Monetary Policy Announcements and the Beta Risk Premium on Nasdaq OMX Stockholm

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ABSTRACT

This research paper analyses the relationship between average excess stock return and market beta on the Nasdaq OMX Stockholm for the period 1999 to 2015. By using the Fama-MacBeth approach and several additional regressions, we are able to examine if the relationship exists on days when the market anticipates receiving news regarding monetary policy decision by the Riksbank, Federal Reserve, European Central Bank and Bank of England. We find a positive relationship on announcement days by the four central banks together but not on non-announcement days. For the individual central banks, a positive relationship is only found for announcement days by the Riksbank and Federal Reserve. These results suggest that market beta is an important measure of systematic risk, as investors demand higher returns when holding high-beta stocks on days when monetary policy decisions are announced. We also find that the average daily excess return is significant positive on announcement days overall and individually on announcement days by the Riksbank and Federal Reserve. In addition, the CAPM is found to be a valid asset pricing model on announcement days overall and on announcement days by the Riksbank and European Central Bank.

Keywords: risk premium, excess return, CAPM, monetary policy, central bank, announcements

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Table of Contents

List of Tables

List of Figures

1. Introduction

Today, we see a macroeconomic environment where central banks are in the epicentre of the world economy. They are all pulling in different directions in order to stimulate their respective economies while investors are standing in the trenches, watching nervously. How do central banks affect the stock markets and their behaviour? By studying the Nasdaq OMX Stockholm, we try to shed light on this matter and our research focuses on the risk-aspect of monetary policy decisions. Are investors exposed to higher risk due to the practices of central banks and are they compensated for this potential increase in risk? This paper is trying to disentangle the concept of systematic risk by examining if there is a positive beta risk premium on days when central banks announce pre-scheduled monetary policy decisions. A positive beta risk premium exists if a positive relationship between market beta and expected excess stock return, as stated by the CAPM, is found. Sweden, as a small and export driven economy, is not just dependent on its own domestic monetary policy but is also affected by foreign central banks. Consequently, we examine the effects that the Swedish Riksbank, Federal Reserve (Fed), European Central Bank (ECB) and Bank of England (BoE) have on the relationship between market beta and expected excess stock return. This is the first research paper that investigates this relationship on the Nasdaq OMX Stockholm. Secondarily, we investigate whether CAPM is a valid asset pricing model, and how the average excess returns vary, for the different types of trading days.

In theory, stock market beta should be an important explanatory factor of the risk premium, but the majority of the early empirical research on the CAPM have found weak support for the relation between market beta and expected excess return (e.g. Douglas, 1968; Jensen et al., 1972; Fama and MacBeth, 1973). However, initially Black CAPM developed some traction among academics (e.g. Stambaugh, 1982), and together with the CAPM's simplicity the model quickly became a standard tool for students and practitioners. Today the CAPM is still in use, despite more recent empirical research arguing that much of the variation in expected excess stock returns are unrelated to the market beta (Fama and French, 2003; 2004).

When the market anticipates pre-scheduled news from central banks, individual investors do not know if the market will react positively or negatively, only that an event will take place and thus incur a level of uncertainty. Therefore, given that assets respond to news, rational investors should expect a greater risk exposure and thus require a higher rate of return around macroeconomic announcements (Savor and Wilson, 2013). With evidence of a higher risk premium on macroeconomic announcement days, Savor and Wilson (2014) investigated if there is a relationship between market beta and average excess stock return on these specific trading days. Announcement days are, by Savor and Wilson, defined as dates when the market anticipates receiving news regarding inflation, unemployment and federal funds rate decisions. They found that stock prices behave very differently compared to on normal trading days and that there is a relationship between market beta and average excess stock return. Hence, we believe that there is a need for further research on this relationship and particularly in small open economies like Sweden since such markets are rarely covered in research on either the effect of central banks or the CAPM.

The methodology in this paper draws inspiration from Savor and Wilson (2014) and is divided into four separate stages. First, we analyse the relationship between average excess return and unconditional full-sample beta using a single cross-sectional regression. In the second stage, we analyse the relationship between average excess return and time-varying beta using the Fama-Macbeth approach and a pooled regression to test directly for differences in beta risk premium between central banks. In the third stage, we analyse the relationship between average excess return and time-varying beta using the Fama-Macbeth approach and a pooled regression while controlling for variables suggested by Fama and French (1992) and Jegadeesh and Titman (1993). In the fourth and final stage, we examine if the average excess returns for each type of trading day are significant positive or not. The sample constitutes of 178 stocks listed on the Nasdaq OMX Stockholm for the period 1999-01-01 to 2015-12-31. We choose to limit the study to the Nasdaq OMX Stockholm since we are only interested in examining the relationship on a single market and not exploiting the general effect of announcement days.

In this research paper, a strong relationship is found between average excess return and beta on announcement days by the four central banks together, implying that there is a positive beta risk premium. This result holds for individual stocks and various stock portfolios sorted on either estimated beta or industry affiliation. However, for non-announcement days we cannot prove that there is a significant relationship between average excess return and beta, and therefore no beta risk premium, positive or negative, can be acknowledged. These findings imply that beta is an important measure of systematic risk, as investors tend to demand higher returns when holding high-beta stocks on days when monetary policy decisions are announced. Studying the individual central banks, the only robust results state that there is a positive beta risk premium on announcement days by the

Riksbank and Fed. Moreover, the results for announcement days by ECB are too weak to draw any decisive conclusions and we found that announcement days by BoE are similar to non-announcement days.

The remaining seven chapters of this research paper are structured as follows. In chapter 2, the theoretical framework and hypotheses are presented. In chapter 3, the previous empirical research on the CAPM and the effect of central banks on asset prices are reviewed. In chapter 4, a description of, and a motivation for, the collected data are presented. In chapter 5, the methodology is carefully explained and motivated. In chapter 6, the empirical findings are analysed and discussed. In chapter 7, the conclusion drawn from the analyses of the empirical findings is presented.

2. Theoretical Framework and Hypotheses

In this chapter, the theory of monetary policy is presented followed by a review of the relevant theoretical cornerstones of portfolio theory. The theory of monetary policy focuses on the transmission mechanism and the portfolio theories reviewed are Modern Portfolio Theory and the Capital Asset Pricing Model. In addition, the chapter is concluded by a presentation of, and a motivation for, the defined hypotheses.

2.1. Monetary policy theory

The main objective of monetary policy is to maintain domestic price stability. However, the overall objectives may differ across central banks. The Riksbank's sole objective is to maintain a low and stable inflation rate of 2% per annum ("The inflation target", 2011). In contrast, Fed, ECB and BoE have additional objectives such as maximum employment, moderate long-term interest rates and stable economic growth (Reserve, 2005; European Union, 2012; "Monetary Policy Framework", n.d.).

To pursue the set of objectives, central banks conduct monetary policy activities mainly by controlling the policy rates, and for the Riksbank the tool is the repo rate. The repo rate is the interest rate at which commercial banks borrow and deposit funds at the Riksbank ("Repo rate, table", n.d.). In turn, a change in the repo rate affects the rate at which commercial banks borrow and lend money to each other during the day, called overnight rate ("How changes in the repo rate affect inflation", 2011). Moreover, central banks have additional tools to their disposal such as quantitative easing and currency intervention. Using the policy rate as a tool, central banks believe they can maintain price stability and achieve their objectives through a process called the transmission mechanism. The transmission mechanism describes how changes in the policy rate affect inflation, market rates and the rest of the economy. The effect of monetary policy can be divided into three channels, which are all essential to understand for investors. The first channel is the interest rate channel, which display the most direct effect of a change in the policy rate. Both short-term and long-term market interest rates increase when central banks increase policy rates. Investors tend to save more and postpone consumption when interest rates are high. Moreover, the present value of future returns decrease as interest rates increase, which leads to a decrease in prices of financial and real assets such as stocks and property. Also, higher interest rates make it more expensive to fund investments in real assets. In all, this leads to a lower demand among households and firms, which in turn lowers the inflation (Hörngren, 1995).

The second channel is the exchange rate channel, which treat the effect of monetary policy activities on exchange rates. Normally, an increase in the policy rate leads to an increase in the exchange rate and vice versa. This is the case, since at higher interest rates, domestic assets become more attractive than assets in other currencies which in turn lead to inflow of capital and an increase in the demand for the domestic currency. An appreciation in the exchange rate affects the domestic economy in two ways. Firstly, domestically produced goods and services become more expensive relative to foreign goods and services. This leads to a decrease in the demand for domestic goods and in turn a lower inflation rate. Secondly, the prices of traded goods and services, denoted in domestic currency, change. Meaning that both imported and import-competing goods and services become cheaper, which in turn lowers the inflation (Hörngren, 1995).

The last channel, called the credit channel, treats the effect of monetary policy activities on the demand of credit. When there is a rise in market interest rates, banks decrease their supply of credit and buy bonds instead. Moreover, firms' profitability decrease when market interest rates rise which lead to a lower demand of credit. Consequently, the overall demand in the economy decreases, since firms which cannot or do not want to borrow funds need to postpone investments (Hörngren, 1995). The process of maintaining price stability is complicated, but by pursuing either expansionary or conservative monetary policy, central banks believe they can increase and decrease overall demand and inflation through the abovementioned channels.

2.2. Modern portfolio theory

Modern portfolio theory, introduced by Markowitz (1952), assumes that all investors are risk averse, meaning that given specific returns rational investors would want to minimize their risk exposure. This implies that investors only undertake higher level of risk if they are compensated with higher returns. Investors can, however, actively reduce their risk exposure by combining risky assets that are not perfectly positively correlated and hence reduce unsystematic risk. With the abovementioned preferences and the ability to diversify, Markowitz (1959) argued that there exist efficient portfolios, for which to achieve, investors maximize expected returns given a specific level of risk measured by the portfolios' variances. If it is possible to achieve a higher expected return without increasing the variance, or decreasing the variance without decreasing expected return, the portfolio in question is not efficient. Together, these efficient portfolios create the so called efficient frontier which can be plotted in a risk-expected return space.

Using the work by Markowitz, Tobin (1958) proposed that under certain conditions, the investment choice for investors can be broken down into a two-stage process, known as the separation theorem. First, investors choose an optimum combination of risky assets. The optimal portfolio is found where the efficient portfolio frontier is tangent to the so called capital allocation line. Along this line the highest risk-adjusted return, measured by the Sharpe ratio, is achieved. Then investors choose, based on their individual preferences, the allocation between the optimal risky portfolio and the risk-free asset (Bodie et al., 2014).

2.3. Capital Asset Pricing Model

The Capital Asset Pricing Model or just simply the CAPM is an extension of the modern portfolio theory and was jointly developed by Sharpe (1964) and Lintner (1965). The model explains the relationship between an asset's expected return and its level of risk. Sharpe and Lintner proved that if there are no market frictions then the market portfolio (a value-weighted portfolio constituting of all assets available on a market) will be a mean-variance efficient portfolio given that investors optimally hold mean-variance efficient portfolios and have homogenous expectations. Therefore, the equation for the Sharpe-Lintner CAPM (referred to as the CAPM throughout the rest of this paper) is a product of the mean-variance efficiency of the market portfolio, introduced by Markowitz. In the model, it is assumed that it is possible to lend and borrow at a risk-free rate, and the one-period expected return of a risky asset can be expressed as follows:

$$E[R_i] = R_f + \beta_{i,m}\left(E[R_m] - R_f\right) \quad (2.1)$$

$$\beta_{im} = \frac{Cov[R_i, R_m]}{Var[R_m]} \quad (2.2)$$

where R_m is defined as the return of the market portfolio, R_f is the return of the risk-free asset and $\beta_{i,m}$ is a measure of the level of systematic or non-diversifiable risk. The CAPM can also be expressed in terms of the return in excess of the risk-free interest rate and thus be written as follows:

$$E[Z_i] = \beta_{i,m} E[Z_m] \quad (2.3)$$

$$\beta_{im} = \frac{Cov[Z_i, Z_m]}{Var[Z_m]} \quad (2.4)$$

where Z_m is the excess return for the market portfolio and Z_i the excess return for the specific asset. As the equations above state, the CAPM implies that an asset's expected return should be linearly related to the covariance between its return and the market portfolio's. The implications of the CAPM, can be displayed by the so called security market line, illustrated in Figure 1. It demonstrates the expected rate of return of a risky asset as a function of its beta and with an intercept equal to the risk-free rate. In conclusion, the CAPM argues that the expected excess return on a risky asset is equal to its level of systematic risk, beta, times the expected excess market return.

Figure 1 – The security market line

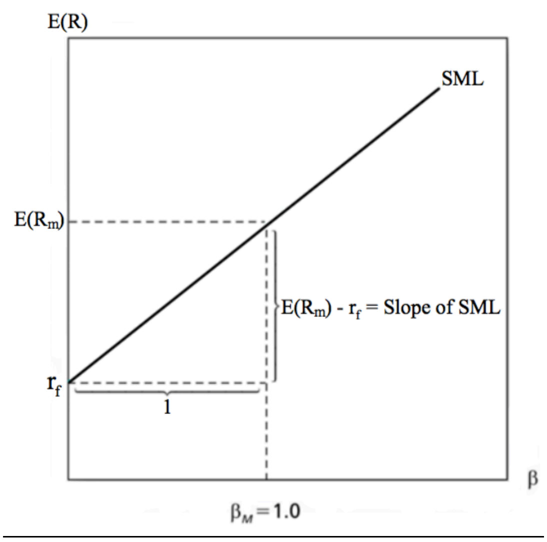


Figure 1. Investments (Bodie et al., 2014, p 298)

2.4. Hypotheses

The empirical research that have investigated if Sharpe-Lintner CAPM, as stated by equation (2.3), can explain excess returns have focused on three aspects: (1) If the intercept is equal to zero; (2) If the cross-sectional variation in expected excess returns are solely explained by market beta; (3) If the market risk premium is positive (Campbell et al, 1997). The main purpose of this research paper is to test whether there is a positive relationship, as stated by the CAPM, between market beta and average excess stock return on announcement days of central banks. Therefore, we focus on the third aspect and hence our hypotheses are stated as follows:

A:
H_0: The beta risk premium is not positive on announcement days
H_1: The beta risk premium is positive on announcement days

B:
H_0: The beta risk premium is zero on non-announcement days
H_1: The beta risk premium is different from zero on non-announcement days

C:
H_0: The beta risk premium is not positive on announcement days by the Riksbank
H_1: The beta risk premium is positive on announcement days by the Riksbank

D:
H_0: The beta risk premium is not positive on announcement days by the Federal Reserve
H_1: The beta et risk premium is positive on announcement days by the Federal Reserve

E:
H_0: The beta risk premium is not positive on announcement days by the European Central Bank
H_1: The beta risk premium is positive on announcement days by the European Central Bank

F:
H_0: The beta risk premium is not positive on announcement days by the Bank of England
H_1: The beta risk premium is positive on announcement days by the Bank of England

Hypotheses *A* and *B* test the joint effect of all four central banks and are motivated by the findings of Savor and Wilson (2014). They examined the US stock market and they found a positive beta risk premium on macroeconomic announcement days and negative or no beta risk premium on other days. Hypothesis *C* is also motivated by the findings of Savor and Wilson (2014) stating that the domestic central bank affects the beta risk premium positively. In addition, as stated by the interest rate channel, changes in domestic repo rate should have an effect on stock prices. Hypotheses *D, E* and *F* draw inspiration from empirical research (e.g. Ehrmann and Fratzscher, 2009) stating that domestic stock market returns react similarly to announcements by foreign central banks as by the domestic central bank. This reaction is indirectly linked to the beta risk premium and therefore it is of interest to examine if the beta risk premiums associated with announcements by ECB, BoE and Fed are positive. In addition, according to the exchange rate channel, monetary policy activities affect the demand of domestic financial assets contra foreign financial assets.

As stated by the security market line, the intercept in the CAPM should normally be equal to the risk-free rate but since the return data used in this research paper are excess returns the intercept should be equal to zero. If this holds and if the beta risk premium (measured as the estimated regression coefficient associated with beta) is not found significant different from the average stock market excess return, Cochrane (2009) argue that the relationship, as stated by the CAPM, may hold and that the CAPM functions as a valid asset pricing model. Therefore, it is believed that the CAPM holds for announcement days but not for non-announcement days.

3. Literature review

In this chapter, the relevant literature is reviewed and discussed. First, a review of the empirical research studying the CAPM and the relationship between expected returns and market beta is presented. Thereafter, an examination of the literature on central banks and their effect on stock markets is presented. Lastly, the research examining if and how central banks affect the relationship between market beta and average excess return is discussed.

