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**IMPLIED VOLATILITY RESPONSE TO SCHEDULED U.S.
MACROECONOMIC NEWS ANNOUNCEMENTS: BANKING SECTOR AP-
PROACH ON EUREX OPTIONS MARKET**

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ABSTRACT

This thesis investigates how scheduled macroeconomic news releases affect stock market uncertainty on industry level. The study takes a banking sector approach by using data from the Eurex option market. For this purpose, an eight-firm market portfolio is constructed to represent the entire market. These eight firms are BASF, Daimler-Chrysler, E. ON, Nokia, RWE, SAP, Siemens, and Total. Proportion to this, a banking sector portfolio is constructed by using seven banks. These banks are Allianz, BNP Paribas, Credit Suisse, Credit Agricole, Deutsche Bank, Societe Generale, and UBS. To examine the impact of the U.S. macroeconomic releases for stock valuation, the behavior of these two portfolios' implied volatilities are investigated.

The study focuses on 7 macroeconomic news announcements selected on the basis of the previous literature and the Bureau of Labor Statistics classifications of major economic indicators. The 7 macroeconomic news releases are the Employment Report (ER), the Producer Price Index (PPI), the Consumer Price Index (CPI), the National Association of Purchasing Managers Survey (NAPM, Manufacturing), the Import and Export Price Indices (USIEX), Retail Sales, and the Employment Cost Index (ECI). Addition to this, Federal Reserve's Open Market Committee Meetings are also included to the study.

The reaction of the portfolios' implied volatilities to the macroeconomic news releases is estimated by using dummy variables in regression analysis. The empirical results show that the U.S. macroeconomic news announcements have significant influence on stock valuation. Moreover, the results convey that the banking sector reacts differently compared to the market reaction. Out of the seven macroeconomic news announcements the Consumer Price Index and the Import and Export Price Indexes seems to have significant influence in the case of the market portfolio, whereas the bank portfolio reacts only to the NAPM: Manufacturing release with a statistical significance. In addition, Federal Reserve's FOMC news announcements have significant influence on both portfolios' stock valuation.

KEYWORDS: options, implied volatility, macroeconomic news announcements

1. INTRODUCTION

Since there is a high degree of integration among economies, investors operating on local markets are not only interested in the condition of the domestic economy but also in the outlook of the world economy. Moreover, firms operating in several market areas are not dependent on the situation on one particular market but rather the worldwide economic situation affects their profitability. Because of the crucial role of the USA in determining the development of the world economy, the major indicators on the US economy can be expected to be important for the valuation of stocks not only on the US market but also on foreign markets as well. (Nikkinen & Sahlström 2004: 201–202.)

Reactions in the options market may be more informative about information processing for several reasons. Black (1975) was the first to suggest that the higher leverage available in the options market might induce informed traders to transact in options rather than in stocks. Since a one percent change in the stock price will induce at least one percent change in the option price, any price reaction to earnings announcements in the stock will imply a more pronounced relative price change in the option. On the other hand, the arbitrage linkage between stock and option prices creates new trading opportunities in both markets for investors who believe that the securities are miss-priced relative to each other. Characteristics of options are also useful when hedging assets. The distribution of the returns can be made asymmetric, which is not the case in the pure stock price process. For call options, the downside risk is limited to the price paid for the option. Options writers responding to the demand for options will typically hedge their own positions using other financial instruments.

While scheduled announcements affect the realized behavior of asset prices, they also have an impact on the market's expectation of future volatility (see, e.g., Donders & Vorst, 1996; Ederington & Lee, 1996). According to the famous option pricing model by Black and Scholes (1973) and Merton (1973), the option value is a nonlinear function of five factors, which are the underlying stock price, time to expiration of the option, the exercise price of the option, the risk-free interest rate, and the underlying asset price volatility. Volatility of the underlying security is the most important component of the option price premium. In the model developed by Black and Scholes all of the other four variables can be measured beforehand, except the volatility. The Black–Scholes model assumes volatility to be constant over the remaining lifetime of the option contract. One can use different volatility estimates when dealing with options. One of the

most important is called implied standard deviation or implied volatility. It results when the market price of the option is set equal to the theoretical option price in the model. Implied volatility can be interpreted as market's consensus assessment of coming volatility of an underlying asset. Therefore, understanding the behavior of implied volatility is essential when trading options. The crucial role of the volatility in option price stimulates many traders to make assumptions of coming uncertainty and thus trade with volatility. On the opposite side, there are investors who are interested in hedging their portfolios against the volatility. In practice there is still quite heterogeneous valuation of volatility. Sometimes implied volatility may reach a very high level, whereas occasionally it stays on lower grade. It is essential in successful option trading to evaluate the fair level of implied volatilities i.e. assess whether option are traded at too low or too high costs. (Mayhew 1995: 8–11; Hull 2003: 10–14.)

Since the pioneer seminar paper by Ball and Brown (1968), the impact of information releases on stock prices has been the focus of countless studies in financial economic literature. An issue, which has received much less attention in previous researches, is the impact of information releases in derivatives market. A derivative can be defined as a financial instrument whose value depends on the values of other, more basic underlying variables. Very often the variables underlying derivatives are the prices of traded assets. A stock option, which is under consideration in this study, is a derivative whose value is dependent on the price of a stock. (Hull 2003: 1.)

In the case of scheduled news (macroeconomic news announcements, earnings figures etc.), market participants are aware that some information will be given out to the market on a precise date but the content of the release is unknown. Due to the uncertainty linked to the informational content of the announcement, investors expect a higher average volatility (positive or negative price change) on that day. If this is the case, the pattern that should be observed in terms of implied volatility is a gradual rise during the announcement period, peak on before the news release, and return to its long-term level afterwards. (Nikkinen & Sahlström 2003: 3–4.)

1.1. Purpose of the study

This thesis investigates how scheduled macroeconomic news releases affect stock market uncertainty on industry level. Many market participants believe that macroeconomic

news has a major impact on the prices of financial assets. The evolution in recent years of an industry to predicting the figures to be released in upcoming releases supports this belief. A considerable number of scheduled macroeconomic announcements can be regarded as valuable for investors. According to the previous studies by Christie-David, Chaudhry and Koch (2000), Ederington and Lee (1993, 1996), Fleming and Remolona (1999), Harvey and Huang (1991), and Nikkinen and Sahlström (2001), the Employment Report (ER), the Producer Price Index (PPI), and the Consumer Price Index (CPI) have a significant impact on the pricing processes of financial assets. Addition to this, Graham, Nikkinen and Sahlström (2003) found that the National Association of Purchasing Managers Survey (NAPM, Manufacturing), the Import and Export Price Indices (USIEX), Retail Sales, and the Employment Cost Index (ECI) have also a notable influence on stock valuation. These reports are major macroeconomic indicators, which are widely followed by investors all around the world. Therefore, these seven U.S. macroeconomic news announcements are chosen to investigate the industry-specific uncertainty.

