2.648)	0.078 (0.557)	0.437** (2.355)	0.267 (1.471)	22
German preliminary CPI	-0.005 (-0.188)	0.030 (1.482)	-0.035 (-0.521)	-0.032 (-0.459)	-0.062 (-0.978)	53
German trade balance	-0.001 (-0.066)	-0.001 (-0.072)	-0.010 (-0.328)	0.011 (0.406)	0.012 (0.317)	76
ECB refinancing rate	/	/	/	/	/	/
EU retail sales	0.104 (1.604)	-0.045 (-0.658)	-0.009 (-0.369)	0.018 (0.800)	0.063 (1.054)	74

Note. I estimate the regression model (5), $R_t = \alpha + \beta_1 S_t + \beta_2 D_t + \beta_3 (S_t D_t) + \varepsilon_t$; Corresponding t-values are in parentheses.

* statistically significant at 10% level

** statistically significant at 5% level

*** statistically significant at 1% level

4.3 Nonlinearity response results

As stated earlier, nonlinearity refers to the fact that prices react differently depending on whether the surprise is big or small. I define big surprises as those that are bigger than the median of the absolute value of all surprises and small surprises as those that are smaller or equal than the median of the absolute value of all surprises.

Table 6 represents the nonlinearity response results. The data did not seem to demonstrate a widespread presence of nonlinearity in my sample. β_3, which measures the t-statistic of

the difference between big surprises (which are measured by β_1) and small surprises (which are measured by δ), is almost always insignificant. Ideally, of course, the results would give three characteristics: (1) significant β_3 coefficient, (2) significance among both subsets and (3) the effects of both subsets exhibiting the same sign.

Table 6. Estimate of regression model for euro/dollar nonlinearity test

Announcement	**α**	β_1	γ	δ	β_3	**No. obs.**
U.S. nonfarm payroll	-0.323 (-0.991)	0.182 (0.775)	-0.061 (-0.293)	0.489 (0.796)	0.307 (0.469)	80
U.S. GDP advance	-0.178 (-0.601)	0.124 (0.580)	0.146 (0.994)	-0.656 (-1.027)	-0.780 (-0.923)	27
U.S. core CPI	-0.334 (-0.652)	0.210 (0.983)	-0.018 (-0.520)	0.084* (1.916)	-0.126 (-0.831)	80
U.S. trade balance	0.106** (2.066)	-0.053 (-1.475)	-0.064 (-0.907)	0.302 (1.268)	0.355* (1.654)	80
U.S. federal funds rate	/	/	/	/	/	/
U.S. retail sales	-0.084 (-1.000)	0.020 (0.368)	-0.059 (-0.847)	0.203 (0.833)	0.183 (0.666)	80
German unemployment rate	-0.056 (-1.362)	0.042 (1.461)	-0.008 (-0.250)	-0.013 (-0.131)	-0.055 (-0.572)	80
German preliminary GDP	-0.580** (-3.053)	0.423*** (3.151)	-0.023 (-0.336)	0.218 (0.785)	-0.205 (-0.480)	27
German preliminary CPI	0.012 (0.243)	0.017 (0.525)	0.019 (0.871)	-0.068 (-1.102)	-0.084 (-1.185)	76
German trade balance	-0.019 (-0.546)	-0.001 (-0.056)	-0.003 (-0.089)	0.028 (0.346)	0.029 (0.356)	80
ECB refinancing rate	/	/	/	/	/	/
EU retail sales	0.033 (0.392)	-0.029 (-0.557)	-0.004 (-0.117)	0.039 (0.512)	0.068 (0.735)	80

Note. I estimate the regression model (5), $R_t = \alpha + \beta_1 S_t + \beta_2 D_t + \beta_3 (S_t D_t) + \varepsilon_t$; Corresponding t-values are in parentheses.

* statistically significant at 10% level

** statistically significant at 5% level

*** statistically significant at 1% level

This is, however, not the case with the nonlinearity test. While U.S. trade balance does exhibit significant β_3 coefficient indicating the difference between β_1 and δ, it does not exhibit significance among both subsets. This makes the underlying explanation weaker. I can state that there is a different exchange rate response to U.S. trade balance news

surprises when the news surprise is big and when the news surprise is small. However, since both subsets are not statistically significant, I cannot speculate on the direction or magnitude of surprises in big surprises relative to the small surprises.