3.1. Early research on the CAPM

The empirical research examining the validity of the CAPM have focused on three different implications. First, whether expected returns on risky assets are only linearly related to their betas. Second, if the market risk premium is positive. Third, if assets with market betas equal to zero have expected returns equal to the risk-free rate (Fama and French, 2004). The more recent papers challenging the theory of CAPM, argue that a large amount of the variation in assets' expected returns are not explained by their markets betas and have therefore focused on finding alternative explanatory variables. A thorough review of the more recent papers studying this can be found in *Appendix B*. Moreover, a review of the most prominent papers examining the validity of the CAPM on the Swedish stock market can be found in *Appendix C.*

3.1.1. Cross-sectional studies

The first studies implementing cross-section regressions, focused on examining the intercept and slope of the relation between expected returns and market beta. The approach was to use a single cross-sectional regression with average asset returns as the dependent variable and market betas as the explanatory variable. Douglas (1968) conducted one of the first tests of CAPM using cross-sectional regressions on individual stocks, for the period 1946 to 1963. His results implied an intercept much larger than the risk-free interest rate and a beta coefficient with statistical significance but too low to suffice the CAPM. However, the study by Douglas and similar studies were criticised by academics for two reasons. First, when estimating betas for individual stocks, the betas can become poorly estimated which in turn can lead to measurement errors when estimating the regressions. Second, the regressions yield positive correlation in the residuals, which affect the standard errors of the coefficients in the cross-sectional regression.

To deal with the first problem, often called the error-in-variables problem, academics started sorting stocks into portfolios based on individual betas in order to improve the precision of estimated betas, but at the cost of potential loss of information. This approach quickly became the standard procedure in empirical tests of the CAPM. The first practitioners of this approach were Blume (1970), Friend and Blume (1970) and Jensen et al. (1972). However, in recent years the trend has shifted and academics are now more concerned about the potential loss of information. In order to tackle the problem with positive correlation in the residuals Fama and MacBeth (1973) proposed an alternative methodology to the single cross-sectional regression of average returns on market betas. Their approach involved estimating the cross-sectional regression of average monthly returns on betas month-by-month. Consequently, they estimated the regression once for each observation in their dataset. The estimated intercepts and slopes from each regression created time-series means and together with the standard errors of the means they could calculate whether the average premium for beta was positive and if the intercept was equal to the risk-free interest rate. Using this approach on data for the period 1926 to 1968, Fama and MacBeth found that they could not reject their hypothesis that the relationship between expected average return and beta is linear. As with the portfolio procedure, this approach also became standard in the empirical tests of the CAPM.

3.1.2. Time-series studies

The approach to test the CAPM, using time-series regressions, has its origin in Jensen (1968) and was first implemented by Jensen et al. (1972) among others. The time series regression by Jensen (1968) states that if the Sharpe-Lintner risk-return relation holds, then the intercept must be equal to zero for all assets. Using this regression, one can examine if an asset's average excess return is entirely explained by its systematic risk measured by market beta. Jensen et al. (1972) argued that cross-sectional tests can be misleading when examining if excess return of a risky asset is equal to its level of systematic risk, beta, multiplied by the excess market return. To avoid the possible problems with a cross-sectional approach, they also used a time-series approach to test the validity of the CAPM. They grouped all stocks listed on the New York Stock Exchange into ten portfolios based on their market betas and examined the portfolios for different periods in the interval 1926 to 1966. Using the time-series approach, they found that high-beta assets had significant negative intercepts while low-beta assets had significant positive intercepts, with the effects becoming stronger over time. Moreover, using the cross-sectional approach they found that the relationship between average excess return and beta was positively linear for the period 1931 to 1965, but both the intercept and the slope varied over different subperiods. These results are contradictory to the traditional CAPM and hence they concluded that the model was not consistent with their dataset.

Time-series regressions have also been implemented by Gibbons (1982) and Stambaugh (1982) in order to test if expected returns of assets are linearly related to their market betas. Gibbons presented a multivariate statistical framework involving likelihood ratio tests to examine the CAPM on data for the period 1926 to 1975. He argued that the framework would eliminate the errors-in-variables problem and that the precision of estimated risk premiums would increase. The research paper by Stambaugh also included likelihood ratio tests. He examined, for different asset classes, if expected return is linearly related to market beta, if the intercept is equal to the risk-free interest rate and if the risk premium is positive. Both abovementioned papers concluded that the intercept is not equal to the risk-free interest rate but neither could reject that expected return is linearly related to market beta and that the risk premium is positive.

To conclude, most of the earlier studies (cross-sectional and time-series) on the validity of the CAPM point in the same direction; the average value of the intercept is estimated as being larger than the risk-free interest rate, and the average value of the risk premium is less than the average market return in excess of the risk-free interest rate. The result of a weak relationship between average return and beta is more consistent with the Black CAPM, developed by Black (1972), since it only predicts a positive premium. Therefore, Black CAPM got more approval than Sharpe-Lintner CAPM among academics in the earlier studies (Fama and French, 2004). However, up to this point there were academics arguing that the

CAPM had not been tested properly. Roll (1977) argued that what had been tested was the efficiency of a certain proxy for the market portfolio and not the true market portfolio. Meaning that the prospects for the analyses have not been good enough since data on the true market portfolio of invested wealth is hard to capture. On the other hand, this argument can be imposed on almost any economic model.

3.2. Monetary policy and its effect on stock markets

Macroeconomic variables such as output, employment and inflation are often used when defining the objectives of monetary policy even though the effects it has on these variables are at the most indirect. In contrast, the financial markets are more directly affected by changes in the monetary policy rates. Therefore, in order to achieve the objectives of central banks, policymakers try to influence economic behaviour by affecting asset prices and returns. Hence, to understand the policy transmission mechanism it is of most importance to understand the relation between monetary policy and asset prices (Bernanke and Kuttner, 2005). The body of literature studying the effect of monetary policy activities tend to focus on Fed and its effect on domestic as well as foreign stock markets. Below, a brief review of the previous research is presented but a more thorough review can be found in *Appendix D.*

There are several research papers discussing the effect of monetary policy activities by Fed on the US stock market. A selection of the most prominent and well-cited papers are Jensen and Johnson (1995), Thorbecke (1997), Ehrman and Fratzcher (2004), Rigobon and Sack (2004), Bernanke and Kuttner (2005), Basistha and Kurov (2008), and Savor and Wilson (2013). The above-mentioned papers have of course used different approaches to examine the effect of monetary policy activities on the US stock market, but the overall collective conclusion is that there is a negative relationship between changes in policy rates and stock market returns. For example, Bernanke and Kuttner (2005) found that on days of an unexpected 25 basis point decrease in the federal funds rate, the market index increases by 1%. However, not all research papers have been able to find a significant relationship between monetary policy activities and stock market returns (e.g. Roley and Sellon, 1998; Bomfim and Reinhart, 2000).

As mentioned, there are also research papers examining the effect of monetary policy activities by Fed on foreign stock markets. Several of the most influential and well-cited papers written on the subject are Conover et al. (1999), Ehrmann and Fratzscher (2009), Wongswan (2009), and Leaven and Tong (2012). Applying different approaches, countries and samples, they all found that foreign stock markets are affected by the activities by Fed. Most interestingly, Conover et al. (1999) found that Fed have a larger impact than the Riskbank on the Swedish stock market.

3.3. The relation between CAPM and monetary policy decisions

Up to this point, we have reviewed empirical research on the relevance of the CAPM and if monetary policy decisions affect stock markets. To our knowledge, there is only one legitimate paper that has combined these two areas of research, namely Savor and Wilson (2014). They examined the US stock market on days when the market anticipated receiving news regarding monetary policy decisions, inflation rate and unemployment rate, so called macroeconomic announcement days. As the previous research on the CAPM points out, there is no clear relation between market beta and average excess stock return. Using a sample of individual stocks and various stock portfolios for the period 1964 to 2011, Savor and Wilson tested if a direct relation between market beta and average excess return could be found on these announcement days. In addition, they also performed similar tests for treasury bonds and currency carry-trade portfolios, but that is of less significance for our research paper. As mentioned by previous research, the choice of market index is of greatest importance when examining the CAPM. Savor and Wilson decided to use the CRSP NYSE/AMEX/NASDAQ value-weighted index of all listed shares in order to acquire a good proxy for the entire stock market. The market betas were computed using two different approaches; a single unconditional full-sample beta and time-varying betas over rolling one-year windows using daily returns. For robustness they also estimated betas over rolling five-year windows using monthly returns, which yielded similar results.

Savor and Wilson chose to divide their methodology into two separate stages. In the first stage, they deployed a two-step testing approach for the CAPM. First, stocks were sorted into value-weighted stock portfolios based on market beta, downside beta, idiosyncratic risk, industry, and size and book-to-market. Second, treating each portfolio type separately the average excess returns for each individual portfolio were computed and regressed against its estimated unconditional full-sample beta. This procedure was performed separately for announcement days and non-announcement days.

In the second stage, Savor and Wilson treated announcement days and non-announcement days separately and applied the Fama-Macbeth approach. In more detail, they estimated a cross-sectional regression of daily excess returns on time-varying betas for each observation. Using the cross-sectional estimates, which together formed a time-series, they calculated the average of the coefficients over time. They also computed the standard error as the time-series deviation of the cross-sectional estimates divided by the square root of the number of observations for each sample. Implementing this approach and by applying a t-test, Savor and Wilson were able to determine if the mean of the estimated coefficients were statistically significant and if the differences in coefficient estimates of announcement and non-announcement days were statistically significant. Moreover, Savor and Wilson wanted to test more directly whether the beta coefficients were different on announcement days and non-announcement days. They estimated a panel regression using all observations including a dummy variable capturing announcement days and an extra beta variable.

The procedure in the second stage was performed for a pooled sample of all individual stocks as well as for the different stock portfolios mentioned above. For robustness, the second stage was repeated for a sample of all individual stocks using several control variables such as size measured by the natural logarithm of market capitalisation, book-to-market value of equity and past one-year stock return. They also performed the second stage procedure on equal-weighted beta portfolios and on smaller beta portfolios, which yielded similar results. Moreover, average excess returns for each portfolio were calculated and presented for announcement and non-announcement days separately. Lastly, Savor and Wilson performed tests on one-quarter-ahead forecasts of return volatility using different predictive variables, and the risk-return trade-off. However, the latter is not relevant for this research paper and is therefore not discussed any further.

The results from the described methodology can be summarised as follows. Savor and Wilson found a strong positive relationship between stock market beta and average excess return on announcement days. This finding holds for individual stocks as well as for portfolios sorted on estimated beta, downside beta, idiosyncratic risk, industry, and size and book-to-market value of equity. On the contrary, they found that market betas were negatively related or unrelated to average excess return on non-announcement days. These relationships even hold when controlling for firm size, book-to-market value of equity and past one-year return. They also found evidence that the beta risk premium on announcement days are statistically significant higher than on non-announcement days. According to these results, they concluded that market beta represents an important measure for systematic risk. In other words, investors require higher returns to hold stocks with higher betas when they expect to receive important macroeconomic news.

4. Data

In this chapter, the dataset is presented and the sources used are motivated, followed by a discussion on diagnostics tests.

4.1. Time period

We retrieve data in daily frequencies in order to be able to identify the effect on each individual announcement day. We choose to examine the period 1999-01-01 to 2015-12-31. The starting date is motivated by two reasons; it was the date the European Central Bank started conducting monetary policy activities ("ECB, ESCB and the Eurosystem", n.d.) and the date the Riksbank was by law granted its independence from the government ("20th century", 2011). Furthermore, we want to include current data in our study and hence the date 2015-12-31 is chosen. In order to estimate the time-varying betas, we also retrieve return data dating back to 1995-12-31.

4.2. Press releases by central banks

As mentioned in the introduction, the purpose of this thesis is to capture the effect of monetary policy decisions by central banks on the Nasdaq OMX Stockholm. To capture the effect, we retrieve all dates when the market anticipated receiving news regarding monetary policy decisions. These days are referred to as announcement days (A-days) and days when no press releases are scheduled are referred to as non-announcement days (N-days). The central banks we consider are the Riksbank, the Federal Reserve, the European Central Bank and the Bank of England. Unscheduled monetary policy meetings is not included in the study, since investors have not taken these into account when considering their risk exposure and expected rate of return. An example of a day that we exclude was in 2001 when all four central banks jointly decreased their policy rates in unscheduled meetings following the terrorist attacks in the United States.

The announcement days are retrieved from the central banks' respective webpages. It is of greatest importance that the dates are correct. To ensure this, we carefully read the historical press releases and we also contact each central bank to confirm the time and dates of the press releases. Since Fed announces monetary policy decisions after the Nasdaq OMX Stockholm closes, we define the subsequent trading day on the Nasdaq OMX Stockholm as the announcement day. For the three remaining central banks, we define the days of the press releases as the announcement days. Moreover, there is a small number of announcement days that coincide but we believe that including these in our sample do not distort the results.

Lastly, we are only interested in the effects of the announcements themselves hence no weight is put on if the decisions were to change the policy rates or not.

Table 1 – Announcement days

Central bank	Number of A-days
Riksbank	130
Federal Reserve	135
European Central Bank	230
Bank of England	200

4.3. Market index

To capture the market returns of the Nasdaq OMX Stockholm we use the OMX Stockholm Benchmark Index (OMXSB) created by Nasdaq OMX. The index series is given in daily frequency and we retrieve data for the period 1995-12-31 to 2015-12-31. It constitutes of the 74 largest and most traded stocks listed on Nasdaq OMX Stockholm. It is the only market index, provided by Thomson Reuters Datastream, with a series adjusted for both dividend payments and splits dating back to 1995-12-31. We adjust for dividends since the share price on post-dividend days should, according to theory and empirical research, decrease (e.g. Elton and Gruber, 1970). Not adjusting could possibly distort the results. We believe that OMXSB is highly correlated with the general movements of the entire Nasdaq OMX Stockholm since when value-weighting all the individual stocks, large cap stocks will be assigned substantially higher weights and thus dominate the directional movements. To make sure that OMXSB replicates the Nasdaq OMX Stockholm, a correlation test between the index and the OMXSPI All Share index is conducted. Lastly, to calculate daily and monthly returns based on the market index, we use the natural logarithm according to the following equation:

$$R_t = \ln\left(\frac{P_t}{P_{t-1}}\right) \tag{4.1}$$

According to Fama (1965), using equation (4.1) will result in the yield, with continuous compounding, from holding the stock for the specific period.

4.4. Stocks

The original sample constitutes of all 304 stocks listed on the Nasdaq OMX Stockholm. For each individual stock we retrieve a total return index, adjusted for dividend payments and splits, from Thomson Reuters Datastream. We also retrieve data on market capitalisation and price-to-book value of equity. The data series are given in daily frequencies and we retrieve data for the period 1995-12-31 to 2015-12-31. The original sample of 304 stocks is reduced since numerous stocks do not have adequate datasets. We start by excluding all stocks that do not have at least four years of historical returns, since for the calculation of time-varying betas 36 months of data is needed before the year of study. If a specific firm has more than one kind of stock listed, we only include the most frequently traded stock. Additionally, stocks that are in general very illiquid and not traded on a daily basis are also excluded from the sample. By reducing the sample based on these criteria we end up with a sample of 178 stocks and a complete list can be found in *Appendix E*. The sample size varies through the study since not all firms have been listed since 1999-01-01 and Thomson Reuters Datastream does not provide data on specific firm characteristics for all stocks. This means that the sample in stage one and four constitutes of 76 stocks, stage two of 178 stocks and stage three of 162 stocks (see chapter 5). Lastly, the individual stock returns are calculated using the natural logarithm of the total return index

4.5. Risk-free interest rate

In line with the traditional CAPM, we assume that there exists a risk-free asset yielding a risk-free interest rate. In this study, we use the Swedish 3-Month Treasury Bill provided by the Swedish National Debt Office as a proxy for the risk-free rate. The data is given in daily frequency and is retrieved for the period 1995-12-31 to 2015-12-31. However, the interest rates are annual and therefore the daily returns are first calculated.

4.6. Industry

In several stages of the study, the sample is sorted into different stock portfolios based on industry affiliation. To create industry portfolios, we use an industry categorisation provided by Avanza Bank. On its website each stock on the Nasdaq OMX Stockholm is categorised according to the scheme in Table 2.