Furthermore, the study also focuses on the impact of the Federal Open Market Committee (FOMC) meetings. The monetary policy of the Federal Reserve affects macroeconomic variables, such as interest rates, directly and indirectly. The FOMC decides its policy in regular meetings. Shortly after each of its meetings, the FOMC issues a statement that includes its assessment of the economic outlook. Therefore, it can expect that the monetary policy conducted by the FOMC is closely followed by the market participants. (Nikkinen et al. 2003: 1–2.)

To investigate industry-specific uncertainty, industry-specific implied volatilities of EUREX options are used. Implied volatility can be interpreted as a market's expectation of the average return volatility over the remaining life of the option contract. Therefore, it is expected that the uncertainty around the scheduled macroeconomic news release will be reflected in implied volatility. (Nikkinen et al. 2003: 2.)

There are some previous studies on the impact of the U.S. macroeconomic news to uncertainty. For instance, Ederington et al. (1993) used data from interest rate and foreign exchange rate markets. Fleming et al. (1999) used data from the US treasury market, and Christie-David et al. (2000) used data from gold and silver markets. This paper contributes to the existing literature by using firm-specific data. Consequently, it is possible to investigate, if the implied volatility behaves differently between different industries or even individual firms. The study concentrates to investigate whether banking industry

responses differently to macroeconomic news announcement compared to the market as general. Banking industry has some unique features. For instance, banks are the primary source of liquidity for all other classes and sizes of institutions, both financial and non-financial, and they are the transmission belt for monetary policy. Therefore, it is reasonable to believe that banking sector might response differently to the macroeconomic news. Since the study uses a banking sector approach, a portfolio of seven banks from the EUREX option market are chosen to represent banking industry. These seven banks are Allianz, BNP Paribas, Credit Suisse, Credit Agricole, Deutsche Bank, Societe Generale, and UBS. In proportion, eight most liquid firms, excluding banks, from the EUREX option market are chosen to represent the market portfolio. According to the monthly stats of February 2006, the eight most liquid firms, excluding banks, of the EUREX are BASF, Daimler–Chrysler, E. ON, Nokia, RWE, SAP, Siemens, and Total.

1.2. Research hypothesis

Financial asset prices are more volatile around scheduled information releases such as macroeconomic news announcements and earnings announcements than on nonannouncement days. News announcements contain relevant information on the values of financial assets and therefore affect the valuation of these assets. Hence, volatility is higher than normal on the scheduled announcement day since the information is incorporated into prices after the news announcement. This phenomenon has been empirically documented by Ederington et al. (1993) by using data from interest rate and foreign exchange rate markets, by Fleming et al. (1999) by using data from the US treasury market, and by Christie-David et al. (2000) by using data from gold and silver markets. (Nikkinen et al. 2004: 203–204.)

Since the Black–Scholes model assumes that daily stock returns are independently and identically distributed random variables, daily variances are additive. Consequently, the average implied variance over the remaining life of the option contract can be calculated by summing the individual daily variances and dividing this sum by the number of days until the expiration date (Merton, 1976). This result can be applied when the scheduled announcements are investigated. (Nikkinen et al. 2004: 204.)

The observed pattern that volatility is higher on a news release day is caused by the fact that news releases contain relevant information on the values of financial assets and

therefore affect the valuation of these assets. Due to the price adjustment process, it can be expected that volatility will be higher than normal on the scheduled announcement day, inasmuch as the information is incorporated into prices after the news release. (Nikkinen et al. 2003: 3–4.)

Since the release of the new information should resolve the uncertainty associated with the future value of the underlying equity value, it should be expected that the implied volatility will drop following the macroeconomic announcements. Therefore, the first hypothesis is set in to the following form:

H₁: On days with no scheduled macroeconomic news announcement both portfolios' implied volatility increases.

Since financial market participants anticipate a volatility shock on the event date whatever the informational content of the news announcement, implied volatility increases before important macroeconomic news announcement dates. Addition to this, according to Ederington et al. (1993), the implied volatility tends to grow on days with no scheduled macroeconomic news announcements. Therefore, the second hypothesis is set in to the following form:

H₂: On days with macroeconomic news announcement both portfolios' implied volatility decreases.

1.3. Previous studies

During the last decades there have been made a handful of researches on the topic of macroeconomic news announcements' influence to the implied volatilities. In 1981, Patell and Wolfson studied the effect of investors' anticipations of impending informative disclosures on the behavior of option and stock prices. In the study the authors analyzed preannouncement option price in order to discern investors' beliefs about the range of possible stock price reactions expected to accompany a forthcoming disclosure whose actual content is not yet known. As a result of the study, Patell and Wolfson reported a large increase in the implied volatility 20 days prior to the news release day and a significant drop two days after.

Harvey et al. (1991) examined the volatility implications of around-the-clock foreign exchange trading with transaction data on futures contracts from Chicago Mercantile Exchange and the London International Financial Futures Exchange. They found higher U.S.–European and U.S.–Japanese exchange–rate volatilities during U.S. trading hours and higher European cross–rate volatilities during European trading hours. While the disclosure of private information through trading may have partly explained these volatility patterns, the authors concluded that the increased volatility is more likely driven by macroeconomic news announcements. An analysis of inter– and intraday data also revealed that volatility increases at times that coincide with the release of U.S. macroeconomic news.

Ederington et al. (1993) examined the impact of scheduled macroeconomic news announcements on interest rate and foreign exchange futures markets. They analyzed Treasury bond, Eurodollar, and Deutschemark futures to determine the market response to 19 macroeconomic news releases, such as the employment report, the consumer price index (CPI), and the producer price index (PPI). These reports are considered to be major macroeconomic indicators, and therefore chosen for the study. Ederington and Lee identified that these announcements are responsible for most of the observed time-of-day and day-of-the-week volatility patterns in these markets. They also found that most of the significant impact on return volatility occurs in the first minute after the release, although volatility remains outstandingly higher than normal for roughly fifteen minutes and slightly elevated for several hours.