I should note that nonlinearity measures only the size of the response, not the sign. Therefore, it is possible that β_1 and δ exhibit different signs, although this might seem strange at first sight. Different signs of β_1 and δ imply that a small surprise might depreciate (appreciate) the currency while the big surprise might appreciate (depreciate) the currency. Although my data shows such effects on some occasions, none of it was statistically significant.

Again, the U.S. Federal funds rate and ECB refinancing rate announcements were excluded from this test.

4.4 Business cycle response results

I have divided the business cycle response into two subsets. The first subset includes the period from the first quarter of 2008 to the second quarter of 2009, which is a period where both the U.S. and EU economies were in recession, as defined by NBER and CEPR. The second subset includes the period from the third quarter of 2009 to the second quarter of 2011, when both economies were in a period of expansion and recovery.

There are a bit more statistically significant results in business cycle response test than the asymmetric and nonlinearity tests. As we can see from the Table 7, there are three instances when there was a discrepancy between the effects of recession period and expansion period. Again, the ideal scenario would include these three characteristics: (1) significant β_3 coefficient (2) significance among both subsets and (3) the effects of both subsets exhibiting the same sign.

However, this is not the case with the business cycle test. While U.S. core CPI, U.S. trade balance and EU retail sales all exhibit significant β_3 coefficients indicating the difference between β_1 and δ, they do not exhibit significance among both subsets, making the underlying explanation weaker. I can state that there is a different exchange rate response to news surprises in the period of recession and in the period of expansion. However, since both subsets are not statistically significant, I cannot speculate on the direction or magnitude of surprises in one period relative to the surprises in the other period.

Interestingly, there is one example where the sign of the response is contradictory to what one might expect. The result for U.S. GDP advance announcement in the recession period is significant and positive, with a $\beta_1 = 0.181$ and t-stat of $t = 1.810$. This means that a positive surprise in GDP advance release actually depreciates the dollar. Without additional analysis, I can only speculate on the reason for this phenomenon. The

depreciation of the U.S. dollar might have happened because of the severe recession in the United States in this period. Even though both United States and Europe were officially in recession, the United States were hit by the first wave of the financial crisis much more strongly than Europe, where the hit came a little bit later. I suspect that in the recession period, especially in the first months of 2008, the U.S. dollar was poised to depreciate. Of course, this explanation does not fully grasp the situation during the recession period, because the U.S. trade balance report had a significant and negative sign on the euro/dollar exchange rate, appreciating the U.S. dollar in the case of a positive surprise. Although the U.S. GDP advance result is counterintuitive, it is statistically significant.

Table 7. Estimate of regression model for euro/dollar business cycle test

Announcement	**α**	**β_1**	**γ**	**δ**	**β_3**	**No. obs.**
U.S. nonfarm payroll	0.074 (0.460)	-0.016 (-0.122)	-0.194 (-1.390)	-0.180 (-1.407)	-0.165 (-0.910)	42
U.S. GDP advance	0.254* (2.173)	0.181* (1.810)	0.092 (0.861)	0.028 (0.155)	-0.153 (-0.741)	14
U.S. core CPI	0.094* (1.950)	-0.013 (-0.377)	0.032 (0.983)	- 0.136*** (-4.397)	-0.123** (-2.673)	42
U.S. trade balance	-0.018 (-0.383)	-0.144** (-2.604)	0.091** (2.761)	-0.015 (-0.298)	0.129* (1.728)	42
U.S. federal funds rate	/	/	/	/	/	/
U.S. retail sales	-0.061 (-0.843)	-0.010 (-0.241)	-0.030 (-0.669)	0.078 (1.285)	0.088 (1.118)	42
German unemployment rate	-0.032 (-1.298)	-0.028 (-1.418)	0.010 (0.478)	-0.023 (-1.387)	0.005 (0.196)	42
German preliminary GDP	-0.174 (-1.875)	0.271** (3.595)	-0.037 (-0.996)	0.203*** (7.410)	-0.068 (-0.942)	14
German preliminary CPI	-0.025 (-1.174)	0.001 (0.024)	0.033* (1.768)	-0.010 (-0.396)	-0.010 (-0.286)	39
German trade balance	0.000 (0.015)	0.012 (0.562)	0.009 (0.331)	0.007 (0.290)	-0.005 (-0.136)	42
ECB refinancing rate	/	/	/	/	/	/
EU retail sales	0.062 (1.305)	0.121** (2.198)	0.011 (0.644)	0.007 (0.466)	-0.114** (-2.393)	42

Note. I estimate the regression model (5), $R_t = \alpha + \beta_1 S_t + \beta_2 D_t + \beta_3 (S_t D_t) + \varepsilon_t$; Corresponding t-values are in parentheses.