Table 2 – Industry categories

Industrial goods and services	Real Estate	Material
Durable goods and services	Healthcare	Telecom
Consumer goods and services	Information technology	Energy
Financial institutions		

4.7. Diagnostics tests

As mentioned above, the data in this research paper is collected from Thomson Reuters Datastream and thus can be considered as reliable. Moreover, the dates for the announcement days are collected from each central bank's respective webpage and can thus also be considered as reliable. In order to establish that our estimated regressions generate unbiased and reliable results, we perform several diagnostics tests. When dealing with the Fama-MacBeth approach, potential issues such as cross-sectional correlation and heteroscedasticity in the error terms are not causing any problems (e.g. Jagannathan and Wang, 1998; Cochrane, 2009). However, the issue of autocorrelation is not corrected for in the approach, but since autocorrelation is normally not an occurrence for stocks when testing daily or even weekly holding periods we do not correct for a potential autocorrelation problem (Fama and French, 1988). In the pooled regressions we have to use standard errors that are robust to potential variance and covariance properties. Therefore, we adjust for cross-sectional correlation of the residuals. By doing so, misleadingly small standard errors will be avoided. Not adjusting for potential biases can lead to very large t-statistics and too low p-values, which is undesirable for the legitimacy of the empirical findings.

5. Methodology

The study is divided into four stages where in each; different aspects of the relationship between announcement days of central banks and the Nasdaq OMX Stockholm are examined. In the first stage, we analyse the relationship between average excess return and unconditional full-sample beta as well as examine the validity of the CAPM. In the second stage, we analyse the relationship between average excess return and time-varying beta using the Fama-Macbeth approach and a pooled regression to test directly for differences between the central banks. In the third, we analyse the relationship between average excess return and time-varying beta using the Fama-Macbeth approach and a pooled regression while controlling for additional variables. In the fourth and final stage, we examine if the average excess returns for each particular day are significant positive or not.

5.1. Regressions with full-sample beta

In the first stage, we study the relationship between average excess return and beta by deploying an ordinary least square (OLS) regression with average excess return as the dependent variable and estimated full-sample beta as the explanatory variable. The regression can be expressed as follows:

$$\bar{Z}_i = \gamma_0 + \gamma_1 \beta_{i,m} + \varepsilon_i \tag{5.1}$$

where $\bar{Z}_i$ is a (1xN) vector of average daily excess returns and $\beta_{i,m}$ is a (1xN) vector of estimated full-sample beta. In this thesis, excess return is defined as “the difference in any particular period between the actual rate of return on a risky asset and the actual risk-free rate” (Bodie et al., 2014). The beta we use in this regression is an unconditional full-sample beta estimated using the CAPM on daily returns for the period 1999-01-01 to 2015-12-31. The OLS regression is designed as follows:

$$R_{i,t} - R_{f,t} = \alpha_{i,m} + \beta_{i,m}\left(R_{m,t} - R_{f,t}\right) + \varepsilon_{i,t} \tag{5.2}$$

where $R_{i,t}$ is a (Tx1) vector of daily returns for entity i, $R_{m,t}$ is a (Tx1) vector of daily market returns and $R_{f,t}$ is a (Tx1) vector of the risk-free rate. In this research paper the variable of interest is excess return and therefore the CAPM is rewritten to facilitate excess return as the dependent variable. The OLS regression is hence stated as follows:

$$Z_{i,t} = \alpha_{i,m} + \beta_{i,m} Z_{m,t} + \varepsilon_{i,t} \tag{5.3}$$

where $Z_{i,t}$is a (Tx1) vector of daily excess returns for entity i and $Z_{m,t}$ is a (Tx1) vector of daily excess market returns.

In total, we have a dataset of 4286 observations for each stock, and to test the general effect of central banks on the relationship between average excess return and beta we estimate regression (5.1) for the 549 announcement days and the 3719 non-announcement days separately. To examine the differences in effects between central banks, we also run regression (5.1) on announcement days for each central bank separately. This leaves us with six versions of regression (5.1) and we apply this procedure on a pooled sample with 76 stocks unsorted, which we consider as the main regressions. Moreover, we run additional regressions with the sample sorted according to two different kinds of stock portfolios. The stocks are sorted into portfolios in order to reduce the “errors-in-variables problem”. This method was first introduced by Blume (1970) and has since been used in several studies (e.g. Fama and Macbeth, 1973) to minimize the problem. It will increase the precision of beta estimates but forming portfolios may result in loss of information. Nevertheless, the stocks are first sorted into 10 portfolios based on estimated full-sample beta. Secondly, the stocks are sorted into 9 industry portfolios based on the categorisation provided by Avanza Bank. We first value-weight the portfolios to match the value-weighted market index but for robustness we also create and test equal-weighted portfolios. The weighting-formulas are stated as follows:

$$R_p^V = \sum_{i=1}^{n} \left(R_i * \frac{MV_i}{\sum_{i=1}^{n} MV_i} \right) \tag{5.4}$$

$$R_p^E = \sum_{i=1}^{n} \left(R_i * \frac{1}{N} \right) \tag{5.5}$$

where R_p^V is the return of stock portfolios p when value-weighted and R_p^E is the return of stock portfolios p when equal-weighted.

In addition, this research paper seeks to examine if the relationship as stated by the CAPM holds for each type of trading day. To examine this, we test if the estimated beta-coefficient (i.e. the estimated slope coefficient associated with beta) for each respective trading day is significant different from the slope of the security market line. If a beta-coefficient is not found significant different from the slope of the security market line and if the intercept is zero, it can be argued that the relationship as stated by the CAPM may hold for that particular kind of trading day. According to Cochrane (2009), the slope of the security market line is equal to the average stock market excess return and is therefore used as the hypothesised mean value. To test if the estimated beta-coefficients differ from the mean values we use a one-sample Student’s t-test. The formula for the test statistic is stated as follows:

$$t = \frac{\hat{\beta} - \beta_0}{SE_{\hat{\beta}}} \tag{5.6}$$

where $\hat{\beta}$ is the estimated beta-coefficient, β_0 is the hypothesised mean equal to the average stock market excess return and $SE_{\hat{\beta}}$ is the standard error of the least-squares estimate.

Moreover, in this test the number of degrees of freedom is $n-2$. We conduct this procedure for A-days, N-days and the announcement days for each central bank separately using a pooled sample of all individual stocks and the different stock portfolios.

5.2. Regressions with time-varying beta

In the second stage, we adopt the Fama-Macbeth methodology to test the relationship between average excess return and estimated beta using a cross-sectional regression. It was first developed by Fama and Macbeth (1973) and the basis of this model is to at first estimate each observation in cross section and then average the estimates in time dimension. The cross-sectional regression is given as follows:

$$Z_{i,t+1} = \gamma_{0,t} + \gamma_{1,t}\hat{\beta}_{i,t} + \varepsilon_t \tag{5.7}$$

where $Z_{i,t+1}$ is a (1xN) vector of excess returns for time period $t+1$ and $\hat{\beta}_{i,t}$ is a (1xN) vector of estimated betas. In this stage, we allow the betas to vary over time, which enables the estimated betas to reflect changes in economic conditions and characteristics of underlying assets. The estimation method for time-varying beta used in this research paper was considered by Asgharian and Hansson (2000). They use a three-year rolling window on monthly data which implies that each portfolio or stock will have a different beta each month. We use monthly returns when estimating time-varying beta since using daily or weekly returns could lead to biased estimates due to the non-trading problem, with illiquid stocks underestimating beta and liquid stocks overestimating beta (Damodaran, 1999). With OLS, the time-varying betas can be estimated using the following model:

$$\begin{gathered} Z_{i,s} = \alpha_{i,t} + \beta_{i,t} Z_{m,s} + \varepsilon_{i,s} \qquad s = t-35, \dots, t \\ cov(\eta_{i,s}, \eta_{j,s}) = 0 \qquad for\ i \neq j \\ cov(\eta_{i,s}, \eta_{j,s}) = a_{i,t}^2 \qquad for\ i = j \end{gathered} \tag{5.8}$$

where $Z_{i,s}$ is a (36x1) rolling vector of monthly excess returns for stock i, $\beta_{i,t}$ is the time-varying beta for time period t and $Z_{m,s}$ is a (36x1) rolling vector of monthly excess market returns. We once again use excess returns to calculate betas since it is the variable of interest in this research paper.

As mentioned in chapter 3, the Fama-Macbeth methodology is divided into two steps. We first use OLS to, at each given t, estimate regression (5.7) in cross section using a sample of all 178 stocks. This yields a number of T estimates of $\gamma_{0,t}$ and $\gamma_{1,t}$. The second step involves creating a time series of all estimates of $\hat{\gamma}_{0,t}$ and $\hat{\gamma}_{1,t}$, and analysing the mean of the coefficients. Since stock returns are normally and temporally independent and identically distributed (IID), estimated coefficients will also be normally distributed and IID (Campbell et al, 1997). This allows us to test for statistically significance in the estimated coefficients using an ordinary Student's t-test. The equations for the procedure can be presented as follows:

$$w(\hat{\gamma}_i) = \frac{\hat{\gamma}_i}{\hat{\sigma}_{\gamma_i}} \tag{5.9}$$

where

$$(\hat{\gamma}_i) = \frac{1}{T}\sum_{t=1}^{T} \hat{\gamma}_{i,t} \tag{5.10}$$

and

$$\hat{\sigma}^2_{\gamma_i} = \frac{1}{T(T-1)}\sum_{t=1}^{T} \left(\hat{\gamma}_{i,t} - \hat{\gamma}_i\right)^2 \tag{5.11}$$

where $w(\hat{\gamma}_i)$ denotes the t-statistic, $\hat{\gamma}_i$ is the average of estimated coefficients, $\hat{\sigma}_{\gamma_i}$ is the standard error of estimated coefficients and $(T-1)$ is the number of degrees of freedom.

We conduct this procedure with regression (5.7) and the calculation of t-statistic separately for the 549 announcement days and the 3719 non-announcement days. To test for differences between central banks, observations for each central bank are tested separately as well. In order to analyse the differences between estimated coefficients from regression (5.7), we deploy a Welch's test that enables us to test if $\hat{\gamma}_{1,t}^{A-days}$ is significantly larger than $\hat{\gamma}_{1,t}^{N-days}$. Using this approach, we can also examine if the differences between the four central banks are statistically significant. The Welch's test is preferred when the two samples examined have unequal variances and sample sizes. It was developed by Welch (1947) and the formula for t-statistic and degrees of freedom is given by:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}} \tag{5.12}$$

and

$$v \approx \frac{\left(\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}\right)^2}{\frac{s_1^4}{N_1^2(N_1 - 1)} + \frac{s_2^4}{N_2^2(N_2 - 1)}} \tag{5.13}$$

where $\bar{X}$ is the estimated coefficients for entity *1* and *2*, s^2 is the sample variance and *N* is the sample size.

In addition to the Fama-MacBeth methodology, we expand this stage by introducing two different regressions where we in both use a sample of all 178 stocks and all 4268 daily observations pooled together. The first regression distinguishes between announcement days and non-announcement days and the second separate the specific announcement days of each central bank. The regressions are formulated as follows:

$$Z_{i,t+1} = \gamma_0 + \gamma_1 \hat{\beta}_{i,t} + \gamma_2 D_{t+1}^{A-day} + \gamma_3 \hat{\beta}_{i,t} D_{t+1}^{A-day} + \varepsilon_{i,t+1} \tag{5.14}$$

$$\begin{aligned} Z_{i,t+1} = \gamma_0 + \gamma_1 \hat{\beta}_{i,t} + \gamma_2 D_{t+1}^{Riks} + \gamma_3 \hat{\beta}_{i,t} D_{t+1}^{Riks} + \gamma_4 D_{t+1}^{ECB} + \gamma_5 \hat{\beta}_{i,t} D_{t+1}^{ECB} + \\ \gamma_6 D_{t+1}^{BoE} + \gamma_7 \hat{\beta}_{i,t} D_{t+1}^{BoE} + \gamma_8 D_{t+1}^{Fed} + \gamma_9 \hat{\beta}_{i,t} D_{t+1}^{Fed} + \varepsilon_{i,t+1} \end{aligned} \tag{5.15}$$

where D_{t+1} is a dummy-variable that equals one if day $t+1$ is an announcement day in regression (5.14) and equals one if day $t+1$ is an announcement day of a specific central bank in regression (5.15), and zero otherwise. In regression (5.14) and similar in (5.15), γ_0 represents the intercept for N-days, γ_1 the beta-coefficient for N-days, γ_2 the difference in intercept between A-days and N-days and γ_3 the difference in beta-coefficient between A-day and N-days. Thus, applying this step enables us to directly examine for example whether the beta coefficients are significantly higher on announcement days than on non-announcement days as well as if it differs across central banks.

When implementing the above methodology with regression (5.7), the Student's t-test, the Welch's test, regression (5.14) and regression (5.15), we first apply it on a pooled sample with all 178 stocks unsorted. These are the main regressions in stage two. Then, in order to reduce the errors-in-variables problem, we run additional regressions with the sample of stocks sorted into different value-weighted portfolios based on estimated betas and industry affiliation. First, we analyse the ten beta portfolios constructed based on the time-varying betas. In order to accommodate changes in estimated betas, we rebalance portfolios on

January 1st each year based on the estimated beta at the time of rebalance. Secondly, we construct and examine ten industry portfolios using Avanza Bank's industry categorisation. Finally, we combine the beta and industry portfolios and examine them together.

5.3. Regressions with time-varying beta and control variables

In the third stage, we apply the Fama-MacBeth procedure, as formulated above, but we introduce three control variables. The first two are firm size, measured as the natural logarithm of market capitalisation, and book-to-market ratio which is the book value of equity divided by market value of equity. Both of which are, by Fama and French (1992), identified as being related to average return. The third variable included is past one-year stock return, which according to Jegadeesh and Titman (1993) can partially explain the returns of stocks. Including these variables and time-varying beta as estimated above, the Fama-Macbeth regression (5.7) can be written as:

$$Z_{i,t+1} = \gamma_{0,t} + \gamma_{1,t}\hat{\beta}_{i,t} + \gamma_{2,t} lnMV_{i,t} + \gamma_{3,t} B/M_{i,t} + \gamma_{4,t} R_{i,t}^{Past\ 1-year} + \varepsilon_{i,t+1} \quad (5.16)$$

and the pooled regressions (5.14) and (5.15) can be written as

$$Z_{i,t+1} = \gamma_0 + \gamma_1\hat{\beta}_{i,t} + \gamma_2 lnMV_{i,t} + \gamma_3 B/M_{i,t} + \gamma_4 R_{i,t}^{Past\ 1-year} + \gamma_5 D_{t+1}^{A-day} + \gamma_6 \hat{\beta}_{i,t} D_{t+1}^{A-day} + \varepsilon_{i,t+1} \quad (5.17)$$

$$Z_{i,t+1} = \gamma_0 + \gamma_1\hat{\beta}_{i,t} + \gamma_2 lnMV_{i,t} + \gamma_3 B/M_{i,t} + \gamma_4 R_{i,t}^{Past\ 1-year} + \gamma_5 D_{t+1}^{A-day} + \gamma_6 D_{t+1}^{Riks} + \gamma_7 \hat{\beta}_{i,t} D_{t+1}^{Riks} + \gamma_8 D_{t+1}^{ECB} + \gamma_9 \hat{\beta}_{i,t} D_{t+1}^{ECB} + \gamma_{10} D_{t+1}^{BoE} + \gamma_{11} \hat{\beta}_{i,t} D_{t+1}^{BoE} + \gamma_{12} D_{t+1}^{Fed} + \gamma_{13} \hat{\beta}_{i,t} D_{t+1}^{Fed} + \varepsilon_{i,t+1} \quad (5.18)$$

where $lnMV_{i,t}$ is the natural logarithm of market capitalisation for firm *i*, $B/M_{i,t}$ is the book-to-market ratio for firm *i* and $R_{i,t}^{Past\ 1-year}$ is the past one-year return for firm *i.* In this stage we only treat the sample as a pooled sample with 162 stocks unsorted. Applying the Fama-MacBeth approach and by using regression (5.16) and the Student's t-test, we examine announcement days and non-announcement days separately. We also analyse possible differences between central banks by separating observations for each central bank. Thereafter, the differences in estimated coefficients are tested if statistically significant using the Welch's test. With regression (5.17) and (5.18) we estimate two separate regressions with all stocks as a pooled sample and including all 4268 daily observations. In regression (5.17), we distinguish between announcement days and non-announcement days and in regression (5.18), we also separate announcement days based on which central bank that release news on each day.

5.4. T-test for average excess returns

In this section, we examine if the average excess returns for each particular day are significant positive. These tests are performed to investigate how the excess returns differ across the different type of trading days, irrespectively of the market betas. In order to examine this, we use ten full-sample beta portfolios and nine industry portfolios that are all value-weighted. Starting with announcement days, the average excess return for all beta portfolios are calculated and then tested if significant higher than zero using a one-sample student's t-test. The formula for the test statistic is stated as follows:

$$t = \frac{\bar{X} - \mu_0}{s/\sqrt{n}} \tag{5.19}$$

where $\bar{X}$ is the estimated average excess return, μ_0 is the hypothesised mean equal to zero, s is the sample standard deviation and n is equal to the sample size. Moreover, in this test the number of degrees of freedom is $n - 1$. This procedure is then applied on non-announcement days and on the announcement days for each central bank separately. With the average excess returns of the six different trading days tested, the whole procedure is then repeated but sorting the stocks into the nine industry portfolios.