A few years later from their previous research, Ederington and Lee (1995) afresh their study on the impact of scheduled macroeconomic news announcements, such as the employment report, the consumer price index, and the producer price index, on the Treasury bond, Eurodollar, and Deutschemark futures markets. This time they explored the short-run dynamics of the price adjustment to new information. Using 10–second returns and tick-by-tick data, the authors found that the market price begins adjusting almost immediately following a news release, generally within the first 10 seconds. The major adjustment to the initial release is basically complete within 40 seconds, and zero drift is observed after three minutes.

A news announcement's impact on market uncertainty depends largely on whether the announcement is scheduled or unscheduled. In 1996, Ederington et al. examined the impact of information releases on market uncertainty as measured by the implied standard deviation (ISD) from option markets. Distinguishing between scheduled and un-

scheduled announcements, they found that scheduled releases lead to a drop in the implied volatility, as the uncertainty regarding the announcement is resolved. Unscheduled releases give an opposite result implicating that the implied volatility raises following price innovations due to these announcements.

Nikkinen et al. (2001) examined how the U.S. macroeconomic news releases affect uncertainty in domestic and foreign stock exchanges. They investigated the behavior of the implied volatilities from the U.S. and Finnish markets around the employment report, producer price index (PPI), and consumer price index (CPI) reports. Nikkinen and Sahlström found that implied volatility increases prior to the macroeconomic news release and drops after the announcement in both markets. Furthermore, they discovered that the employment report causes the largest effect on implied volatilities and that the uncertainty associated with the U.S. macroeconomic figures is rejected in the Finnish market as well.

Graham et al. (2003) investigated the relative importance of macroeconomic news releases for stock valuation. The study focused on 11 macroeconomic news announcements, and the results showed that five out of the 11 releases have significant influence on stock valuation. These were the Employment Report, NAPM (manufacturing), Producer Price Index, Import and Export Price Indices, and Employment Cost Index. Of the five announcements, the Employment Report had NAPM (manufacturing) had the greatest impact on stock valuation. Graham, Nikkinen and Sahlström also discovered that the time of the announcement has a moderating impact on the relationship between macroeconomic announcement and its importance.

Nofsinger and Prucyk (2003) examined the reaction of the market for the Standard & Poors 100 Index option (OEX) to scheduled macroeconomic news announcements. They used option implied volatility to proxy for the level of uncertainty in the market around these announcements. Their main finding was that the options market has a greater reaction to bad news compared to good news. Bad news elicits a quick and strong response to trading volume. Comparatively, good news is followed by strong volume that arrives hours after the announcement.

Closely to the earlier study of Nofsinger et al. (2003), Nikkinen et al. (2003) concentrated to investigate the behavior of the implied volatility of the S&P 100 index around the Federal Open Market Committee (FOMC) meeting days and around the employment, producer price index (PPI), and consumer price index (CPI) reports. As a result of

the study, the authors found that implied volatility increases prior to the scheduled news and drops after the announcement. In addition, investors regard the FOMC meetings as highly significant for valuing stocks as hypothesized.

Due to the U.S. great influence on the world's economy, Nikkinen et al. (2004) investigated the relative importance of scheduled U.S. and European macroeconomic news announcement on the German and Finnish stock markets. To define the importance of domestic and U.S. news releases, they analyzed implied volatilities on these markets. The result of the study showed that the U.S. employment report and the Federal Open Market Committee meetings days have a significant impact on implied volatilities on both markets, whereas domestic news releases proved to have no impact on implied volatility whatsoever.

Nikkinen, Omran, Sahlström and Äijö (2006) investigated how global markets are integrated with respect to the scheduled U.S. macroeconomic news announcements. They analyzed the behavior of GARCH volatilities around ten important scheduled U.S. macroeconomic news announcements on 35 local stock markets that were divided into six regions. These regions were the 7G countries, the European countries other than G7 countries, developed and emerging Asian countries, the countries of Latin America, and countries from Transition economies. The result of the study confirms earlier findings that the consumer price index, employment cost index, employment situation, and NAPM reports are the most influential U.S. macroeconomic news announcements (see e.g. Graham et al., 2003). However, the general importance of the news releases varied across the world's regions. The authors found that the 7G countries, the European countries other than G7 countries, developed and emerging Asian countries are closely integrated with the world's stock market, whereas Latin America and Transition economies were not affected by U.S. macroeconomic news announcements.

2. MARKET EFFICIENCY

The primary role of the capital market is allocation of ownership of the economy's capital stock. In general terms, the ideal is a market in which prices provide accurate signals for resource allocation: that is, a market in which firms can make production–investment decisions, and investors can choose among the securities that represent ownership of firms' activities under the assumption that security prices at any time 'fully reflect' all available information. A market in which prices always 'fully reflect' available information is called 'efficient'. (Fama 1970: 383.)

If stock prices are bid immediately to fair levels, given all available information, it must be that they increase or decrease only in response to new information. New information, by definition, must be unpredictable; if it could be predicted, then the prediction would be part of today's information. Thus stock prices that change in response to new (unpredictable) information also must move unpredictably. This is the essence of argument that stock prices should follow a *random walk*, that is, that prices changes should be random and unpredictable. Far from a proof of market irrationality, randomly evolving stock prices are the necessary consequence of intelligent investors competing to discover relevant information on which to buy or sell stocks before the rest of the market becomes aware of that information. If prices are determined rationally, then only new information will cause them to change. Therefore, a random walk would be the natural result of prices that always reflect all current knowledge. Indeed, if stock prices movements were predictable, that would be damning evidence of stock market inefficiency, because the ability to predict prices would indicate that all available information was not already reflected in stock prices. Therefore, the notion that stocks already reflect all available information is referred to as the efficient market hypothesis. (Bodie, Kane & Marcus 2002: 341.)

The Efficient Market Hypothesis (EMH) has become an increasingly widely accepted concept since interest in it was reborn in the 1950s and 1960s under the title of the 'theory of random walks' in the finance literature and 'rational expectations theory' in the mainstream economics literature (Jensen, 1978). There are three forms of the hypothesis. The definitions according to Fama (1970) are the weak form of the EMH, the semi-strong form of EMH, and the strong form of EMH.

2.1. Weak form market efficiency

The weak-form hypothesis asserts that stock prices already reflect all information that can be derived by examining market trading data such as the history of past prices, trading volume and short interest. This version of the hypothesis implies that trend analysis is fruitless. Past stock price data are publicly available and virtually costless to obtain. The weak-form hypothesis holds that if such data ever conveyed reliable signals about future performance, all investors already would have learned to exploit the signals. Ultimately, the signals lose their value as they become widely known because a buy signal, for instance, would result in an immediate price increase. (Bodie et al. 2002: 342–343.)