* statistically significant at 10% level

** statistically significant at 5% level

*** statistically significant at 1% level

Another interesting observation can be made with the German preliminary GDP release. Even though there is no difference between the reactions in recession and expansion period, the significant values of β_1 and δ are both positive and large. This shows us that the markets closely watched this indicator throughout the whole period, which coincides with the overall regression results.

As was the case with asymmetric and nonlinearity tests, the U.S. Federal funds rate and ECB refinancing rate announcements were excluded also from this test.

4.5 Liquidity response results

In this thesis I argue that if a market is characterized by a high level of trading activity and is therefore (perfectly) liquid, news surprises should be incorporated in the foreign exchange rate almost immediately. In a less liquid market, trading activity is lower and therefore the news surprises take longer to be incorporated in the market.

The liquidity test differs from the previous tests in terms of changing the dependent variable instead of independent variable. Let me first explain how to interpret the results. The β_3 (or β_4) coefficient, which measures the t-statistic of the difference between the 1-minute exchange rate response and 5-minute (or 30-minute) responses, implicitly measures liquidity. If β_3 (or β_4) coefficient is significant, this represents somewhat lower liquidity in the market, as the exchange rate takes longer than one minute to incorporate the news surprises. If β_3 (or β_4) coefficient is insignificant, the market is liquid around certain announcement.

Let us first look at the 5-minute liquidity test. The first thing to notice is that the sign of the response is the same as the sign of the 1-minute response in all announcements that have significant responses. This indicates that the significant 1-minute response was not a knee-jerk reaction where the market would correct itself in the next few minutes. In other words, the same announcements cause an appreciation (depreciation) one minute after the announcement as well as five minutes after the announcement.

As expected, the euro/dollar market is liquid around most of the announcements. This is to be expected because this currency pair has the highest trading volume in the foreign exchange market, so the information is probably incorporated quickly. Indeed, only in two instances the results show me that it takes longer than one minute for news surprises to be incorporated into the exchange rate. The β_3 coefficient is significant in the cases of U.S. GDP Advance and German preliminary CPI. The U.S. GDP advance announcement is not significant one minute after the announcement, which shows us that for this announcement more than one minute is needed to produce a significant reaction. On the other hand, German preliminary CPI result does show lesser liquidity in five minutes after the

announcement, but fails to have a significant effect at the five-minute mark, preventing any further conclusion about the actual size or sign of the effect.

Next, let us look at the 30-minute liquidity test. As was the case with the 5-minute test, the sign of the 30-minute response is the same as the sign of the 1-minute response in all announcements that have significant responses, indicating no knee-jerk reactions. Again, the same announcements cause an appreciation (depreciation) 1 minute after the announcement as well as 30 minutes after the announcement.

Table 8. Estimate of regression model for euro/dollar for 5-minute liquidity test

Announcement	α_2	β_2	$\mathbf{R^2}$	β_3	**No. obs.**
U.S. nonfarm payroll	0.004 (0.047)	-0.288*** (-3.170)	0.114	-0.087 (-1.351)	80
U.S. GDP advance	-0.067 (-0.809)	-0.194** (-2.287)	0.173	-0.140** (-2.220)	27
U.S. core CPI	0.021 (0.555)	-0.050 (-1.342)	0.023	0.030 (0.979)	80
U.S. trade balance	0.065 (1.466)	-0.043 (-0.979)	0.012	-0.016 (-0.402)	80
U.S. federal funds rate	-0.002 (-0.010)	-0.321** (-2.068)	0.075	-0.092 (-1.019)	55
U.S. retail sales	-0.043 (-1.101)	-0.001 (-0.028)	0.000	0.013 (0.469)	80
German unemployment rate	0.009 (0.390)	-0.034 (-1.548)	0.030	-0.002 (-0.097)	80
German preliminary GDP	-0.103** (-2.012)	0.266*** (5.172)	0.517	0.041 (1.110)	27
German preliminary CPI	0.016 (0.799)	-0.013 (-0.650)	0.006	-0.031** (-2.092)	76
German trade balance	-0.002 (-0.078)	0.007 (0.320)	0.001	-0.002 (-0.131)	80
ECB refinancing rate	-0.049 (-0.782)	0.145** (2.324)	0.064	0.048 (1.405)	81
EU retail sales	0.051** (2.173)	0.037 (1.629)	0.033	0.003 (0.143)	80