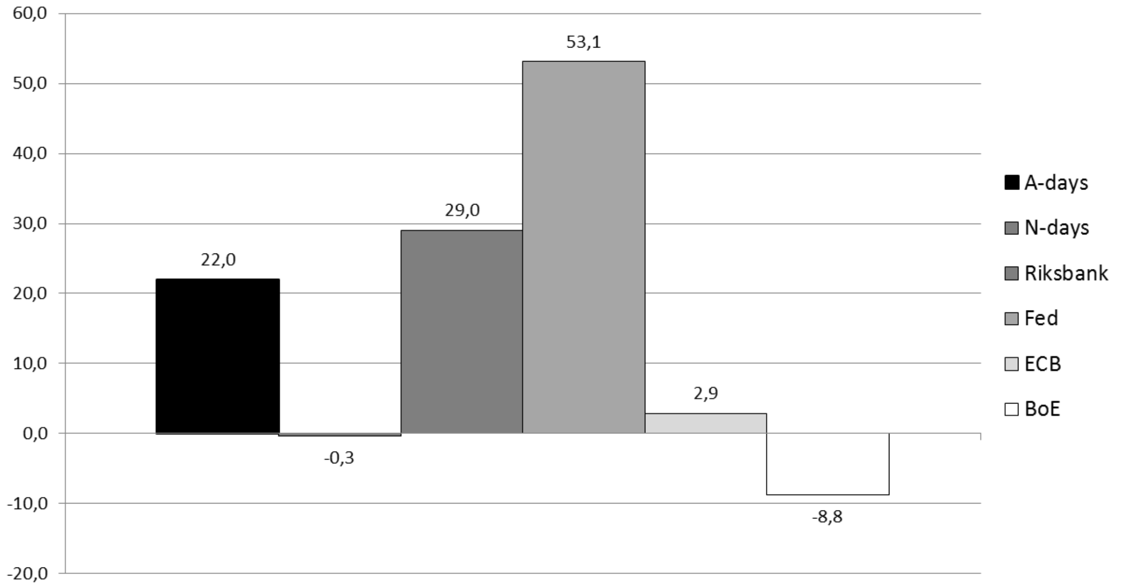
6. Empirical Findings and Analysis

In this section, the results and analysis following the methodology are presented. First, the average stock market excess return for each particular day and the results from the regressions with unconditional full-sample beta are presented, followed by the results from the regressions with time-varying beta. Then the results from the regressions with time-varying beta including control variables are presented. Lastly, the average daily excess return for each value-weighted portfolio is reviewed. In the regressions, the estimated slope coefficients associated with beta are referred to as the beta-coefficients. Throughout the rest of the research paper, the average daily excess returns are stated in basis points and in line with Savor and Wilson (2014) the estimated beta-coefficients are interpreted as the change in average daily excess returns as a result of an increase in beta of one. Also, the intercepts are interpreted as the change in average excess return that they impose, measured in basis points. The main tables for each stage are found in this chapter, but for the additional tables see *Appendix A*.

6.1. Findings from regressions with full-sample beta

Figure 2 – Average daily stock market excess returns

The table reports the findings on the average daily stock market excess returns for announcement and non-announcement days as well as for each individual central bank. A-days represents announcement days, N-days represents non-announcement days, and Riksbank, Fed, ECB and BoE represent the announcement days for each individual central bank. The return is given by the average daily basis point change in the OMX Stockholm Benchmark Index (OMXSB).



In order to see if the estimated beta-coefficients are in line with the security market line, as stated by the CAPM, the average stock market excess return for each particular day is estimated. The results are presented in Figure 2 and as can be seen for A-days the average daily stock market excess return is 22,0 basis points. In contrast, for N-days it is found to be -0,3 basis points. Among the individual central banks, Fed exhibits the highest average daily stock market excess return with 53,1 basis points, followed by Riksbank at 29,0 basis points. Moreover, for announcement days by ECB it is only 2,9 basis points and for BoE it is negative at -8,8 basis points.

In Table 3, the results from the main regressions with full-sample beta as the dependent variable are presented. As can be seen for A-days, there is a strong positive relationship between average excess return and beta, with a coefficient of 21,8 basis points which is

Table 3 – Pooled sample with full-sample beta

The table reports the results from regression (5.1) with average excess return as the independent variable and unconditional full-sample beta as the explanatory variable. A-days represents the announcement days for all central banks and N-days represents the normal trading days when no announcements occur. Riksbank, Fed, ECB and BoE represent the announcement days for each central bank respectively. $\hat{\alpha}$ is defined as the estimated intercept, $\hat{\beta}$ is defined as the estimated coefficient related to full-sample beta and β_0 the average stock market excess return for each particular type of trading day. For the all the beta-coefficients, except for N-days, one-sided t-tests are used. For N-days, the intercepts and the hypothesis tests two-sided t-tests are used instead. The level of statistical significance 1%/5%/10% are denoted ***/**/* respectively. The figures in parentheses are the t-statistics.

	Pooled sample of individual stocks			
Type of day	$\hat{\alpha}$	$\hat{\beta}$	R^2	$\hat{\beta} - \beta_0$
A-days	-0,00016 (-0,38)	0,00218*** (3,94)	0,173	-0,00003 (-0,05)
N-days	0,00076*** (4,44)	-0,00001 (-0,07)	0,000	0,00002 (0,09)
Riksbank	-0,00023 (-0,25)	0,00279*** (2,39)	0,071	-0,00011 (-0,10)
Fed	-0,00081 (-1,00)	0,00533*** (5,19)	0,267	0,00002 (0,02)
ECB	-0,00101 (-1,42)	0,00145* (1,60)	0,034	0,00116 (1,28)
BoE	0,00216*** (3,42)	-0,00254 (-3,17)	0,120	-0,00166** (-2,08)

significant at the 1%-level. In contrast, for N-days no significant relationship is found. On announcement days by the Riksbank and Fed, the relationship between average excess return and beta is significant positive at the 1%-level, with beta-coefficients of 27,9 and 53,3 basis points respectively. The beta-coefficient for ECB is also found significant positive but only at the 10%-level and with a value of 14,5 basis points. On the contrary, BoE is not found significant positive. Considering the intercepts, they are found significant different from zero for N-days and BoE. In addition, for the six different set of observations, only the beta-coefficient for BoE is significant different from its average daily stock market excess return. This implies that the relationship, as stated by the CAPM, may hold for announcement days overall and individually for the Riksbank, Fed and ECB. The R^2:s fluctuate widely, with beta explaining a larger fraction of the cross-sectional variation in average excess returns on announcement days compared to non-announcement days. The same can be said about Fed when compared to announcement days by the Riksbank, ECB and BoE.

The results from the additional regressions with full-sample beta as the dependent variable are presented in Table 7, 8 and 9 (see *Appendix A*). As can be seen, the relationship between average excess return and beta is found significant positive for A-days in all of the additional regressions. For N-days, the results are also rather unanimous since the relationship between average excess return and beta is only found significant different from zero in one of the additional regressions. Moreover, the additional regressions confirm the significant positive relationship between excess returns and beta for announcement days by the Riksbank and Fed. In contrast, the results regarding ECB cannot confirm the weak significant positive relationship found by the main regression. For BoE, no significant positive relationship can be found which is in line with the results from the main regression. The intercepts for N-days and BoE are found strongly significant different from zero as in the main regressions. In two of the additional regressions, the intercept for Fed is found weakly significant which contradicts the result from the main regression. Furthermore, similar to the main regression, the beta-coefficient for BoE is significant different from its hypothesised mean in two of the additional regressions. For N-days and Fed, there are weak results suggesting that the beta-coefficients are significant different from their hypothesised means. In general, the R^2:s are larger in the additional regressions. The R^2 for A-days is larger than that for N-days, and Fed has most frequently the largest R^2 among the individual central banks.

From the tests in stage one that examine the relationship between average excess return and full-sample beta, the most robust result is that the beta-coefficient for A-days is found significant positive for all regressions. This argues that there is a positive beta risk premium on days when the stock market anticipates receiving information regarding monetary policy decisions, and thus null-hypothesis *A* can be rejected. As the beta-coefficient for N-days is only significant different from zero in one regression, a rejection of null-hypothesis *B* is not possible, suggesting that the beta risk premium on non-announcement days is zero. These results imply that, when investors expect to receive news regarding monetary policy decisions, beta should be reckoned as an important measure of systematic risk as investors demand a higher return for holding high-beta stocks on such days. This is in line with the earlier research by Savor and Wilson (2014), who found a positive relationship between full-sample beta and average excess return on days of macroeconomic announcements. However, they also found a significant negative relationship on non-announcement days which somewhat differs from our results. Moreover, the overall results from the main and additional regressions in stage one, argue that there is a positive beta risk premium on days when the Riksbank or Fed announces monetary policy decisions and thus null-hypotheses *C* and *D* may be rejected. For announcement days by ECB and BoE, there are barely any significant positive results, hence null-hypotheses *E* and *F* cannot be rejected and thus there is no evidence in stage one of a positive beta risk premium on these trading days.

Before reviewing stage two we can, based solely on the results in stage one, determine if CAPM is suitable as an asset pricing model for the different trading days. As argued by Cochrane (2009), CAPM can be reckoned as a sufficient model when examining excess returns if the intercept is equal to zero and if the estimated beta-coefficient is not found significant different from the average stock market excess return. Examining the results from Table 3, 7, 8 and 9, we can conclude that the CAPM is a valid model for announcement days overall since the intercept is not found significant different from zero in any of the regressions and none of the estimated beta-coefficients are significant different from the average stock market excess return. In contrast, the results for non-announcement days are very different since the intercepts are found significant different from zero in all regressions. Regarding the individual central banks, it is found that the CAPM is clearly a valid asset pricing model for announcement days by the Riksbank and ECB. The results for Fed vary as CAPM is rejected in two out of seven regressions and hence we cannot firmly conclude that CAPM is applicable for announcement days by Fed. Similar to non-announcement days, the CAPM is not at all applicable for announcement days by BoE.

6.2. Findings from regressions with time-varying beta

Table 4 reports the main findings in stage two. In this stage, the Fama-MacBeth approach and pooled regressions are applied on a sample including all individual stocks. As can be seen in the table, there is a positive relationship between average excess return and beta for A-days, however it is only significant at the 10%-level and with a coefficient of 6,4 basis points. Moreover, the coefficient for N-days is significant different from zero at the 1%-level, with a coefficient of -5,1 basis points. Among the individual central banks, the beta-coefficients for Riksbank and ECB are found significant positive at the 10%-level with coefficients of 11,5 and 12,4 basis points respectively. Examining the intercepts, they are only significant different from zero for A-days, N-days and Fed. The average R^2:s are very the difference in the beta-coefficient between A-days and N-days is 11,5 basis points and similar for A-days and N-days, and for the individual central banks ECB yields the highest

Table 4 – Pooled sample with time-varying beta

The table reports the results from the Welch's tests and the regressions (5.7), (5.14) and (5.15) with average excess return as the independent variable and time-varying beta as the explanatory variable using all stocks as a pooled sample. In the Fama-MacBeth regression, A-days represents the announcement days for all central banks and N-days represents the normal trading days when no announcements occur. Riksbank, Fed, ECB and BoE represent the announcement days for each central bank. $\widehat{\alpha}$ is defined as the estimated intercept and $\widehat{\beta}$ is defined as the estimated coefficient related to time-varying beta. In the pooled regression, $\widehat{\beta}$ represents the coefficient associated with the time-varying beta. A-days, Riksbank, Fed, ECB and BoE represent the coefficient for each respective dummy variable and β the actual estimated time-varying beta. In the Fama-MacBeth regressions, one-sided t-tests are used for all the beta-coefficients, except for N-days. For N-days and all the intercepts as well as for the Welch's tests, two-sided t-tests are used. In the pooled regression, one-sided t-tests are used for all day-specific beta-coefficients, while two-sided t-tests are used for the intercept, $\widehat{\beta}$ and the day-specific intercepts. The levels of statistical significance 1%/5%/10% are denoted ***/**/* respectively. The figures in parentheses are the t-statistics.

Fama-MacBeth regressions				**Welch's test**		
Type of day	$\widehat{\alpha}$	$\widehat{\beta}$	**Avg. R^2**	**Difference**	$\widehat{\alpha}$	$\widehat{\beta}$
A-days	0,00079** (2,05)	0,00064* (1,47)	0,035	A-days - N-days	0,00027 (0,64)	0,00115** (2,51)
N-days	0,00052*** (3,44)	-0,00051*** (-3,44)	0,032	Riksbank - Fed	-0,00198* (-1,85)	0,00092 (0,89)
Riksbank	0,00058 (0,82)	0,00115* (1,39)	0,035	Riksbank - ECB	0,00135 (1,47)	-0,00009 (-0,08)
Fed	0,00256*** (3,16)	0,00023 (0,36)	0,022	Riksbank - BoE	0,00045 (0,47)	0,00135 (1,24)
ECB	-0,00077 (-1,31)	0,00124* (1,63)	0,040	Fed - ECB	0,00333*** (3,33)	-0,00101 (-1,03)
BoE	0,00013 (0,19)	-0,0002 (-0,28)	0,036	Fed - BoE	0,00243** (2,32)	0,00043 (0,45)
				ECB - BoE	-0,00090 (-1,01)	0,00144 (1,39)

Pooled regressions

$\widehat{\alpha}$	$\widehat{\beta}$	**A-day**	**A-day* β**	**R^2**
0,00063*** (3,96)	-0,00052*** (-3,80)	0,00043 (0,97)	0,00098** (2,26)	0,000

$\widehat{\alpha}$	$\widehat{\beta}$	**Riksbank**	**Riksbank* β**	**Fed**	**Fed* β**	**ECB**	**ECB* β**	**BoE**	**BoE* β**	**R^2**
0,00068*** (4,28)	-0,00053*** (-3,87)	0,00021 (0,21)	0,00128* (1,47)	0,00142 (1,63)	0,00128** (1,93)	-0,00205*** (-2,74)	0,00229*** (2,74)	0,00130 (1,50)	-0,00148 (-1,66)	0,001

significant at the 5%-level. For the individual central banks, no significant differences in beta-coefficients are found between the respective announcement days. However, it appears that the intercept is significant larger for Fed than for the three other central banks.

The main pooled regressions in Table 4 show several significant results. For interpretation, the general intercept and beta-coefficient captures the effect associated with N-days. The dummy variables *A-day*, *Riksbank*, *Fed*, *ECB* and *BoE* captures the differences in intercepts compared to N-days. The dummy variables multiplied by the corresponding betas illustrate the differences in beta-coefficients compared to N-days. In the regressions, both general intercepts are found significant different from zero at the 1%-level, with a value of 6,3 basis points in the first and 6,8 basis points in the second. In the first regression, the intercept for A-days is not significant larger than for N-days. Moreover, in the second, the intercept for announcement days by ECB is 20,5 basis points smaller than for N-days and significant at the 1%-level. None of the other individual central banks display a significant larger or smaller intercept than that for N-days. The general beta-coefficients are found significant different from zero at the 1%-level, with negative coefficients. The beta-coefficient for A-days is found to be, at the 5%-level, 9,8 basis points significant larger than for N-days. In addition, the beta-coefficients for announcement days by Riksbank, Fed and ECB are, at the 10%-level, 5%-level and 1%-level respectively, significant higher than for N-days. The coefficient for Riksbank is 12,8 basis points, for Fed 12,8 and for ECB 22,9.

The additional regressions in stage two are illustrated in Table 10, 11 and 12 (see *Appendix A*). In the Fama-Macbeth regressions, there is a strong significant positive relationship between average excess return and beta for A-days, which strengthen the result of the main regression. For N-days, the beta-coefficient is mostly significant different from zero, with a negative value, confirming the relationship as stated by the main regression. Moreover, the additional regressions confirm the significant positive relationship for the Riksbank. In contrast, as not proven by the main regression, the relationship between average excess return and beta is found to be significant positive for Fed. Also, the significant beta-coefficient for ECB, provided by the main regression, cannot be verified by the additional regressions. Lastly, there is no significant beta-coefficient for BoE, which is in line with the main regression. Examining the intercepts, the additional regressions suggest an intercept equal to zero for A-days, which is not in line with the main regression. As in the main regression, there is support for the intercepts being significant different from zero for N-days and Fed. In general, the R^2:s are larger in the additional regressions and the ranking of the

R^2:s are preserved. From the Welch's test, it is still found that the beta-coefficient for A-days is significant larger than that of N-days. In addition, support is found for the beta-coefficient for Fed being significant larger than that for ECB and BoE. Lastly, weak support is found for the beta-coefficient for Riksbank being significant larger than that for BoE. Examining the intercepts, there is evidence of a significant larger intercept for announcement days by Fed compared to ECB and BoE.