The weak form of EMH has found general acceptance in the financial community along with the popularity of technical analysis. Samuelson (1965) and Mandelbrot (1966) have proved that if the flow of information is unimpeded and if there are no transactions costs, the tomorrow's price change in speculative markets will reflect only tomorrow's 'news' and will be independent of the price changes today. However, 'news' by definition is unpredictable and thus the resulting price changes must also be unpredictable and random. Merton (1980) has shown that changes in the variance of stock's return (price) can be predicted from its variance in the recent past.

2.2. Semi-strong form market efficiency

The semi strong-form hypothesis states that all publicly available information regarding the prospects of a firm must be reflected already in the stock price. Such information includes, in addition to past prices, fundamental data on the firm's product line, quality of management, balance sheet composition, patents held, earning forecasts, and accounting practices. Again, if investors have access to such information from publicly available sources, one would expect it to be reflected in stock prices. (Bodie et al. 2002: 343.)

The stronger assertion that all publicly available information has already been impounded into current market prices has proved far more controversial among investment professionals, who practice 'fundamental' analysis of publicly available information as a widely accepted mode of security analysis. In general, the empirical evidence suggests

that public information is so rapidly impounded into current market prices that fundamental analysis is not likely to be fruitful. (Malkiel, 1989.)

Various tests have been conducted to ascertain the speed of adjustment of market prices to new information. Fama, Fisher, Jensen, and Roll (1969) examined the effect of stock splits on equity prices. While not providing any economic benefit themselves, splits are usually accompanied or followed by dividend increases that do convey to the market information about management's confidence about the future progress. Thus, while splits usually do result in higher share prices, the market appears to adjust to the announcement fully and immediately. Substantial returns can be earned prior to the split announcement, but there is no evidence of abnormal returns after the public announcement. In cases where dividends were not raised following the split, firms suffered a loss in price, presumably because of the unexpected failure of the firm to increase its dividend. Dodd (1981) found no evidence of abnormal price changes following the public release of the merger information. Although merger announcements can raise market prices substantially, it appears that the market adjusts fully to the public announcements.

Although the vast majority of studies support the semi-strong version of EMH, there have been some studies that do not. Ball (1978) found that stock-price reactions to earnings announcements are not complete. However, Watts (1978) performed corrections suggested by Ball (1978) to reduce the estimation bias and still found abnormal returns. Rendleman, Jones, and Latané (1982) also found a relation between unexpected quarterly earnings and excess returns subsequent to the announcement date. Bamber (1986) studied unexpected earnings announcements and trading volume and found a continuous (positive) relation between trading volume and the magnitude of unexpected earnings. Datta and Dhillon (1993) showed that bondholders react positively (negatively) to unexpected earnings increases (decreases). Also, Pearce and Roley (1983) found that stock prices respond only to the unanticipated changes in the money supply, as predicted by the efficient market hypothesis.

2.3. Strong form market efficiency

The strong-form version of the efficient market hypothesis states that stock prices reflect all information relevant to the firm, even including information available only company insiders. This version of the hypothesis is quite extreme. Few would argue

with the proposition that corporate officers have access to pertinent information long enough before public release to enable them profit from trading on that information. (Bodie et al. 2002: 343.)

As the previous studies indicate, stock splits, earnings, dividend increase, and merger announcements can have substantial effects on the share prices and thus, insider trading on such information can create profits before the announcement date, as documented by Jaffe (1974). While such trading is generally illegal the fact that the market often at least partially anticipates the announcements suggests the possibility of profiting on the basis of privileged information. Thus, the strongest form of the EMH is clearly disproved. Nevertheless, there is considerable evidence that the market comes reasonably close to the strong-form efficiency. (See e.g. Friend, Brown, Herman & Vickers (1962); Jensen (1969).)

In general, the empirical evidence in favor of EMH is strong. However, along with the general support for EMH there has been anomalous evidence inconsistent with the hypothesis in its strongest forms, as reviewed by Jensen (1978) and Ball (1978). For example, Shiller (1981) argued that variations in aggregate stock prices are much too large to be justified by the variation in subsequent dividend payments, which is an apparent rejection of the EMH. However, Marsh and Merton (1983) concluded that Shiller's findings are a result of misspecifications rather than a result of market inefficiency, which is supported by Kleidon (1986).

2.4. The EMH and information-efficient equilibrium

According to the EMH, security prices fully reflect all available information. But how does this process occur? The answer depends on whether the markets are fully aggregating information or only averaging information. In a market that is fully aggregating information, even if a piece of information is held only by a single individual, it will be fully reflected in security prices as though every participant in the market is fully aware of that piece of information. In a market that is averaging information, security prices will only reflect the average impact of different pieces of information. This is because not every individual is equally well-informed and the response of security prices to new information depends on the balance between 'informed' and 'uninformed' investors. (Blake 2000: 393.)

A strong-form efficient market requires information to be fully aggregating: if this is the case, then not even insiders can exploit their informational advantage. A semi-strong-form efficient market requires only that the market is averaging information. In an information-averaging market there is an important distinction between 'informed' and 'uninformed' investors. Informed investors (e.g. institutional investors or rich private clients) invest in costly research and aim to use their superior information to take trading positions and hence to make excess returns. Current security prices respond to the activities of the informed investors. Uninformed investors, on the other hand, do not invest in collecting information, but, by seeing what is happening to security prices, they can infer the information acquired by the informed traders. In this way, all investors become informed. Is it better to be an informed investor, or an uninformed investor? The choice is between paying for costly information and using it to generate excess returns, or saving on information costs and allowing others to ensure that prices reflect available information. The answer depends on which strategy leads to the greatest return after costs. (Blake 2000: 393.)

3. OPTIONS

A derivative can be defined as a financial instrument whose value depends on (or derives from) the values of others, more basic underlying variables. There are two basic types of options. A call option gives the holder the right to buy the underlying asset by a certain date for a certain price. A put option gives the holder the right to sell the underlying asset by a certain date for a certain price. The price in the contract is known as the exercise price or strike price; the date in the contract is known as the expiration date or maturity. American options can be exercised at any time up to the expiration date. European options can be exercised only on the expiration date itself.¹ (Hull 2003: 6.)

3.1. Derivative trading

In the last 20 years derivatives have become increasingly important in the world of finance. Futures and options are now traded actively on many exchanges throughout the world. A derivatives exchange is a market where investors trade standardized contracts that have been defined by the exchange. Derivatives exchanges have existed for a long time. The Chicago Board of Trade (CBOT) was established in 1848 to bring farmers and merchants together. Initially its main task was to standardize the quantities and qualities of the grains that were traded. Within a few years the first futures-type contract was developed. It was known as a *to-arrive contract*. Speculators soon became interested in the contract and found trading the contract to be an attractive alternative to trading the grain itself. A rival futures exchange, the Chicago Mercantile Exchange (CME), was established in 1919. Now futures exchanges exist all over the world. (Hull 2003: 1.)