Note. I estimate the regression model (6), $R_3 = \alpha_3 + \beta_3 S_t + \varepsilon_{t3}$; Corresponding t-values are in parentheses.

* statistically significant at 10% level

** statistically significant at 5% level

*** statistically significant at 1% level

There are only three announcements around which the market is less liquid in the 30-minute time frame. These are U.S. nonfarm payrolls, German preliminary GDP and ECB refinancing rate. β_4 coefficient, which measures the difference between 1-minute and 30-minute responses, is significant in all three cases. In contrast to the 5-minute liquidity test, the significance of β_1 and β_3 fulfils the three criteria: (1) significant β_4 coefficient, (2) significance among both subsets and (3) the effects of both subsets exhibiting the same sign.

Table 9. Estimate of regression model for euro/dollar for 30-minute liquidity test

Announcement	α_3	β_3	R^2	β_4	**No. obs.**
U.S. nonfarm payroll	-0.224* (-1.763)	-0.403*** (-3.204)	0.116	-0.202* (-1.856)	80
U.S. GDP advance	0.011 (-0.084)	-0.084 (-0.548)	0.012	-0.030 (-0.225)	27
U.S. core CPI	0.022 (0.320)	-0.071 (-1.056)	0.014	0.009 (0.139)	80
U.S. trade balance	-0.070 (-0.829)	-0.063 (-0.744)	0.007	-0.035 (-0.447)	80
U.S. federal funds rate	0.117 (0.487)	-0.455* (-1.935)	0.066	-0.226 (-1.468)	55
U.S. retail sales	-0.004 (-0.061)	-0.046 (-0.644)	0.005	-0.032 (-0.455)	80
German unemployment rate	-0.016 (-0.301)	-0.044 (-0.870)	0.010	-0.011 (-0.253)	80
German preliminary GDP	-0.108 (-1.297)	0.435*** (5.236)	0.523	0.210** (2.484)	27
German preliminary CPI	0.038 (0.768)	-0.049 (-0.973)	0.013	-0.067 (-1.393)	76
German trade balance	0.041 (1.041)	0.049 (1.232)	0.019	0.040 (1.050)	80
ECB refinancing rate	-0.152 (-1.549)	0.346*** (3.531)	0.136	0.249*** (3.546)	81
EU retail sales	0.030 (0.803)	0.050 (1.357)	0.023	0.015 (0.432)	80

Note. I estimate the regression model (7), $R_4 = \alpha_4 + \beta_4 S_t + \varepsilon_{t4}$; Corresponding t-values are in parentheses.

* statistically significant at 10% level

** statistically significant at 5% level

*** statistically significant at 1% level

The interpretation, however, is a little different for the three significant announcements. On one hand, the U.S. nonfarm payroll and ECB refinancing rate releases exhibit a larger β_3 than β_1. This indicates that while the market did react significantly around these two releases in the first minute after the announcement, the move of the exchange rate continued up to the thirty minutes after the announcement. This indicates a clear sign of

lesser liquidity around these two releases, as the markets needed more time to incorporate all of the new information to the exchange rate.

On the other hand, β_3 was smaller than β_1 for the German preliminary GDP release. This indicates that the news surprise first appreciated the euro (depreciated the dollar) in the first minute after the release and then started depreciating the euro (appreciating the dollar) up to the 30 minutes after the release, indicating a correction of the initial response. This is shown by the significant difference between $\beta_3 = 0.435$ and $\beta_1 = 0.225$. This result is intriguing, as it represents the only example of a significant correction of the initial 1-minute response.