The results from the additional pooled regressions in stage two confirm the significant positive general intercepts although not as significant as in the main regression. As in the main pooled regression, no support is found for a significant larger intercept for either A-days, the Riksbank or BoE compared to N-days. However, a larger intercept for Fed is found. In the main regression, the difference in intercept for ECB is clearly found significant, but this result is not supported by the additional regressions. The general beta-coefficients are not found significant different from zero as they are in the main regressions. However, as in the main regression, the beta-coefficients for A-days is significant larger than that for N-days. Furthermore, the beta-coefficient for Fed is still significant larger than that for N-days. For the Riksbank and ECB, there is no support for the beta-coefficients being larger than that for N-days, which is not in line with the main regression.

In stage two, focusing on time-varying beta, the results are quite similar to those in stage one. Using the Fama-MacBeth approach, we find strong evidence for a positive beta risk premium for A-days which suggests a rejection of null-hypothesis *A* as in stage one. However, for N-days, there seems to be a negative relationship between average excess return and beta which suggests that null-hypothesis *B* should be rejected. This confirms beta's importance as a measure of systematic risk and the results are in line with those of Savor and Wilson (2014). Considering the individual central banks, there is evidence suggesting that the beta-coefficients for the Riksbank and Fed are significant positive and therefore rejections of null-hypotheses *C* and *D* are in order. In contrast, we cannot reject null-hypotheses E or F since weak or no evidence of significant beta-coefficients is found for ECB and BoE. From the Welch's tests and the pooled regressions in stage two, we can conclude that the beta-coefficient for A-days is significant larger than that for N-days. This entails that the beta risk premium is higher on days when the market expects to receive news regarding monetary policy decisions. The results on the individual central banks are not as conclusive. The results from the Welch's tests and the pooled regressions, clearly state that the beta risk premium on announcement days by Fed is higher than that by BoE. The difference between Fed and ECB is not as clear since the Welch's tests indicate a higher beta risk premium for Fed while the results from the pooled regressions are ambiguous. The main pooled regression states that the beta risk premium is higher for ECB whereas the additional pooled regressions state unanimously that the beta risk premium is higher for Fed. The beta risk premium on announcement days by the Riksbank might be higher than BoE, as indicated by the main pooled regression. However, the results of the Welch's tests only show weak or no significant support for that premise. No more significant results from the Welch's tests can be found, but the pooled regressions might suggest that the beta risk premium for announcement days by Fed is higher than that by the Riksbank, and ECB is higher than that by BoE.

In the paragraph above, the so called beta effect is analysed, but as recognized by the intercepts there are also general announcement day effects unrelated to beta. For A-days, there is no support for a general announcement day effect. For the individual central banks, the overall results might suggest that the intercept for Fed is significant larger than for the other central banks. This implies that the general announcement day effect is highest for Fed.

6.3. Findings from regressions with time-varying beta and control variables

Table 5 presents the results from stage three with the regressions including control variables. As can be seen from the Fama-MacBeth regressions, the beta-coefficient for A-days is found to be 15,1 basis points and significant positive at the 1%-level. Similarly, the beta-coefficient for N-days is found significant different from zero at the 1%-level, but with a value of only 3,1 basis points. The beta-coefficients for Riksbank, Fed and ECB are significant positive at the 1%-level, 10%-level and 1%-level respectively. The beta-coefficient for Riksbank is 21,4 basis points, Fed is 11,9 basis points and ECB is 22,1 basis points. Furthermore, the intercept is found to be significant different from zero for N-days, Riksbank and Fed at the 5%-level and for BoE at the 10%-level. Examining the control variables, it can be seen that the results for size vary with the coefficient being significant different from zero in all but one regression. For book-to-market value of equity, the coefficient is significant different from zero for N-days and Fed. Lastly, past one-year return is found strongly significant different from zero for all regressions. The R^2:s are found to be constant over the different regressions with Fed yielding the lowest value of 9,2% and ECB the highest with 11,2%. From the Welch's tests, the beta-coefficient for A-days is found significant larger than that for N-days. The difference is 12,0 basis points and significant at the 5%-level. No additional differences in beta-coefficients are found significant using the

Table 5 – Pooled sample with control variables

The table reports the results from the Welch's tests and the regressions (5.7), (5.14) and (5.15) with average excess return as the independent variable and time-varying beta as the explanatory variable including three control variables using all stocks as a pooled sample. In the Fama-MacBeth regression, A-days represents the announcement days for all central banks and N-days represents the normal trading days when no announcements occur. Riksbank, Fed, ECB and BoE represent the announcement days for each central bank. $\hat{\alpha}$ is defined as the estimated intercept and $\hat{\beta}$ is defined as the estimated coefficient related to time-varying beta. Further, ln(MV) is the slope coefficient related to size, B/M is the slope coefficient related to book-to-market value to equity and -1Y return is the slope coefficient related to past one-year stock return. In the pooled regression, $\hat{\beta}$ represents the slope coefficient associated with the time-varying beta. A-day, Riksbank, Fed, ECB and BoE represent the coefficient for each respective dummy variable and β the actual estimated time-varying beta. In the Fama-MacBeth approach one-sided t-tests are used for all the beta-coefficients, except for N-days. For N-days and all the intercepts as well as for the Welch's tests, two-sided t-tests are used. In the pooled regression, one-sided tests are used for all day-specific beta-coefficients, while two-sided t-tests are used for the intercept, the control variables, $\hat{\beta}$ and the day-specific intercepts. The levels of statistical significance 1%/5%/10% are denoted ***/**/* respectively. The figures in parentheses are the t-statistics.

	Fama-MacBeth regression							Welch's test		
Type of day	$\hat{\alpha}$	$\hat{\beta}$	ln(MV)	B/M	-1Y return	Avg. R^2		Difference	$\hat{\alpha}$	$\hat{\beta}$
A-days	-0,00125 (-1,40)	0,00151*** (3,32)	0,00018* (1,81)	-0,00041 (-1,26)	0,00494*** (8,91)	0,106		A-days - N-days	-0,00165* (-1,73)	0,00120** (2,51)
N-days	0,0004** (2,29)	0,00031*** (3,18)	-0,00007*** (-3,99)	-0,00013** (-2,11)	0,00459*** (36,68)	0,096		Riksbank - Fed	0,00039 (0,16)	0,00095 (0,86)
Riksbank	-0,00372** (-2,24)	0,00214*** (2,52)	0,00036* (1,89)	0,00071 (1,03)	0,00595*** (5,18)	0,106		Riksbank - ECB	-0,00312 (-1,44)	-0,00007 (-0,07)
Fed	-0,00411** (-2,17)	0,00119* (1,64)	0,00079*** (3,95)	-0,00136** (-2,25)	0,00452*** (4,13)	0,092		Riksbank - BoE	-0,00640*** (-3,01)	0,00161 (1,40)
ECB	-0,0006 (-0,42)	0,00221*** (2,75)	-0,00009 (-0,55)	-0,00034 (-0,66)	0,00525*** (5,84)	0,112		Fed - ECB	-0,00351 (-1,50)	-0,00102 (-0,96)
BoE	0,00268* (1,97)	0,00053 (0,68)	-0,00034** (-2,18)	-0,00046 (-0,92)	0,00395*** (4,79)	0,097		Fed - BoE	-0,00679*** (-2,94)	0,00066 (0,62)
								ECB - BoE	-0,00328* (-1,67)	0,00168 (1,51)

Pooled regression

$\hat{\alpha}$	$\hat{\beta}$	ln(MV)	B/M	-1Y return	A-day	A-day * β	R^2
0,0002 (0,62)	-0,00014 (-1,04)	-0,00002 (-0,47)	-0,00012 (-0,88)	0,00374*** (10,71)	0,00041 (0,93)	0,00101** (2,32)	0,005

$\hat{\alpha}$	$\hat{\beta}$	ln(MV)	B/M	-1Y return	Riksbank	Riksbank * β	Fed	Fed * β	ECB	ECB * β	BoE	BoE * β	R^2
0,00024 (0,75)	-0,00015 (-1,10)	-0,00005 (-0,45)	-0,00012 (-0,87)	0,00374*** (10,74)	0,00023 (0,23)	0,00133* (1,47)	0,00141* (1,58)	0,00128** (1,87)	-0,00206*** (-2,76)	0,00235*** (2,81)	0,00127 (1,47)	-0,00148 (-1,67)	0,005

Welch's test. Examining the intercept, it is found that the intercept for N-days is significant larger than that for A-days. Also, there is evidence suggesting that the intercept for BoE is significant larger than for the three other central banks.

The results from the pooled regressions differ, to some extent, from the previous results as neither of the two general intercepts are found significant different from zero. For A-days, the Riksbank and BoE, the intercepts are not found to be significant different from that for N-days. Moreover, the intercept for Fed is, at the 10%-level, 14,1 basis points significant larger than that for N-days. In contrast, the intercept for ECB is, at the 1%-level, significant smaller than that for N-days with a difference of 20,6 basis points. None of the general beta-coefficients are found significant different from zero. Furthermore, for A-days the beta-coefficient is, at the 5%-level, 10,1 basis points significant larger than for N-days. Similarly, for the Riksbank, Fed and ECB it is also significant larger at the 10%-level, 5%-level and 1%-level respectively, with the differences being 13,3, 12,8, and 23,5 basis points. Examining the control variables, only past one-year return is found to be significant different from zero.

Based on the results from the Fama-MacBeth approach in stage three, we are able to firmly reject null-hypotheses *A, C* and *E*. This implies that there is a positive beta risk premium on announcement days overall and by the Riksbank and ECB individually. On announcement days by Fed, there is a weak significant positive beta risk premium suggesting that we may be able to reject null-hypothesis *D*. Surprisingly, the beta-coefficient for N-days is found to be significant different from zero with a positive value and thus we can reject null-hypothesis *B*. Based on the results for BoE, we are not able to reject null-hypothesis F. From the Welch's test and the pooled regression in stage three, we can conclude that the beta-coefficient for A-days is significant larger than that for N-days. Relying on the Welch's tests, no conclusion can be made regarding the differences between the individual central banks. However, according to the pooled regression the beta risk premium is highest on announcement days by ECB followed by Riksbank, Fed and BoE. Examining the general announcement day effects, we can conclude that there is a positive effect on announcement days by Fed. In contrast, the announcement day effect for ECB is found to be negative.

6.4. Analysis of findings from regressions

To summaries the findings in stages one, two and three, strong support for a final rejection of null-hypothesis *A* is found and therefore we can firmly conclude that it should be rejected. This argues that the beta risk premium is significant positive on days when the market expects to receive news regarding monetary policy decisions. Said relationship appears to hold for individual stocks and various test portfolios sorted on estimated beta and industry affiliation. Savor and Wilson (2014) arrives at a similar conclusion for macroeconomic announcement days on the US stock market. They found a positive beta risk premium for individual stocks, various stock portfolios and other asset classes such as bonds and currencies. Moreover, the results for non-announcement days vary considerably. In stage one we were not able to reject null-hypothesis *B* but in stage two and three we were able to do so since the beta risk premium were found to be significant different from zero. In stage two the beta-coefficient were found negative and in stage three positive but noticeably smaller than that of announcement days. This means that the beta risk premium is probably around zero on days when no monetary policy decisions are announced, and therefore a final rejection of null-hypothesis *B* is not possible. In contrast, Savor and Wilson (2014) were able to decisively conclude that there is a negative beta risk premium on days when no macroeconomics news are released to the markets. Nevertheless, our results suggest that rational investors expect a higher rate of return when exposed to higher systematic risk on days when monetary policy decisions are announced. However, this is not true for normal trading days since investors are in general not compensated for higher exposure to systematic risk. Previous research on the validity of the CAPM (e.g. Douglas, 1968; Jensen et al., 1972; Fama and MacBeth, 1973) have found similar results suggesting that the relationship between market beta and average excess return is very weak regardless of the type of day. The research implies that rational investors are, in general, not properly compensated for higher exposure to systematic risk as some of our results suggest. Furthermore, the difference in the beta-coefficient between announcement and non-announcement days is throughout stage two and three, both in the Welch’s tests and the pooled regression, significant different from zero, confirming that the beta risk premium is higher on announcement days.

Today, there are no theoretical frameworks that can explain our results, as the CAPM is not sufficient in explaining why investors are compensated for higher systematic risk on announcement days when there is no such relationship on normal trading days. A plausible explanation to our findings could be that the behaviour of investors and their attention to risk are different on days when their focus is set to macroeconomic risk factors, such as monetary policy announcements. Announcement days may therefore provide investors with a clearer signal of aggregate risk and expected returns which contrast their expectations to those on non-announcement days. Another explanation could be that the stock price movements on non-announcement days contain a common noise factor. De Long et al. (1990) argue that asset returns contain common noise factors and such factors are neither priced nor related to fundamentals. If it is assumed that this noise factor is only present on non-announcement days, then news on these days are mostly about aggregate variables such as earnings and consumption, plus this noise term. However, on announcement days the market focuses on learning about an important state variable. On these announcement days all stocks should be rewarded with a higher risk premium, but when examining returns in cross-section it can be argued that stocks more exposed to the state variable should outperform the other stocks. In equilibrium theory of finance, when systematic risk increases, a higher risk premium is required by investors to hold aggregate wealth (e.g. Pollet and Wilson, 2010). However, if the stock market is not a suitable proxy for aggregate wealth and if a non-systematic component to stock market returns exists, it can be argued that market returns comprehend a so called noise factor. On announcement days, this non-systematic component is of relative less importance as the focus of investors is set to the announced news, and therefore investors are compensated for the systematic risk. Moreover, the findings might be explained by that the information on announcement and non-announcement days differs in the sense that the disagreement about growth in aggregate variables (e.g. earnings and consumption) is lower on announcement days. Hong and Sraer (2012) argue that higher-beta assets tend to be overvalued when opportunities of arbitrage are limited and when there is disagreement regarding aggregate growth. This premise is somewhat consistent with our results since we found weak evidence for a negative beta risk premium on non-announcement days. If this disagreement is absent on announcement days then it could be argued that a positive beta risk premium is reasonable. However, we can only speculate about possible explanations for our results. In order to decisively determine a primary explanation, formal testing has to be conducted.

There are also two alternative explanations to these results as Savor and Wilson (2014) points out. The premise is that there is nothing unique about announcement days per se, but the days have some or several features also shared with other days. They first examine this by studying days when average market returns are predictably higher than normal, such as the turn of the month and the month of January. For these periods, they found that the relationship between average excess return and beta is not strongly positive as it is on announcement days. This argue that the first alternative explanation is not valid when studying macroeconomic announcement days and thus most probably not valid for our sample. The second alternative explanation that Savor and Wilson consider is if announcement days tend to be days when the market experience extreme movements which could explain the results. However, in their previous study (see Savor and Wilson, 2013) they found that volatility, kurtosis and skewness do not change on announcement days. This suggest that the second alternative explanation is not valid either.

To further summaries the overall findings, the results for the individual central banks are somewhat surprising. Due to a clear relationship between average excess return and beta on announcement days by the Riksbank, we can firmly reject null-hypothesis *C*. This implies that there is a significant positive beta risk premium on these trading days. The result is relatable to that of Savor and Wilson (2014) since they also found that domestic monetary policy decisions by Fed, along with unemployment and inflation news, imposed a positive beta risk premium on the domestic stock market. This is also in line with theory as the transmission mechanism, explained by Hörngren (1995) and advocated by the Riksbank, have a clear effect on the domestic stock market due to its influence on market interest rates. Moreover, as mentioned there are several empirical papers studying the effect of monetary policy decisions on domestic stock markets (e.g Ehrman and Fratzscher, 2004; Bernanke and Kuttner, 2005; Rigobon and Sack, 2004). These studies support that the Riksbank, as a domestic central bank, should have an effect on the Nasdaq OMX Stockholm but not necessarily in the form of a positive beta risk premium.