The Chicago Board Options Exchange (CBOE) started trading call option contracts on 16 stocks in 1973. Options had traded prior to 1973 but the CBOE succeeded in creating an orderly market with well-defined contracts. Put option contracts started trading on the exchange in 1977. The CBOE now trades options on over 1200 stocks and many different stock indices. Like futures, options have proved to be very popular contracts. Many other exchanges throughout the world now trade options. For instance, located in Frankfurt, Germany, Eurex is the world's leading futures and options exchange. It is

¹ Note that the term *American* or *European* do not refer to the location of the option or the exchange.

jointly operated by Deutsche Börse AG and SWX Swiss Exchange. But not all trading is done on exchanges. The *over-the-counter market* is an important alternative to exchanges and, measured in terms of the total volume of trading, has become much larger than the exchange-traded market. (Cuthbertson & Nitzsche 2001: 177–178.)

3.2. Option positions

There are two sides to every option contract. On one side is the investor who has taken the long position (i.e., has bought the option). On the other side is the investor who has taken a short position (i.e., has sold or written the option). The writer of an option receives cash up front, but has potential liabilities later. The writer's profit or loss is the reverse of that for the purchaser of the option. There are four types of option positions (Cuthbertson et al. 2001: 9–16, 169–173.):

1. A long position in a call option
2. A long position in a put option
3. A short position in a call option
4. A short position in a put option

It is often useful to characterize European option positions in terms of the terminal value or payoff to the investor at maturity. The initial cost of the option is then not included in the calculation. If K is the strike price and S_T is the final price of the underlying asset, the payoff from a long position in a European call option is

$$(3.1) \quad \max(S_T - K, 0).$$

This reflects the fact that option will be exercised if $S_T > K$ and will not be exercised if $S_T \leq K$. The payoff to the holder of short position in the European call option is

$$(3.2) \quad -\max(S_T - K, 0) = \min(K - S_T, 0).$$

The payoff to the holder of a long position in a European put option is

$$(3.3) \quad \max(K - S_T, 0)$$

and the payoff from a short position in a European put option is

$$(3.4) \quad -\max(k - S_T, 0) = \min(S_T - K, 0).$$

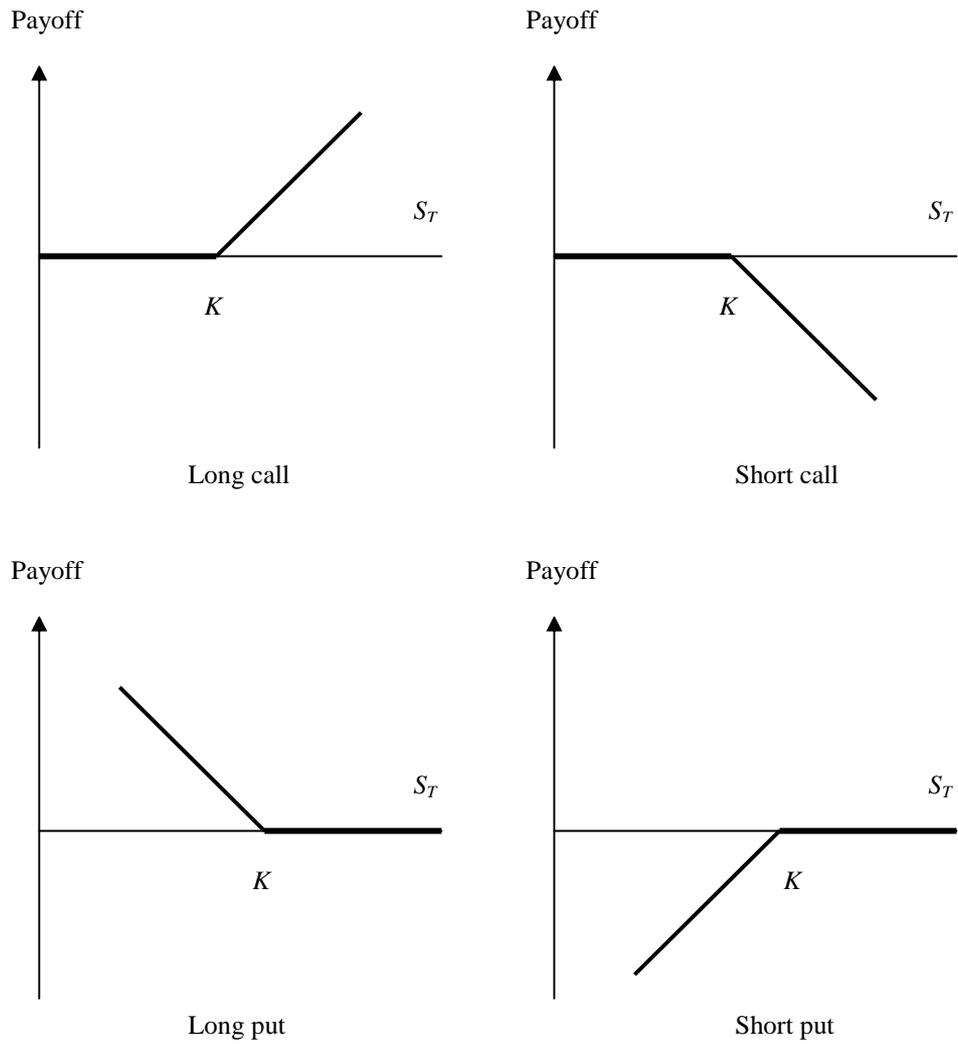


Figure 1. Payoffs from position in European options: K = Strike price, S_T = price of asset at maturity. (McDonald 2006: 53.)

3.3. Types of Traders

Derivatives markets have been outstandingly successful. The main reason is that they have attracted many different types of traders and have a great deal of liquidity. When an investor wants take one side of a contract, there is usually no problem in finding someone that is prepared to take the other side. Three board categories of traders can be identified: hedgers, speculators, and arbitrageurs. Hedgers use futures, forwards, and options to reduce the risk that they face from potential future movements in a market variable. Speculators use them to bet on the future direction of a market variable. Arbitrageurs take offsetting positions in two or more markets to lock in a profit. (Cuthbertson et al. 2001: 19–22.)