It is unclear what drives such a movement, however, I can speculate on the reason. As the GDP is the comprised of many different components, the growth of the total GDP might not be the most relevant information for the market participants. As such, investors might need more time to analyze and determine the true impact of the announcement. Cheung and Chinn (2001) provide an example of this from their survey results. They talk about the difference between growth that results from rising exports and growth that results from rising inventory release. In the first case, the rise in GDP in viewed as a positive, while in the second case, the rise in the GDP might be considered as negative. Consequently, this might have different impact on the exchange rates. I speculate that this is the case also with the German preliminary GDP response. Clearly, the growth in GDP is good for the economy and it appreciates its currency (hence, the initial 1-minute significant response), however, after a more detailed analysis of the GDP number, the market takes into account also certain components that may have a negative (or less positive) effect on the exchange rate.

5 SUGGESTIONS FOR FUTURE RESEARCH

The empirical results in this paper show that there is a significant and widespread influence of various macroeconomic news surprises on the exchange rate movements. My methodological approach closely follows the approach that was used in multiple prior studies on the announcement effects, however I also incorporate a slightly different approach by testing not only for the overall response to the news, but also for the potential patterns in the response. Even though that numerous studies, including my own, prove that fundamental announcement releases matter in the foreign exchange market, I believe there is still room for further research in this field.

The first direction for further research would be to investigate the patterns of the exchange rate responses in more detail. My research included asymmetric response test, nonlinearity test, business cycle test and liquidity test. It would be interesting, though, to expand and combine these tests in order to get an even clearer picture of the responses. For example, one might observe how the exchange rates react not only to positive or negative and big

and small surprises separately, but also how they would react to big, negative surprises versus big, positive surprises. Or, it might be interesting to go even further and observe the big, negative surprises in recession periods versus the big, positive surprises in expansion periods. The possibilities here are almost endless and they might uncover some interesting patterns in exchange rate movements. Of course, such approach would require a much longer database than the one used in this study. Even though I used a relatively long database ranging from January 2008 to August 2014, I still found myself with only a few observations for some of the announcements in particular tests. This happens due to the fact that each more specifically defined subset lowers the number of observations. If we combine various tests together, this would lower the number of observations even further, reducing the viability of the study. A long, comprehensive dataset is therefore required in order to research this topic further.

Another interesting direction for further research would be to include a different measurement of market expectations. As noted earlier, the survey data that is used to capture market expectations has several shortcomings. Most notably, the lag between the respondents submitting their survey results and the actual time of the macroeconomic announcement release, the relatively small amount of respondents for the less important releases and the fact that some individuals that participate in the surveys not be motivated enough (in monetary terms) to provide their most considered estimations of future economic releases could significantly affect the actual response to the news. One possible solution would be to use a methodology that was developed by Rigobon and Sack (2008). Their method included the measurement of »true news«, which they define as the difference between the actual number of economic release and the number that was expected one instant before the release. The »true news« is different from the standard measurement of news surprise (the difference between the actual number of economic release announcement and the number that was expected at the time of the survey) by a random measurement error. Rigobon and Sack (2008) argue that even though their methodology does have some benefits to measuring the effects of news on exchange rates, their methodology would be difficult to use in practice. Still, I believe future researchers should take this into account when estimating exchange rate responses to news surprises.

The third recommendation also regards the announcement data. In this paper, I use the median value of the announcement data as an official market expectation. I believe the median value is a better estimator than the average value because of the elimination of potential bias from outliers. However, the median value also has its shortcomings. Consider two scenarios, where the median value of the market survey data is the same but the dispersion of the data around that median value is different. In the first scenario, the individual expectations are concentrated closely to the median value, meaning that the market has reached a consensus about the expectation. In the second scenario, the values are much more dispersed around the median value, meaning that the market did not reach a consensus about the expectation. In the case of an announcement value that differs from the median value, we can expect that the market will react more strongly in the first

scenario, where the market was more certain about the expected value. In the other case, the response of the exchange rate might not be so significant. Therefore, I would recommend that future researchers include projections about dispersion of survey data to their studies.

Fourth, some announcements are released at the same time. For example, U.S. nonfarm payroll announcement is always released at the same time as U.S. unemployment rate. It would be interesting to expand the methodological model in a way that both of these announcements and their news surprises would reflect the response of the exchange rates. A multivariate model that includes all these concurrent announcements would be required to determine these effects. I believe that while such an approach might give us valuable insight into the importance of announcements and provide more accurate results from a strictly analytical view, in reality markets look mostly at one announcement in such cases, especially in the extreme short-run. A U.S. nonfarm payrolls is considered much more important that U.S. unemployment rate. Core U.S. CPI announcement is considered more important than the overall U.S. CPI announcement. As such, I believe that my methodological approach in this study is superior to the multivariate one, however I also believe it would be interesting to explore both.