From the overall results, we can also reject null-hypothesis *D* since there is a significant positive relationship between average excess return and beta on announcement days by Fed. This implies that there is a significant beta risk premium on these specific trading days. In addition to the described beta effect, there is also a significant positive general announcement day effect on days when Fed announces monetary policy decisions. Fed's ability to affect foreign stock markets, such as the Nasdaq OMX Stockholm, is well recorded in previous empirical studies. Conover et al (1999), Wongswan (2009) and Ehrmann and Fratzscher (2009) have all found that US monetary policy activities have a major impact on foreign stock market returns but they have not studied the effect on the relationship between average excess return and beta per se. Nevertheless, the effect on stock returns might imply that investors expect a shift in risk or that their awareness of risk increase on announcement days by Fed. The effect of the actions of Fed on the Nasdaq OMX Stockholm is probably due to several reasons. For starters, the US economy is the world's largest with a GDP of 30 times that of Sweden ("GDP at market prices", n.d.) and also the world's largest importer ("Imports of goods and services", n.d.). Moreover, the US dollar is considered to be the most important currency in the world and thus its movements due to Fed's actions are also deemed essential. The currency has a central role as a medium of exchange and a store of value in finance and international trade. It is also widely seen in governments' foreign exchange reserves and is around the world a popular currency for invoicing and settling import and export transactions (e.g. Goldberg, 2010; Gopinath, 2015). With that in mind, it is reasonable to state that Fed's monetary policy actions have an impact on foreign stock markets. Regarding the characteristics of the Swedish financial market, Nydahl (1999) argues that Swedish firms are highly exposed to the fluctuations in the US dollar. Moreover, Ehrmann and Fratzscher (2009) found that countries that have open and liquid financial markets as well as a high degree of real and financial integration are more affected by US monetary policy shocks. The Swedish financial market is characterised by that (Stafsudd, 2009) and therefore it is not surprising that we found that the Nasdaq OMX Stockholm is affected on announcement days by Fed.

By examining the overall results on announcement days by ECB we are not able to find a significant positive relationship between average excess return and beta over all the three stages. However, a significant positive relationship is established in stage three but it is not sufficient evidence to lead to an overall rejection of null-hypothesis *E.* We can therefore conclude that the beta risk premium is not significant positive on announcement days by ECB. Another noticeable result is that it appears to exist weak evidence for a significant negative general announcement day effect on days when ECB announces monetary policy decisions. The somewhat insignificant effect of announcement days by ECB might be since ECB started conducting monetary policy activities as late as in 1999. Moreover, the 11 initial member states were given a transition period of three years to adopt the euro banknotes and coins, and since inception the number of member states have increased from 11 to 19 ("Phase 4: Three stages to EMU", 2010; "Economic and Monetary Union (EMU)", n.d.). As a result, the role of ECB as a policy maker has increased over the years and may today be regarded as one of the world's most influential central banks. Its influence has increased along with the importance of the euro as it today can be reckoned as an international currency competing with the US dollar and upcoming currencies such as the renminbi (see Chinn and Frankel, 2008; Papaioannou and Portes, 2008; Bénassy-Quéré, 2015). However, our study spans from

1999 to 2015 and the results are therefore partially affected by the early, less influential, years.

A surprising result in our study is found for announcement days by BoE. We are not able to find a significant positive relationship between average excess return and beta in any of the three stages. However, if two-sided tests are applied to the beta-coefficients in stage one, evidence of a negative relationship between average excess return and beta would be found. From the pooled regressions in stage two and three, it appears to exist weak but not sufficient evidence for significant positive general announcement day effect on days when BoE announces monetary policy decisions. Overall, the relationship between average excess return and beta is either not significant positive or significant negative on announcement days by BoE. These results are similar to those of non-announcement days suggesting that BoE does not have a particular effect on the Nasdaq OMX Stockholm. The results may be explained by the premise that monetary policy activities by BoE is of less importance for investors on the Nasdaq OMX Stockholm due to the small size of the UK economy compared to the US economy and the combined economies of the EMU member states ("GDP at market prices", n.d.). Moreover, the less importance of UK monetary policy can be illustrated by the Riksbank's foreign currency reserve as only 4,5% of the reserve is denoted in pounds sterling compared to 53,6% in US dollars and 34,1% in euros ("Gold and foreign currency reserve", 2016). This argues that the importance of the pound sterling is relatively low for Swedish economy.

To conclude the analysis of the beta risk premium, we discuss the differences between the specific trading days. We can firmly state that the beta risk premium is higher on announcement days than on non-announcement days. Regarding the individual central banks, our only certain conclusion is that the beta risk premium is lowest on announcement days by BoE. For the remaining three central banks the results are somewhat ambiguous. The results from the Welch's tests and the additional pooled regressions favour large values for Fed while the main pooled regressions argue for a larger value for ECB. We can therefore not with certainty determine which of the two different days exhibit the largest beta risk premium. It might be argued that this seems a bit strange as we are able to reject the null-hypotheses for the Fed but not for ECB. The fact that the beta risk premium for Fed is found larger than for ECB using two different methods, while ECB is only found larger using a single method, indicate that Fed might be larger than ECB after all. The beta risk premium for Riksbank appears to be somewhere in between that of Fed and BoE. Moreover, an interesting finding is that the day specific announcement effect for Fed appears to be higher than that for the Riksbank, ECB and BoE.

6.5. Findings from average daily excess returns

Table 6 – Average daily excess returns by type of day

The table reports the results from the one-sample student's t-test on average excess return for both beta and industry portfolios that are all value-weighted. For the beta portfolios, portfolio Low include the stocks with the lowest estimated beta and portfolio High include the stocks with the highest estimated beta. A-days represents announcement days, N-days represents non-announcement days, and Riksbank, Fed, ECB and BoE represent the announcement days for each individual central bank. The levels of statistical significance 1%/5%/10% are denoted ***/**/* respectively. The figures in parentheses are the t-statistics.

Value-weighted beta portfolios

Type of day	Low	2	3	4	5	6	7	8	9	High
A-days	0,00111**	0,00184***	0,00182***	0,00226***	0,00128**	0,00080	0,00159**	0,00210***	0,00219***	0,00304***
	(2,20)	(3,22)	(2,68)	(4,33)	(2,02)	(0,84)	(1,86)	(2,67)	(3,09)	(3,30)
N-days	0,00130**	0,00097***	0,00102*	0,00110*	0,0010*	0,00056*	0,00127	0,00084*	0,00092	0,00107
	(1,77)	(2,45)	(1,48)	(1,37)	(1,53)	(1,62)	(1,23)	(1,30)	(1,15)	(0,85)
Riksbank	0,00026	0,00314***	0,00193*	0,00295***	0,0024**	0,00117	0,00157	0,00172	0,00335***	0,00363**
	(0,30)	(2,62)	(1,54)	(2,91)	(1,98)	(0,44)	(0,90)	(1,17)	(2,42)	(1,94)
Fed	0,00241***	0,00317***	0,00293**	0,00356***	0,00367***	0,0035***	0,00365***	0,00628****	0,00573***	0,00634***
	(2,45)	(2,97)	(1,81)	(3,74)	(2,71)	(3,02)	(2,42)	(4,03)	(4,49)	(3,92)
ECB	0,0004	0,00026	0,00107	0,00106	-0,0008	-0,0003	0,0005	0,00003	-0,00021	0,00083
	(0,47)	(0,28)	(1,07)	(1,19)	(-0,86)	(-0,21)	(0,33)	(0,02)	(-0,18)	(0,55)
BoE	0,00018	0,00168**	0,00084	0,0008	-0,00048	-0,00039	-0,00019	-0,00044	-0,00122	-0,00054
	(0,20)	(1,72)	(0,80)	(0,86)	(-0,45)	(-0,34)	(-0,12)	(-0,34)	(-1,00)	(-0,35)

Value-weighted industry portfolios

Type of day	Industrial	Durable	Consumer	Financial	Real estate	Healthcare	Information technology	Material	Telecom
A-days	0,00204***	0,00156***	0,00058	0,00244***	0,00210***	0,00193***	0,00300***	0,00221***	0,0031***
	(2,86)	(2,52)	(0,57)	(3,59)	(2,93)	(2,74)	(2,36)	(3,01)	(3,21)
N-days	0,00095*	0,00112*	0,00059*	0,00106*	0,00132	0,00121*	0,00044	0,00049	0,00069
	(1,29)	(1,40)	(1,61)	(1,57)	(1,09)	(1,57)	(0,42)	(0,81)	(0,64)
Riksbank	0,00231*	0,00052	0,00087	0,0036**	0,00201*	0,00308***	0,00502**	0,00393***	0,00662***
	(1,64)	(0,46)	(0,30)	(2,27)	(1,50)	(2,44)	(1,79)	(2,51)	(3,64)
Fed	0,00516***	0,00503***	0,00372***	0,00469***	0,00524***	0,00411***	0,00478**	0,00188*	0,00615***
	(3,98)	(3,99)	(3,09)	(3,88)	(3,60)	(2,99)	(2,13)	(1,43)	(3,60)
ECB	0,00019	0,000103	-0,00068	0,00105	0,00033	-0,00042	0,00091	0,00177*	-0,00013
	(0,16)	(0,10)	(-0,44)	(0,91)	(0,29)	(-0,37)	(0,44)	(1,45)	(-0,09)
BoE	-0,00084	-0,00025	-0,00051	0,00106	-0,00009	0,00058	-0,00061	0,00046	-0,00116
	(-0,66)	(-0,25)	(-0,43)	(0,79)	(-0,08)	(0,52)	(-0,29)	(0,39)	(-0,72)

In Table 6, the average daily excess returns for stock portfolios sorted by beta and industry affiliation are presented. As can be seen, for A-days the average excess return is significant positive for all beta portfolios besides for portfolio 6. For N-days, the results are not as strong as it is not significant for three of the portfolios and only significant positive at the 10%-level for five of the portfolios. For Riksbank, it is significant positive at the 1%-level for three beta portfolios, at the 5%-level for two portfolios and at the 10%-level for one portfolio. For Fed, the average excess return is significant positive at the 1%-level for nine beta portfolios and at the 5%-level for the remaining portfolio. For ECB, the average excess return is not significant positive for any of the beta portfolios and for BoE it is only significant positive for one of the portfolios. Examining the industry portfolios, the average excess return for A-days is significant positive at the 1%-level for all industry portfolios besides for *consumer goods and services.* For N-days, it is significant positive at the 10%-level for five portfolios and not significant positive for the remaining four. For Riksbank, the excess return is significant positive at the 1%-level for three portfolios, at the 5%-level for two portfolios and at the 10%-level for the remaining two portfolios. Similar to announcement days in general, the excess returns for Fed is highly significant. It is significant positive at the 1%-level for seven portfolios, at the 5%-level for *information technology* and at the 10%-level for *material.* For ECB, the average excess return is only found significant positive for material and that at the 10%-level. Lastly, for BoE, average excess return is not found significant positive for any of the industry portfolios.

In conclusion, the results in Table 6 suggest that, for all kinds of portfolios besides *consumer goods and services,* the average daily excess return appears to be higher on announcement days compared to for non-announcement days as it is barely significant positive for the latter. This implies that there is a clear link between stock prices and risk associated with monetary policy activities as investors require a compensation for bearing the risk. These results are similar to those found by Savor and Wilson (2013). They found that the average excess returns of the US stock market are higher on days when macroeconomic news regarding monetary policy decisions, unemployment and inflation are released. As can be seen from Table 5, the results also point towards that Fed might show the highest average excess return among the individual central banks with the Riksbank ranked second, and ECB and BoE last with barely any significant results. The considerable higher excess returns on announcement days by Fed can potentially be explained by several theories. A possible explanation to the results could be that non-US central banks such as the Riksbank, ECB and BoE act more predictable compared to Fed. This would reduce the element of surprise and in turn also the announcement day-specific excess returns for non-US central banks. Cieslak et al. (2015) state that Fed often releases information to the market outside scheduled meetings, which might suggest that Fed also act unpredictable at scheduled meetings. A second explanation, also argued by Cieslak et al. (2015), is that Fed might be able to provide the market and investors with a better insight of the current and future macroeconomic environment than its counterparts in Europe, due to its vast resources in terms of experienced researchers and proprietary data. A final explanation, as touched upon earlier, is the US dollar's role as an international currency meaning that, at large, Fed sets the global price of money.

7. Conclusion

The main objective of this research paper is to examine whether there is a significant positive beta risk premium on days when central banks announce monetary policy decisions. We find a strong relationship between average excess return and beta on announcement days overall implying that there is a positive beta risk premium. This result holds for individual stocks and various stock portfolios sorted on either estimated beta or industry affiliation. However, for non-announcement days we cannot prove that there is a significant relationship between average excess return and beta, and therefore no beta risk premium, positive or negative, can be acknowledged. These findings imply that beta is an important measure of systematic risk, as investors tend to demand higher returns when holding high-beta stocks on days when monetary policy decisions are announced. Studying the individual central banks, the results demonstrate that there is a positive beta risk premium on announcement days by the Riksbank and the Federal Reserve. Moreover, the results for announcement days by the European Central Bank are too weak to draw any decisive conclusions and we find that announcement days by the Bank of England are similar to non-announcement days. Regarding the differences in beta risk premium between the individual central banks, we can only with certainty conclude that the beta risk premium for Bank of England is the lowest. For the remaining three central banks the results are ambiguous and not decisive.

One of the secondary objectives was to examine if the traditional CAPM is a suitable asset pricing model for the different trading days. From the results, we can firmly state that it holds on announcement days but not for non-announcement days. For the individual central banks, it holds on announcement days by the Riksbank and the European Central Bank. Furthermore, it can be debated whether the CAPM holds on announcement days by the Federal Reserve. The other secondary objective was to examine the average excess return of various stock portfolios for the different trading days. The conclusion we can draw from these results are that on announcement days there are significant positive excess stock returns but not on non-announcement days. Examining the individual central banks, there is only evidence for positive excess stock returns on announcement days by the Riksbank and the Federal Reserve.

To conclude this research paper, we believe that central banks' effect on stock markets is still an area in need of more research. With regard to our study and results, there are several interesting angles that could be further researched in order to contribute to the body of existing literature. An interesting contribution to our study would be to examine how the relationship between average excess return and beta vary over different time periods. Basistha and Kurov (2008) found that business cycles and credit market conditions have a major impact on the effect of monetary policy decisions. For example, it would be interesting to examine how the effect of monetary policy decisions by ECB has changed due to the recent European debt crisis. In addition, since the standard CAPM cannot fully explain our results, and why announcement and non-announcement days differ, it would be encouraged to examine whether alternative models could explain the results. Potential models may include additional priced risk factors (e.g. future market variance) that could explain the difference between announcement and non-announcement days.

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Appendix

Appendix A: Tables

Table 7 – Beta portfolios with full-sample beta

The table reports the results from regression (5.1) with average excess return as the independent variable and unconditional full-sample beta as the explanatory variable using beta-sorted portfolios. A-days represents the announcement days for all central banks and N-days represents the normal trading days when no announcements occur. Riksbank, ECB, BoE and Fed represent the announcement days for each central bank respectively. $\widehat{\alpha}$ is defined as the estimated intercept, $\widehat{\beta}$ is defined as the estimated coefficient related to full-sample beta and β_0 the stock market excess return for each particular type of trading day. For all the beta-coefficients, except for N-days, one-sided t-tests are used. For N-days and the intercepts, two-sided t-tests are used. The level of statistical significance 1%/5%/10% are denoted ***/**/* respectively. The figures in parentheses are the t-statistics.

	Value-weighted portfolios				Equal-weighted portfolios			
Type of day	$\widehat{\alpha}$	$\widehat{\beta}$	R^2	$\widehat{\beta} - \beta_0$	$\widehat{\alpha}$	$\widehat{\beta}$	R^2	$\widehat{\beta} - \beta_0$
A-days	0,00059 (1,21)	0,00153** (2,61)	0,459	-0,00068 (-1,16)	0,00000 (-0,01)	0,00189*** (3,43)	0,595	-0,00031 (-0,56)
N-days	0,00114*** (5,06)	-0,00016 (-0,61)	0,044	-0,00013 (-0,48)	0,00068*** (10,32)	0,00009 (1,16)	0,144	0,00013 (1,58)
Riksbank	0,00062 (0,66)	0,00201* (1,80)	0,288	-0,00090 (-0,80)	0,00027 (0,25)	0,00207* (1,63)	0,249	-0,00083 (-0,66)
Fed	0,00055 (0,86)	0,00450*** (5,89)	0,813	-0,00081 (-1,06)	-0,00054 (-0,71)	0,00481*** (5,22)	0,773	-0,0005 (-0,54)
ECB	0,00031 (0,48)	-0,00003 (-0,04)	0,000	-0,00032 (-0,42)	-0,00075 (-1,47)	0,00104* (1,70)	0,265	0,00075 (1,23)
BoE	0,00156** (2,31)	-0,00193 (-2,41)	0,420	-0,00105 (-1,31)	0,00168* (2,21)	-0,00186 (-2,03)	0,341	-0,00098 (-1,08)

Table 8 – Industry portfolios with full-sample beta

The table reports the results from regression (5.1) with average excess return as the independent variable and unconditional full-sample beta as the explanatory variable using industry-sorted portfolios. A-days represents the announcement days for all central banks and N-days represents the normal trading days when no announcements occur. Riksbank, ECB, BoE and Fed represent the announcement days for each central bank respectively. $\widehat{\alpha}$ is defined as the estimated intercept, $\widehat{\beta}$ is defined as the estimated coefficient related to full-sample beta and β_0 the stock market excess return for each particular type of trading day. For all the beta-coefficients, except for N-days, one-sided t-tests are used. For N-days and the intercepts, two-sided t-tests are used. The level of statistical significance 1%/5%/10% are denoted ***/**/* respectively. The figures in parentheses are the t-statistics.