3.4. Factors affecting option prices

There are six factors affecting the price of a stock option:

1. The current stock price, S_0
2. The strike price, K
3. The time to expiration, T
4. The volatility of the stock price, σ
5. The risk-free interest rate, r
6. The dividends expected during the life of the option

Stock price and strike price

If a call option is exercised at some future time, the payoff will be the amount by which the stock price exceeds the strike price. Call options therefore become more valuable as the stock price increases and less valuable as the strike price increases. For a put option, the payoff on exercise is the amount by which the strike price exceeds the stock price. Put options therefore behave in the opposite way from call options. They become less valuable as the stock price increases and more valuable as the strike price increases. (Hull 2003: 167.)

Time to expiration

Both put and call American options become more valuable as the time to expiration increases. Consider two options that differ only as far as the expiration date is concerned. The owner of the long-life option has all the exercise opportunities open to the owner of the short-life option – and more. The long-life option must therefore always be worth at least as much as the short-life option. (Cuthbertson et al. 2001: 192; Hull 2003: 168.)

Although European put and call options usually become more valuable as the time to expiration increases, this is always the case. Consider two European call options on a stock: one with an expiration date in one month, and the other with an expiration date in two months. Suppose that a very large dividend is expected in six weeks. The dividend will cause the stock price to decline, so that the short-life option could be worth more than the long-life option. (Cuthbertson et al. 2001: 192; Hull 2003: 168.)

Volatility

The volatility of a stock price is a measure of how uncertain we are about future stock price movements. As volatility increases, the chance that the stock will do very well or very poorly increases. For the owner of a stock, these two outcomes tend to offset each other. However, this is not so for the owner of a call or a put. The owner of a call benefits from price increases but has limited downside risk in the event of price decreases because the most the owner can lose is the price of the option. Similarly, the owner of a put benefits from price decreases, but has limited downside risk in the event of price increases. The values of both calls and puts therefore increase as volatility increases. (Hull 2003: 168.)

Risk-free interest rate

The risk-free interest rate affects the price of an option in a less clear-cut way. As interest rates in the economy increase, the expected return required by investors from the stock tends to increase. Also, the present value of any future cash flow received by the holder of the option decreases. The combined impact of these two effects is to decrease the value of put options and increase the value of call options. (Hull 2003: 168.)

It is important to emphasize that we are assuming that interest rates change while all other variables stay the same. In particular, we are assuming that interest rates change

while the stock price stays the same. In practice, when interest rates rise (fall), stock prices tend to fall (rise). The net effect of an interest rate increase and the accompanying stock price decrease can be to decrease the value of a call option and increase the value of a put option. Similarly, the net effect of an interest rate decrease and accompanying stock price increase can be to increase the value of a call option and decrease the value of a put option. (Cuthbertson et al. 2001: 193–194.)

Dividends

Dividends have the effect of reducing the stock price on the ex-dividend date. This is bad news for the value of call options and good news for the value of put options. The value of a call option is therefore negatively related to the size of any anticipated dividends, and the value of a put option is positively related to size of any anticipated dividends. (Hull 2003: 170.)

Table 1. Summary of the effect on the price of a stock option of increasing one variable while keeping all others fixed.² (Hull 2003: 168.)

Variable	European call	European put	American call	American put
Current stock price	+	-	+	-
Strike price	-	+	-	+
Time to expiration	?	?	+	+
Volatility	+	+	+	+
Risk-free rate	+	-	+	-
Dividends	-	+	-	+

² + indicates that an increase in the variable causes the option price to increase; - indicates that an increase in the variable causes the option price to decrease; ? indicates that the relationship is uncertain.

4. OPTION PRICING AND VOLATILITY

This chapter shows how the Black–Scholes model and the one step binomial model for valuing European call and put options on a non–dividend–paying stock are derived. Also the discussion about volatility and its importance for valuing options is covered in this chapter. But before going to these subjects, it is important to understand the mathematical framework of option pricing.

The mathematics of derivative assets assumes that time passes continuously. As a result, new information is revealed continuously, and decision–makers may face instantaneous changes in random news. Hence, technical tools for pricing derivative products require of handling random variables over infinitesimal time intervals. The mathematics of such random variables is known as *stochastic calculus*. (Neftci 2000: 45.)

4.1. Stochastic processes

Any variable whose value changes over time in an uncertain way is said to follow a stochastic process. Stochastic process can be classified as discrete time or continuous time. A discrete–time stochastic process is one where the value of the variable can change only at certain fixed points in time, whereas a continuous–time stochastic process is one where changes can take place at any time. Stochastic processes can also be classified as continuous variable or discrete variable. In a continuous–variable process, the underlying variable can take any value within a certain range, whereas in a discrete–variable process, only certain discrete values are possible. (Hull 2003: 216.)

The Markow property

A Markow process is a particular type of stochastic process where only the present value of a variable is relevant for predicting the future. The past history of the variable and the way that the present has emerged from the past are irrelevant. Stock prices are usually assumed to follow a Markow process. Predictions for the future are uncertain and must be expressed in terms of probability distributions. The Markow property implies that the probability distribution of the price at any particular future time is not dependent on the particular path followed by the price in the past. (Hull 2003: 217.)

The Markow property of stock prices is consistent with the weak form of market efficiency. This states that the present price of a stock impounds all the information contained in a record of past prices. If the weak form of market efficiency were not true, technical analysts could make above average returns by interpreting charts of the past history of stock prices. There is very little evidence that they are in fact able to do this. It is competition in the marketplace that tends to ensure that weak-form market efficiency holds. There are many investors watching the stock market closely. Trying to make a profit from it leads to a situation where a stock price, at any given time, reflects the information in past prices. (Hull 2003: 217.)

Wiener process

Wiener process is a particular type of Markow stochastic process with a mean change of zero and a variance rate of 1.0 per year. It is sometimes referred to as *Browian motion*. Expressed formally, a variable z follows a Wiener process if it has the following two properties:

Property 1. The change δz during a small period of time δt is

$$(4.1) \quad \delta z = \varepsilon \sqrt{\delta t} ,$$

where ε is a random drawing from a standardized normal distribution, $\phi(0,1)$.

Property 2. The values of δz for any two different short intervals of time δt are independent. It follows from the first property that δz itself has a normal distribution with

$$(4.2) \quad \text{mean of } \delta z = 0 ,$$

$$(4.3) \quad \text{standard deviation of } \delta z = \sqrt{\delta t} , \text{ and}$$

$$(4.4) \quad \text{variance of } \delta z = \delta t .$$

The second process implies that z follows a Markow process. (Hull 2003: 218.)