Fifth, it would be interesting to see how different currencies would react to the same announcements. For example, one might suspect that not only euro/dollar currency pair reacts significantly to the U.S. announcement news, but also dollar/yen, pound/dollar, Australian dollar/U.S. dollar, New Zealand dollar/U.S. dollar, Canadian dollar/U.S. dollar and all the other minor U.S. dollar pairs. This would be especially interesting with the relatively illiquid currency pairs and announcements. In particular, I would be interested to know whether the reaction to the same announcement differs from one currency pair to another. Of course, in short-term, there would most probably be a difference because different currency pairs incorporate information at a different pace, however, is there a possibility that eventually all currency pairs incorporate the same information to the same degree. The only difference would be the amount of time needed for the new information to be incorporated. The liquidity test outlined in this paper would be a great method to approach such a question.

So far, the vast majority of studies have focused on U.S. announcements and currency pairs that included the U.S. dollar. My sixth suggestion would therefore be to include more countries, more currency pairs and more announcements. As I believe that the literature has now accepted the view that fundamental announcements matter, this is the next logical step for future research. I attempted to expand this focus and included also the European announcements. However, more economies, especially emerging economies, could be included in future research. Cai et al. (2008) have done such a research on nine emerging economies – Czech Republic, Hungary, Indonesia, South Korea, Mexico, Poland, South Africa, Thailand and Turkey, however they used only the basic approach to measure the overall impact of the announcement releases.

Finally, so far the researchers used mostly 5-minute high-frequency exchange rate data and proved that fundamental announcements matter. I followed the survey results of Cheung and Chinn (2009) in using 1-minute high-frequency data and proved that in many cases the adjustment actually happens as soon as in the first minute after the announcement releases. However, according to the same research by Cheung and Chinn (2009), one third of the respondents indicated that full adjustment takes place in less than ten seconds. Even though it would be harder to obtain such high-frequency data, I would suggest future studies to test the response also in time frames that are shorter than one minute.

CONCLUSION

This thesis tries to provide an answer whether the fundamental macroeconomic announcement releases affect foreign exchange rates in the short-run. Using the best available data I utilize an empirical framework in order to approach this question. In particular, I study the 1-minute response of the euro/dollar exchange rate to various U.S. and European economic releases in the period from 2008 to 2014. I find that news surprises over many of these macroeconomic fundamentals do have significant effects on the movement of the euro/dollar exchange rate. This conclusion complements most of the former research on this topic, showing that fundamental announcements do matter. However, in contrast to most of the previous findings, where 5-minute or even less frequent data was used, I show that the exchange rate adjustment regularly happens within the first minute of the release. In this regard, I corroborate and expand on the findings of Cheung and Chinn (2001), who used survey methodology to suggest the 1-minute adjustment to the news surprises.

While such a conclusion is interesting, this paper differentiates itself from previous work by diving even further into the data in order to determine the potential patterns in the exchange rate responses. In this regard, I perform four tests – asymmetric response test, nonlinearity test, business cycle test and liquidity test.

In general, I find weak evidence for the asymmetry, nonlinearity and business cycle testing. Out of the 12 macroeconomic announcements I study, only U.S. trade balance is found to have a nonlinear response, three releases caused a different effect in times of recession versus the times of expansion (business cycle test) and there was no evidence of any asymmetry in the response of the exchange rate to news surprises.

On the other hand, the evidence of lesser liquidity of the market around some of the announcements was much more prevailing. Out of the 12 announcements I study, five are found to have not fully adjusted to the news surprise within the first minute of the announcement release, but have continued in the same direction for the next 5 or 30 minutes, indicating lesser liquidity.

Even though I find no dominant patterns in the exchange rate responses to the macroeconomic announcements, I believe that the underlying approach to testing for various financial phenomena used in this study is the next logical step in the research of announcement effects on the foreign exchange market. The inclusion of more countries, exchange rates and announcements, coupled with the method of combining several tests together (e.g. how do exchange rates respond to big negative surprises versus the big positive surprises) could give us more insight and a possibility to draw even more expansive conclusions.

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