	Value-weighted portfolios				**Equal-weighted portfolios**			
Type of day	$\widehat{\alpha}$	$\widehat{\beta}$	R^2	$\widehat{\beta}-\beta_0$	$\widehat{\alpha}$	$\widehat{\beta}$	R^2	$\widehat{\beta}-\beta_0$
A-days	0,00075 (0,93)	0,00150* (1,74)	0,303	-0,00071 (-0,83)	-0,00148 (-1,29)	0,00418** (2,80)	0,529	0,00198 (1,33)
N-days	0,00130** (3,34)	-0,00048 (-1,16)	0,161	-0,00045 (-1,08)	0,00175*** (4,66)	-0,00130** (-2,67)	0,504	-0,00126** (-2,60)
Riksbank	0,00034 (0,15)	0,00305 (1,28)	0,190	0,00014 (0,06)	-0,00489 (-1,52)	0,00978** (2,34)	0,440	0,00688 (1,65)
Fed	0,00322* (2,20)	0,00145 (0,93)	0,110	-0,00386** (-2,49)	-0,00002 (-0,01)	0,00455 (1,15)	0,158	-0,00076 (-0,19)
ECB	-0,00015 (-0,15)	0,00054 (0,53)	0,038	0,00025 (0,25)	-0,00283 (-1,28)	0,00399 (1,39)	0,216	0,00370 (1,29)
BoE	0,00118 (1,53)	-0,00147 (-1,79)	0,315	-0,00059 (-0,72)	0,00384*** (3,93)	-0,00476 (-3,75)	0,667	-0,00388** (-3,06)

Table 9 – Beta and industry portfolios with full-sample beta

The table reports the results from regression (5.1) with average excess return as the independent variable and unconditional full-sample beta as the explanatory variable using both beta and industry-sorted portfolios. A-days represents the announcement days for all central banks and N-days represents the normal trading days when no announcements occur. Riksbank, ECB, BoE and Fed represent the announcement days for each central bank respectively. $\hat{\alpha}$ is defined as the estimated intercept, $\hat{\beta}$ is defined as the estimated coefficient related to full-sample beta and β_0 the stock market excess return for each particular type of trading day. For all the beta-coefficients, except for N-days, one-sided t-tests are used. For N-days and the intercepts, two-sided t-tests are used. The level of statistical significance 1%/5%/10% are denoted ***/**/* respectively. The figures in parentheses are the t-statistics.

	Value-weighted portfolios				Equal-weighted portfolios			
Type of day	$\hat{\alpha}$	$\hat{\beta}$	R^2	$\hat{\beta} - \beta_0$	$\hat{\alpha}$	$\hat{\beta}$	R^2	$\hat{\beta} - \beta_0$
A-days	0,00062	0,00156***	0,395	-0,00064	-0,00011	0,00220***	0,472	-0,00001
	(1,50)	(3,33)		(-1,37)	(-0,25)	(3,90)		(-0,01)
N-days	0,00124***	-0,00035	0,119	-0,00031	0,00084***	-0,00011	0,024	-0,00008
	(6,11)	(-1,52)		(-1,37)	(5,96)	(-0,64)		(-0,45)
Riksbank	0,00034	0,00271**	0,235	-0,00019	-0,00021	0,00312**	0,199	0,00022
	(0,32)	(2,28)		(-0,16)	(-0,17)	(2,05)		(0,14)
Fed	0,00166**	0,00313***	0,450	-0,00218**	-0,00033	0,00474***	0,499	-0,00057
	(2,22)	(3,73)		(-2,59)	(-0,36)	(4,11)		(-0,50)
ECB	0,00011	0,00024	0,010	-0,00004	-0,00099	0,00145*	0,146	0,00116
	(0,21)	(0,42)		(-0,08)	(-1,44)	(1,71)		(1,37)
BoE	0,00139***	-0,00171	0,380	-0,00083	0,00199***	-0,00229	0,382	-0,00141*
	(2,95)	(-3,23)		(-1,57)	(3,51)	(-3,24)		(-2,00)

Table 10 – Beta portfolios with time-varying beta

The table reports the results from the Welch's tests and the regressions (5.7), (5.14) and (5.15) with average excess return as the independent variable and time-varying beta as the explanatory variable using value-weighted beta-sorted portfolios. In the Fama-MacBeth regression, A-days represents the announcement days for all central banks and N-days represents the normal trading days when no announcements occur. Riksbank, Fed, ECB and BoE represent the announcement days for each central bank. $\widehat{\alpha}$ is defined as the estimated intercept and $\widehat{\beta}$ is defined as the estimated coefficient related to time-varying beta. In the pooled regression, $\widehat{\beta}$ represents the coefficient associated with the time-varying beta. A-day, Riksbank, Fed, ECB and BoE represent the coefficient for each respective dummy variable and β the actual estimated time-varying beta. In the Fama-MacBeth regressions, one-sided t-tests are used for all the beta-coefficients, except for N-days. For N-days and all the intercepts as well as for the Welch's tests, two-sided t-tests are used. In the pooled regression, one-sided tests are used for all day-specific beta-coefficients, while two-sided t-tests are used for the intercept, $\widehat{\beta}$ and the day-specific intercepts. The levels of statistical significance 1%/5%/10% are denoted ***/**/* respectively. The figures in parentheses are the t-statistics.

Fama-MacBeth regressions

Type of day	$\widehat{\alpha}$	$\widehat{\beta}$	Avg. R^2
A-days	0,00060 (1,05)	0,00143** (1,94)	0,221
N-days	0,00065*** (3,02)	-0,00062** (-2,28)	0,221
Riksbank	-0,00027 (-0,19)	0,00269* (1,61)	0,238
Fed	0,00146 (1,12)	0,00353** (2,35)	0,197
ECB	0,00037 (0,45)	-0,00019 (-0,16)	0,239
BoE	0,00036 (0,40)	-0,00072 (-0,61)	0,236

Welch's test

Difference	$\widehat{\alpha}$	$\widehat{\beta}$
A-days - N-days	-0,00005 (-0,09)	0,00205*** (2,60)
Riksbank - Fed	-0,00173 (-0,90)	-0,00084 (-0,38)
Riksbank - ECB	-0,00064 (-0,40)	0,00288 (1,40)
Riksbank - BoE	-0,00063 (-0,38)	0,00341* (1,67)
Fed - ECB	0,00109 (0,70)	0,00372** (1,93)
Fed - BoE	0,00110 (0,69)	0,00425** (2,22)
ECB - BoE	0,00001 (0,01)	0,00053 (0,31)

Pooled regressions

$\widehat{\alpha}$	$\widehat{\beta}$	A-day	A-day* β	R^2
0,00039* (1,69)	-0,000188 (-0,72)	0,00051 (0,81)	0,00113* (1,50)	0,001

$\widehat{\alpha}$	$\widehat{\beta}$	Riksbank	Riksbank* β	Fed	Fed* β	ECB	ECB* β	BoE	BoE* β	R^2
0,00040* (1,77)	-0,000156 (-0,60)	0,00014 (0,11)	0,00153 (0,93)	0,00227** (2,04)	0,00210** (1,73)	-0,00071 (-0,65)	0,00105 (0,77)	0,00040 (0,34)	-0,00142 (-0,99)	0,002

Table 11 – Industry portfolios with time-varying beta

The table reports the results from the Welch's tests and the regressions (5.7), (5.14) and (5.15) with average excess return as the independent variable and time-varying beta as the explanatory variable using value-weighted industry-sorted portfolios. In the Fama-MacBeth regression, A-days represents the announcement days for all central banks and N-days represents the normal trading days when no announcements occur. Riksbank, Fed, ECB, and BoE represent the announcement days for each central bank. $\hat{\alpha}$ is defined as the estimated intercept and $\hat{\beta}$ is defined as the estimated coefficient related to time-varying beta. In the pooled regression, $\hat{\beta}$ represents the coefficient associated with the time-varying beta. A-day, Riksbank, Fed, ECB and BoE represent the coefficient for each respective dummy variable and β the actual estimated time-varying beta. In the Fama-MacBeth regressions, one-sided t-tests are used for all the beta-coefficients, except for N-days. For N-days and all the intercepts as well as for the Welch's tests, two-sided t-tests are used. In the pooled regression, one-sided tests are used for all day-specific beta-coefficients, while two-sided t-tests are used for the intercept, $\hat{\beta}$ and the day-specific intercepts. The levels of statistical significance 1%/5%/10% are denoted ***/**/* respectively. The figures in parentheses are the t-statistics.

Fama-MacBeth regressions

Type of day	$\hat{\alpha}$	$\hat{\beta}$	Avg. R^2
A-days	0,00067 (1,11)	0,00165** (2,18)	0,228
N-days	0,00019 (0,89)	-0,0002 (-0,74)	0,217
Riksbank	0,00156 (1,16)	0,00151 (0,94)	0,240
Fed	0,00258** (2,23)	0,00230** (1,67)	0,196
ECB	-0,00002 (-0,02)	0,00061 (0,49)	0,253
BoE	-0,0006 (-0,61)	0,00059 (0,47)	0,244

Welch's test

Difference	$\hat{\alpha}$	$\hat{\beta}$
A-days - N-days	0,00047 (0,74)	0,00185** (2,30)
Riksbank - Fed	-0,00102 (-0,57)	-0,00080 (-0,38)
Riksbank - ECB	0,00158 (0,99)	0,00090 0,44)
Riksbank - BoE	0,00216 (1,30)	0,00092 (0,45)
Fed - ECB	0,00260* (1,79)	0,00169 (0,92)
Fed - BoE	0,00318** (2,10)	0,00172 (0,92)
ECB - BoE	0,00058 (0,44)	0,00002 (0,01)

Pooled regressions

$\hat{\alpha}$	$\hat{\beta}$	A-day	A-days* β	R^2
0,00030 (1,35)	-0,00024 (-0,89)	0,00085 (1,32)	0,00125* (1,63)	0,001

$\hat{\alpha}$	$\hat{\beta}$	Riksbank	Riksbank* β	Fed	Fed* β	ECB	ECB* β	BoE	BoE* β	R^2
0,00033 (1,48)	-0,00022 (-0,82)	0,00112 (0,82)	0,00148 (0,92)	0,00233** (2,14)	0,00225** (1,81)	-0,00023 (-0,19)	0,00092 (0,66)	-0,00025 (-0,20)	-0,00064 (-0,44)	0,002

Table 12 – Beta and industry portfolios with time-varying beta

The table reports the results from the Welch's tests and the regressions (5.7), (5.14) and (5.15) with average excess return as the independent variable and time-varying beta as the explanatory variable using value-weighted beta and industry portfolios combined. In the Fama-MacBeth regression, A-days represents the announcement days for all central banks and N-days represents the normal and BoE represent the announcement days for each central bank. $\widehat{\alpha}$ is defined as the estimated intercept and $\widehat{\beta}$ is defined as the estimated coefficient related to time-varying beta. In the pooled regression, $\widehat{\beta}$ represents the coefficient associated with the time-varying beta. A-day, Riksbank, Fed, ECB and BoE represent the coefficient for each respective dummy variable and β the actual estimated time-varying beta. In the Fama-MacBeth regressions, one-sided t-tests are used for all the beta-coefficients, except for N-days. For N-days and all the intercepts as well as for the Welch's tests, two-sided t-tests are used. In the pooled regression, one-sided tests are used for all day-specific beta-coefficients, while two-sided t-tests are used for the intercept, $\widehat{\beta}$ and the day-specific intercepts. The levels of statistical significance 1%/5%/10% are denoted ***/**/* respectively. The figures in parentheses are the t-statistics.

Fama-MacBeth regressions

Type of day	$\widehat{\alpha}$	$\widehat{\beta}$	Avg. R^2
A-days	0,00063 (1,53)	0,00154*** (2,91)	0,225
N-days	0,00042** (2,76)	-0,00041* (-2,13)	0,219
Riksbank	0,00065 (0,67)	0,0021** (1,82)	0,239
Fed	0,00202** (2,32)	0,00292*** (2,86)	0,197
ECB	0,00018 (0,29)	0,00021 (0,24)	0,246
BoE	-0,00012 (-0,18)	-0,00007 (-0,08)	0,240

Welch's test

Difference	$\widehat{\alpha}$	$\widehat{\beta}$
A-days - N-days	0,00021 (0,48)	0,00195*** (3,46)
Riksbank - Fed	-0,00137 (-1,05)	-0,00082 (-0,53)
Riksbank - ECB	0,00047 (0,41)	0,00189 (1,31)
Riksbank - BoE	0,00077 (0,65)	0,00217 (1,50)
Fed - ECB	0,00184* (1,74)	0,00271** (2,03)
Fed - BoE	0,00214* (1,95)	0,00299** (2,24)
ECB - BoE	0,00030 (0,33)	0,00028 (0,23)

Pooled regressions

$\widehat{\alpha}$	$\widehat{\beta}$	A-day	A-day * β	R^2
0,00034 (1,56)	-0,0002 (-0,80)	0,00069 (1,14)	0,00116* (1,58)	0,001

$\widehat{\alpha}$	$\widehat{\beta}$	Riksbank	Riksbank* β	Fed	Fed* β	ECB	ECB* β	BoE	BoE* β	R^2
0,00036* (1,67)	-0,00018 (-0,69)	0,00066 (0,50)	0,00146 (0,92)	0,00231** (2,21)	0,00216** (1,82)	-0,00046 (-0,43)	0,00097 (0,73)	0,00009 (0,07)	-0,00106 (-0,75)	0,002

Appendix B: Alternative explanatory variables of stock returns

The more recent papers challenging the theory of CAPM, argue that a large amount of the variation in assets' expected returns are not explained by their markets betas, and thus reject both Sharpe-Lintner and Black CAPM. One of the first studies on this theme was Basu (1977) who examined if stock returns are related to price-to-earnings ratios (P/E). Using a sample of 753 stocks sorted into portfolios and a test period of 1957 to 1971, Basu estimated a time-series regression with 168 months of return data. The results revealed that future earnings on high (low) P/E-stocks were higher (lower) than predicted by the CAPM. Moreover, Banz (1981) examined all stocks on the New York Stock Exchange for the period 1936-1975 using a cross-sectional approach inspired by Fama and Macbeth (1973) accompanied with a time-series regression inspired by Black and Scholes (1974). Banz found that, when sorting stocks based on their market capitalisation, the average returns yielded by small stocks were higher than would be predicted by the CAPM. This suggests that the CAPM is misspecified according to Banz. In addition, Lakonishok and Shapiro (1986) used a cross-sectional approach for the period 1962 to 1981 to examine the relationship between stock returns and variables such as beta, residual standard deviation and size measured by market capitalisation. He found that neither beta nor residual standard deviation could explain cross-sectional variation in stock returns, but size had an explanatory power. To strengthen the results of the three above-mentioned papers, Reinganum (1981) analysed 556 stocks listed on the New York Stock Exchange and found that portfolios sorted based on either market capitalisation or earnings-to-price ratio yielded different average returns than would have been predicted by the CAPM.

In addition, Bhandari (1988) deployed the Fama-Macbeth approach on a sample of stocks listed on the New York Stock Exchange for the period 1948 to 1979. Bhandari examined if a firm's debt-to-equity ratio could be an explanatory variable for stock returns and he found that the expected returns of stocks were positively related to their debt-to-equity ratios when controlling for market beta and firm size. Furthermore, Statman (1980) and Rosenberg et al. (1985), found in their respective studies a positive relationship between book-to-market value of equity and average returns. The above-mentioned studies suggest that ratios such as earning-to-price, debt-to-equity and book-to-market of equity have an explanatory role of expected returns. This would imply that beta may be an inadequate measure of risk or that financial ratios involving stock prices have information regarding stocks' expected returns not captured by the market betas.