Consider the increase in the value of z during a relatively long period of time, T . This can be denoted by $z(T) - z(0)$. It can be regarded as the sum of the increases in z in N small time intervals of length δt , where

$$(4.4) \quad N = \frac{T}{\delta t} .$$

Thus,

$$(4.5) \quad z(T) - z(0) = \sum_{i=1}^N \varepsilon_i \sqrt{\delta t} ,$$

where the ε_i ($i = 1, 2, \dots, N$) are random drawings from $\phi(0,1)$. From second property of Wiener processes, the ε_i 's are independent of each other. It follows from equation (4.5) that $z(T) - z(0)$ is normally distributed with

$$(4.6) \quad \text{mean of } [z(T) - z(0)] = 0 ,$$

$$(4.7) \quad \text{variance of } [z(T) - z(0)] = N\delta t = T , \text{ and}$$

$$(4.8) \quad \text{standard deviation of } [z(T) - z(0)] = \sqrt{T} .$$

This is consistent with the discussion earlier in this section. (Cuthbertson et al. 2001: 443–444.)

Generalized Wiener Process

The basic Wiener process, dz , that has been developed so far has a drift rate of zero and a variance rate of 1.0. The drift rate of zero means that the expected value of z at any future time is equal to its current value. The variance rate of 1.0 means that the variance of the change in z in a time interval of length T equals T . A *generalized Wiener process* for a variable x can be defined in terms of dz as follows (McDonald 2006: 650–652.):

$$(4.9) \quad dx = adt + bdz ,$$

where a and b are constants.

To understand equation (4.9), it is useful to consider the two components on the right-hand side separately. The adt term implies that x has an expected drift rate of a per unit of time. Without the bdz term, the equation is

$$(4.10) \quad dx = adt ,$$

which implies that

$$(4.11) \quad \frac{dx}{dt} = a .$$

Integrating with respect to time, we get

$$(4.12) \quad x = x_0 + at ,$$

where x_0 is the value of x at time zero. In a period of time of length T , the value of x increases by amount aT . The bdz term on the right-hand side of equation (4.9) can be regarded as adding noise or variability to the path followed by x . The amount of this noise or variability is b times a Wiener process. A Wiener process has a standard deviation of 1.0. It follows that b times Wiener process has a standard deviation of b . In a small time interval δt , the change δx in the value of x is given by equations (4.1) and (4.9) as

$$(4.13) \quad \delta x = a\delta t + b\varepsilon\sqrt{\delta t} ,$$

where, as before, ε is a random drawing from a standardized normal distribution. Thus δx has a normal distribution with

$$(4.14) \quad \text{mean of } \delta x = a\delta t ,$$

$$(4.15) \quad \text{standard deviation of } \delta x = b\sqrt{\delta t} , \text{ and}$$

$$(4.16) \quad \text{variance of } \delta x = b^2\delta t .$$

Similar arguments to those given for a Wiener process show that the change in the value of x in any time interval T is normally distributed with

$$(4.17) \quad \text{mean of change in } x = aT ,$$

$$(4.18) \quad \text{standard deviation of change in } x = b\sqrt{T} , \text{ and}$$

$$(4.19) \quad \text{variance of change in } x = b^2T .$$

Thus, the generalized Wiener process given in equation (4.9) has an expected drift rate of a and a variance rate of b^2 . (Cuthbertson et al. 2001: 444–445.)

Itô Process

A further type of stochastic process can also be defined. This is known as an *Itô process*. This is a generalized Wiener process in which the parameters a and b are functions of the value of the underlying variable x and time t . Algebraically, an Itô process can be written

$$(4.20) \quad dx = a(x, t)dt + b(x, t)dz .$$

Both the expected drift rate and variance rate of an Itô process are liable to change over time. In a small time interval between t and $t + \delta t$, the variable changes from x to $x + \delta x$, where

$$(4.21) \quad \delta x = a(x, t)\delta t + b(x, t)\varepsilon\sqrt{\delta t} .$$

This relationship involves a small approximation. It assumes that the drift and variance rate of x remains constant, equal to $a(x, t)$ and $b(x, t)^2$, respectively, during the time interval between t and $t + \delta t$. (Hull 2003: 222; Cuthbertson et al. 2001: 445.)

Geometric Brownian motion

It is tempting to suggest that a stock price follows a generalized Wiener process, that is, that it has a constant expected drift rate and a constant variance rate. However, this model fails to capture a key aspect of stock prices. This is that the expected percentage return required by investors from a stock is independent of the stock's price. Clearly, the constant expected drift-rate assumption is inappropriate and need to be replaced by the assumption that the expected return (i.e., expected drift divided by the stock price) is constant. If S is the stock price at time t , the expected drift rate in S should be assumed to be μS for some constant parameter μ . This means that in a short interval of time, δt , the expected increase in S is $\mu S \delta t$. The parameter μ is the expected rate of return on the stock, expressed in decimal form. If the volatility of the stock price is always zero, this model implies that

$$(4.22) \quad \delta S = \mu S \delta t .$$

In the limit as $\delta t \rightarrow 0$,

$$(4.23) \quad dS = \mu S dt ,$$

or

$$(4.24) \quad \frac{dS}{S} = \mu dt .$$

Integrating between time zero and time T , we get

$$(4.25) \quad S_T = S_0 e^{\mu T},$$

where S_0 and S_T are stock price at time zero and time T . Equation (4.25) shows that, when the variance rate is zero, the stock price grows at a continuously compounded rate of μ per unit of time.

In practice, of course, a stock price does exhibit volatility. A reasonable assumption is that the variability of the percentage return in a short period of time, δt , is the same regardless of the stock price. This suggests that the standard deviation of the change in a short period of time δt should be proportional to the stock price and leads to the model

$$(4.26) \quad dS = \mu S dt + \sigma S dz,$$

or

$$(4.27) \quad \frac{dS}{S} = \mu dt + \sigma dz.$$

Equation (4.27) is the most widely used model of stock price behavior. The variable σ is the volatility of the stock price. The variable μ is its expected rate of return. This model is known as *geometric Brownian motion*. The discrete-time version of the model is

$$(4.28) \quad \frac{\delta S}{S} = \mu \delta t + \sigma \varepsilon \sqrt{\delta t},$$

or

$$(4.29) \quad \delta S = \mu S \delta t + \sigma S \varepsilon \sqrt{\delta t}.$$

The variable δS is the change in the stock price S in a small time interval δt , and ε is a random drawing from a standardized normal distribution. The parameter μ is the expected rate of return per unit of time from stock, and the parameter σ is the volatility of the stock price. Both of these parameters are assumed constant.