Well-cited papers such as Fama and French (1992; 1996) have further looked into the matter of additional explanatory variables and a misspecified CAPM. Fama and French (1992) used a cross-sectional regression approach for the period 1963 to 1990 to evaluate the effect of earnings-to-price, size measured by market capitalisation, debt-to-equity and book-to-market value of equity ratios on expected stock returns. They found that book-to-market value of equity and size were significant in explaining the cross-sectional variation in average stock returns associated with earnings-to-price, size, debt-to-equity and book-to-market value of equity. Consistent with Reinganum (1981) and Lakonishok and Shapiro (1986), Fama and French (1992) also found little evidence for a relationship between market beta and expected stock returns. By deploying a time-series regression for the period 1963 to 1993, Fama and French (1996) confirmed the results regarding the price-ratios. They also provided evidence that different price-ratios generate, to a certain degree, the same information about expected returns.

The empirical evidence provided by Fama and French in the early 1990s on the shortcomings of the CAPM came to work as a turning point for the research on the CAPM. Instead of trying to prove that the CAPM was an insufficient model, researchers turned to explain why it was insufficient (Fama and French, 2004). Some academics argued that the results contradictory to the CAPM was a sample issue and to meet this critic several studies were conducted on alternative markets. Consistent with Statman (1980) and Rosenberg et al. (1985), Chan et al. (1991) found, by deploying a cross-sectional approach on the Japanese Stock Market for the period 1971 to 1988, a robust relation between book-to-market value of equity and average stock returns. A similar relationship was found by Capaul et al. (1993) on the Japanese Stock Market as well as on four European stock markets. Lastly, Fama and French (1998) examined thirteen non-US markets for the period 1975 to 1995. They found that when sorting stocks based on either book-to-market value of equity, earnings-to-price, cash flow-to-price or debt-to-price there was a large value premium. These three papers suggest that the rejection of the CAPM is not US-specific and thus not a sample problem.

According to Fama and French (2004), there were two explanations for the empirical results dismissing the CAPM. One group of academics argue that there was a need for a more sophisticated asset pricing model and that the CAPM is based on several unrealistic assumptions. For example, it can be argued that the assumption that investors only focus on mean-variance optimisation for one-period horizons is too narrow. These assumptions neglect important factors such as covariance of labour income and future investment opportunities.

Therefore, it is understandable that market beta may not completely capture the risk exposure endured by a specific asset and thus reasonable that the market beta will not perfectly predict expected returns. As a result, several academics have developed alternative versions of the original Sharpe-Lintner CAPM. As mentioned in the introduction, there is the Black CAPM developed by Black (1972). In addition, there is for example the Fama-French Three-Factor Model developed by Fama and French (1993). Moreover, there is the Intertemporal Capital Asset Pricing Model (ICAPM) developed by Merton (1973), the Human-Capital-augmented Capital Pricing Model (HC-CAPM) developed by Jagannathan and Wang (1993) and lastly the Consumption-based Asset Pricing Model (C-CAPM) introduced by Breeden (1979).

The second explanation for the dismissal of the CAPM refers to the behaviour of investors and is supported by academics such as Bondt and Thaler (1987) and Lakonishok et al. (1994). It is argued that sorting stocks based on book-to-market value of equity exposes investor overreaction to good and bad times. Investors tend to extrapolate past returns, resulting in too high (low) stock prices for stocks with low (high) book-to-market value of equity. For this overreaction to settle, we must see high (low) returns for stocks characterised by high (low) book-to-market value of equity (Fama and French, 2004).

Appendix C: CAPM on the Swedish stock market

There are few research papers examining if CAPM can be applied on the Swedish stock market. One of the simpler is Heston et al. (1999) and they examined if beta and size can explain cross-sectional variation in average returns on twelve European countries for the period 1978 to 1995. The entire sample constituted of 2100 firms, of which 134 was listed on the Swedish stock market. They implemented the Fama-Macbeth approach and found that the return premium associated with market beta was positive but not statistically significant while size was negatively related and statistically significant. In addition, Östermark (1991) examined the explanatory power of beta and squared beta on average stock return using the Fama-MacBeth approach. The sample included 93 stocks listed on the Swedish stock market. Östermark found that the coefficient for market beta was similar to those estimated in international research papers using multiple-factor models on the New York Stock Exchange.

More in-depth studies on the Swedish stock market have been conducted by Asgharian and Hansson (2000, 2002). In the former, Asgharian and Hansson examined if beta and other firm characteristics such as firm size, leverage, earnings-to-price and book-to-market value of equity could explain cross-sectional variation in average stock returns for the period 1983 to 1996. Beta was initially calculated using two different approaches. First, unconditional market betas were calculated using OLS on historical returns. Second, conditional betas were calculated using a bivariate GARCH(1,1) process. They then determined that the beta estimates using GARCH(1,1) was more suited to use as the measure of market risk in the multifactor model. As in the Fama-MacBeth approach, they estimated monthly cross-sectional regressions but used OLS, WLS, and WLS corrected for errors-in-variables. The time-series estimates of the monthly coefficients resulted in no statistical significance for neither beta, earnings-to-price nor firm size. However, they found that book-to-market value of equity was significant positive related, and leverage significant negative related to average stock returns.

In the second paper, Asgharian and Hansson also examined if beta and other firm characteristics such as firm size, leverage, earnings-to-price and book-to-market value of equity could explain cross-sectional variation but for the period 1980 to 1990. However, in this study a different methodology was deployed. First, they used a cross-sectional approach in line with Fama and Macbeth (1973) and then a pooled regression model. Unconditional market betas were calculated using OLS on historical returns and then adjusted according to the method of Litzenberger and Ramaswamy (1979) to avoid the error-in-variables problem.

For the cross-sectional approach they deployed a one-factor model and a multi-factor model and for the pooled regression model only a multifactor model. The results showed that the coefficient for beta was never significant different from zero. However, a few of the firm characteristics were occasionally found statistical significant.

To conclude, the literature treating the Swedish stock market have come to the same conclusion as the international research papers which argue that the market beta cannot alone predict expected return.

Appendix D: Monetary policy and its effect on stock markets

Appendix D.1: The effect of domestic monetary policy decisions

There are several papers that discuss the effect of monetary policy decisions by the Federal Reserve on the US stock market. In the following section, the most prominent and well-cited papers studying this effect are reviewed.

Jensen and Johnson (1995) examined the relationship between changes in the discount rate and the long-term returns on the US stock market for the period 1962 to 1991. They performed an event study and found that there were greater returns and lower variability in periods after a decrease in the policy rate compared to an increase. Using a similar test period, Thorbecke (1997) conducted a study on whether US monetary policy shocks, in for example the federal funds rate, had an effect on US stock market returns for the period 1953 to 1990. From his results, he concluded that monetary policy, using different measures, had a significant impact on ex-ante and ex-post stock returns. In addition, he found that smaller companies were more affected by monetary policy decisions than larger companies.

In a later study, Ehrmann and Fratzscher (2004) examined if US monetary policy had any effects on the US stock market for the period 1994 to 2003. Their results stated that the returns of the S&P 500 index had a strong and highly significant relation with US monetary policy shocks. In addition, the monetary shocks had a larger impact on equity returns in three different situations; (1) when the federal funds rate changes were unexpected, (2) when Federal Reserve changed from expansionary to restrictive monetary policy or vice versa, or (3) when there was high market volatility. Lastly, they found that the effect of US monetary policy shocks varied across industries and firm characteristics. Furthermore, by using a similar test period, Bernanke and Kuttner (2005) quantified and analysed the effect of surprises in monetary policy actions on the US stock market. By performing an event-study for the period 1989 to 2002, they found that the market, a CRSP value-weighted index, increased by approximately 1% during days of unexpected 25 basis point decreases in the federal funds rate. In addition, monetary policy changes that are perceived to be more permanent tend to have a greater impact on the market.

Basistha and Kurov (2008) conducted a study to see whether the effect of monetary policy on US stock returns differs during different states of the economy. Their results claim that the business cycles and credit market conditions have a major impact on the effect of unexpected changes in the federal funds rate on stock returns. In more detail, equity markets react twice as much during recessions and bad credit market conditions than during normal conditions.

Rigobon and Sack (2004) performed a study to examine the effect of changes in monetary policy on stock prices and market interest rates for the period 1994 to 2001. The previous studies have been focusing on event-study approaches but Rigobon and Sack introduced a heteroscedasticity-based identification method to examine the effect of changes in monetary policy. They found, by using both methods, that monetary policy has a significant negative impact on the US stock market with the new method yielding larger estimates in absolute terms.

More recently, Savor and Wilson (2013) examined if the average stock market returns and Sharpe ratios are higher on days when news regarding inflation, unemployment and federal funds rates are announced. This study was conducted on the US stock market using a value-weighted NYSE/NASDAQ/AMEX all share index for the period 1968 to 2009. The main results revealed that on so called announcement days the average excess return was 11,4 basis points compared to 1,1 basis points on non-announcement days. This implies that investors are rewarded for bearing macroeconomic risk and that it amounts for a large portion of the equity risk premium. In addition, the Sharpe ratio was found to be ten times higher on announcement days.

The above-mentioned papers all show that stock markets are heavily affected by monetary policy. However, some papers have not been able to find any significant results and below the most notable are reviewed. Roley and Sellon (1998) had an interesting approach in their research paper where they examined how stock prices, federal funds futures rates and treasury yields were affected on dates when the market expected actions but the Federal Reserve left the federal funds rate unchanged. Roley and Sellon argued that the market may be equally surprised by expected actions not occurring as by unexpected actions occurring. Conducting this study for the period 1988 to 1998, they did not find any significant effects on the stock market. Furthermore, Bomfim and Reinhart (2000) examined how several financial instruments such as treasury security yields, S&P 500 and NASDAQ stock indexes, and long-term treasury bond futures with more, are affected by unanticipated policy decisions regarding the federal funds rate. They conducted the study for the period 1989 to 1998, as well as for two sub-periods denoted pre-1994 and post-1994, but did not find any statistically significant results for the stock indexes.

Appendix D.2: The effect of foreign monetary policy decisions

There are also several papers that discuss the effects of foreign monetary policy decisions on domestic stock markets. In today's globalised world it is argued that the Federal Reserve does not only affect the US stock market, but also foreign stock markets. The most relevant papers discussing this matter are reviewed below.

Conover et al. (1999) studied if monetary conditions in the US and foreign countries had an effect on foreign stock returns. They examined monthly data for 16 different countries, including Sweden, for the period 1956 to 1995. The results from the study state that the stock returns in foreign equity markets were higher during expansive monetary environments in their country compared to restrictive monetary environments. More interestingly, they found that US monetary policy had a major impact on foreign stock returns and several foreign stock markets were more affected by US monetary policy decisions than by their own. Most relevant to this paper is the finding that the Swedish stock market was more affected by US monetary policy than by domestic monetary policy.

In a more recent paper, Ehrmann and Fratzscher (2009) performed, for the period 1990 to 2008, a study on the effect of US monetary policy on 50 different stock markets including all major advanced economies and emerging markets. They found that stock returns decreased on average with 2,7% in case of a 100 basis point tightening in the federal funds rate. However, there was a wide variation in how different stock markets were affected, some barely changed and other changed up to 5%. In addition, they identified what were the driving factors behind the transmission of the monetary shocks. The countries that have open and liquid financial markets as well as a high degree of real and financial integration were more affected by US monetary policy shocks. In all, they concluded that the US monetary policy shocks are to be considered as global, since they have an impact on a significant amount of different markets simultaneously. Furthermore, Wongswan (2009) evaluated the effect of surprises in announcements by Federal Reserve on 15 foreign stock indexes for the period 1998 to 2004 by using high-frequency intraday data. Wongswan found that most of the foreign stock indexes responded to surprises in the current federal funds rate. More recently, Laeven and Tong (2012) studied how monetary policy activities by Fed affect global stock markets for the period 1990 to 2008. They found that global stock markets react negatively (positively) to increases (decreases) in the federal funds rate.

Appendix E: List of stocks

AARHUSKARLSHAMN
ABB
ACANDO ’B’
ACTIVE BIOTECH
ADDTECH ’B’
AF ‘B’
AFRICA OIL
ALFA LAVAL
ALLENEX
ALLTELE ALLM.SVEN.TELAB
ANOTO GROUP
ARISE
ASSA ABLOY ‘B’
ASTRAZENECA
ATLAS COPCO ‘B’
AUTOLIV
AVANZA BANK HOLDING
AVEGA GROUP ‘B’
AXFOOD
B&B TOOLS ‘B’
BE GROUP
BEIJER ALMA ‘B’
BEIJER ELECTRONICS
BILIA ‘A’
BILLERUD KORSNAS
BIOGAIA ‘B’
BIOINVENT INTL.
BIOTAGE
BJORN BORG
BLACK EARTH FARMING
BLACKPEARL RESOURCES
BOLIDEN
BULTEN
BURE EQUITY
BYGGMAX GROUP
CRAD ‘B’
CASTELLUM
CATENA
CAVOTEC
CELLAVISION
CLAS OHLSON ‘B’
CLOETTA ‘B’
CONCENTRIC
CONCORDIA MARITIME ‘B’
CTT SYSTEMS
DEDICARE
DIOS FASTIGHETER
DORO
DUNI
EAST CAPITAL EXPLORER
ELANDERS ‘B’
ELECTRA GRUPPEN
ELECTROLUX ‘B’
ELEKTA ‘B’
ENDOMINES
ENEA
ENIRO
ENQUEST
EOLUS VIND ‘B’
ERICSSON ‘B’
ETRION
FABEGE
FINGERPRINT CARDS ‘B’
FORMPIPE SOFTWARE
G5 ENTERTAINMENT
GETINGE
GHP SPECIALTY CARE
GUNNEBO
HALDEX
HENNES & MAURITZ ‘B’
HEXAGON ‘B’
HEXPOL ‘B’
HIQ INTERNATIONAL
HMS NETWORKS
HOLMEN ‘B’
HUSQVARNA ‘B’
I A R SYSTEMS GROUP
ICA GRUPPEN
INDL.& FINL.SYS.B
INDUSTRIVARDEN ‘C’
INDUTRADE
INTRUM JUSTITIA 22
INVESTOR ‘B’
JM
KAPPAHL
KARO BIO
KAROLINSKA DEVELOPMENT
KINNEVIK ‘B’
KLOVERN ‘A’
KNOW IT
KUNGSLEDEN
LAGERCRANTZ GROUP ‘B’
LATOUR INVESTMENT ‘B’
LINDAB INTERNATIONAL
LOOMIS ‘B’
LUCARA DIAMOND
LUNDBERGFORETAGEN ‘B’
LUNDIN MINING
LUNDIN PETROLEUM
MEDA ‘A’
MEDIVIR ‘B’
MEKONOMEN
MELKER SCHORLING
MILLICOM
MOBERG PHARMA
MQ HOLDING
MYCRONIC
NCC ‘B’
NEDERMAN HOLDING
NET INSIGHT ‘B’
NETENT
NEUROVIVE
NEW WAVE GROUP ‘B’
NIBE INDUSTRIER ‘B’
NOBIA
NOKIA
NOLATO ‘B’
NORDEA BANK
NORDNET ‘B’
NOTE
OASMIA PHARMACEUTICAL
ODD MOLLY INTL.
OPCON

OPUS GROUP
ORESUND INVESTMENT
OREXO
ORIFLAME HOLDING
PEAB ‘B’
POOLIA ‘B’
PRECISE BIOMETRICS
PRICER ‘B’
PROACT IT GROUP
QLIRO GROUP
RATOS ‘B’
RAYSEARCH LABS.B
REJLERS ‘B’
REZIDOR HOTEL GROUP
RNB RETAIL AND BRANDS
ROTTNEROS
SAAB ‘B’
SAGAX
SANDVIK
SAS
SCA ‘B’
SEB ‘C’
SECTRA ‘B’
SECURITAS ‘B’
SEMAFO
SEMCON
SENSYS GATSO
SINTERCAST
SKANSKA ‘B’
SKF ‘B’
SKISTAR ‘B’
SSAB ‘B’
STORA ENSO ‘A’
STUDSVIK
SVENSKA HANDBKN.B
SWEDBANK ‘A’
SWEDISH MATCH
SWEDISH ORPHAN BIOVITRUM
SWEDOL ‘B’
SYSTEMAIR
TELE2 ‘B’
TELIASONERA
TETHYS OIL
TIETO CORPORATION
TRADEDOUBLER
TRELLEBORG ‘B’
TRIGON AGRI
UNIBET GROUP
UNIFLEX ‘B’
VIKING SUPPLY SHIPS
VITROLIFE
VOLVO ‘B’
VOSTOK NEW VENTURES
WALLENSTAM ‘B’
WIHLBORGS FASTIGHETER