The left-hand side of equation (4.28) is the return provided by the stock in a short period of time δt . The term $\mu \delta t$ is the expected value of this return, and the term $\sigma \varepsilon \sqrt{\delta t}$ is the stochastic component of the return. The variance of the stochastic component (and therefore of the whole return) is $\sigma^2 \delta t$. Equation (4.28) shows that $\delta S/S$ is normally dis-

tributed with mean $\mu\delta t$ and standard deviation $\sigma\sqrt{\delta t}$. In other words, (Hull 2003: 222–224; Cuthbertson et al. 2001: 445–446.)

$$(4.30) \quad \frac{\delta S}{S} \sim \phi(\mu\delta t, \sigma\sqrt{\delta t}).$$

Itô's lemma

The price of a stock option is a function of the underlying stock's price and time. More generally, we can say that the price of any derivative is a function of stochastic variables underlying the derivative and time. The most important result about the manipulation of random variables used in continuous-time stochastic processes is known as *Itô's lemma*. Suppose that the value of a variable x follows the Itô process

$$(4.31) \quad dx = a(x, t)dt + b(x, t)dz,$$

where dz is a Wiener process and a and b are functions of x and t . The variable x has a drift rate of a and a variance rate of b^2 . Itô's lemma shows that a function G of x and t follows the process

$$(4.32) \quad dG = \left(\frac{\partial G}{\partial x} a + \frac{\partial G}{\partial t} + \frac{1}{2} \frac{\partial^2 G}{\partial x^2} b^2 \right) dt + \frac{\partial G}{\partial x} b dz,$$

where the dz is the same Wiener process as in equation (4.31). Thus, G also follows an Itô process. It has a drift rate of

$$(4.33) \quad \frac{\partial G}{\partial x} a + \frac{\partial G}{\partial t} + \frac{1}{2} \frac{\partial^2 G}{\partial x^2} b^2$$

and a variance rate of

$$(4.34) \quad \left(\frac{\partial G}{\partial x} \right)^2 b^2.$$

Earlier, we argued that

$$(4.35) \quad dS = \mu S dt + \sigma S dz,$$

with μ and σ constant, is a reasonable model of stock price movements. From Itô's lemma, it follows that the process followed by a function G of S and t is

$$(4.36) \quad dG = \left(\frac{\partial G}{\partial S} \mu S + \frac{\partial G}{\partial t} + \frac{1}{2} \frac{\partial^2 G}{\partial S^2} \sigma^2 S^2 \right) dt + \frac{\partial G}{\partial S} \sigma S dz.$$

Both S and G are affected by the same underlying source of uncertainty, dz . This proves to be very important later on in the derivation of the Black–Scholes results. (Cuthbertson et al. 2001: 446–447.)

4.2. Black–Scholes option pricing theory

The revolution on derivative securities, both in the stock exchange markets and in academic communities, began in the early 1970's. In 1973, the Chicago Board of Options Exchange started the trading of options in exchanges, although options had been regularly traded by financial institutions in the over-the-counter markets previously. In the same year, Black et al. (1973) and Merton (1973) published their celebrated seminar papers on the theory of option pricing. Since then the growth of the field of derivative securities has been phenomenal.

The Black–Scholes general equilibrium formulation of the option pricing theory is attractive since the final valuation formulas deduced from their model is a function of a few observable variables (except one, which is the volatility parameter) so that the accuracy of the model can be ascertained by direct empirical tests with market data. When judged by its ability to explain the empirical data, the option pricing theory is widely acclaimed to be the most successful theory not only in finance, but in all areas of economics. (Kwok 1998: 32.)

A writer of a European call option on a stock is exposed to the risk of unlimited liability if the stock price rises acutely above the strike price. To protect his short position in the option, he should consider purchasing certain amount of stock so that the loss in the short position in the option is offset by the long position in the stock. In this way, he is adopting the hedging procedure. A hedge position combines an option with its underlying asset so as to achieve the goal that either the stock protects the option against loss or the option protects the stock against loss. This risk-monitoring strategy has been commonly used by practitioners in financial markets. By adjusting the proportion of the stock and option continuously in a portfolio, Black et al. (1973) demonstrated that investors can create a riskless hedging portfolio where all market risks are eliminated. In an efficient market with no riskless arbitrage opportunity, any portfolio with a zero

market risk must have an expected return equal to the riskless interest rate. The Black–Scholes formulation establishes the equilibrium condition between the expected return on the option, the expected return on the stock and the riskless interest rate. This leads to the *Black–Scholes–Merton differential equation*. (Kwok 1998: 32–33.)

4.2.1. Black–Scholes–Merton differential equation

In their seminar paper, Black et al. (1973) illustrated how to use riskless principle to derive the governing partial differential equation for the price of a European call option. Black and Scholes made the following assumptions on the financial market:

1. Trading takes place in continuously in time
2. The riskless interest rate r is known and constant over time
3. The asset pays no dividend
4. There are no transaction costs in buying or selling the asset or the option, and no taxes
5. The assets are perfectly divisible
6. There are no penalties to short selling and the full use of proceeds is permitted
7. There are no riskless arbitrage opportunities

The stock price process is assumed to follow the *geometric Brownian motion*, which is developed in equation (4.26):

$$(4.37) \quad dS = \mu S dt + \sigma S dz .$$

Suppose that f is the price of a call option or other derivative contingent on S . The variable f must be some function of S and t . Hence, from the *Itó's lemma* equation (4.36),

$$(4.38) \quad df = \left(\frac{\partial f}{\partial S} \mu S + \frac{\partial f}{\partial t} + \frac{1}{2} \frac{\partial^2 f}{\partial S^2} \sigma^2 S^2 \right) dt + \frac{\partial f}{\partial S} \sigma S dz .$$

This gives the random walk followed by f .

The discrete versions of equations (4.37) and (4.38) are

$$(4.39) \quad \delta S = \mu S \delta t + \sigma S \delta z$$

and

$$(4.40) \quad \mathcal{J}f = \left(\frac{\partial f}{\partial S} \mu S + \frac{\partial f}{\partial t} + \frac{1}{2} \frac{\partial^2 f}{\partial S^2} \sigma^2 S^2 \right) \mathcal{J}t + \frac{\partial f}{\partial S} \sigma S \mathcal{J}z,$$

where $\mathcal{J}S$ and $\mathcal{J}f$ are the changes in f and S in a small time interval $\mathcal{J}t$. Now constructing a portfolio by choosing the stock and the derivative, the Wiener process can be eliminated. The appropriate portfolio is as follows:

$$(4.41) \quad -1 : \text{derivative}, \text{ and}$$

$$(4.42) \quad + \frac{\partial f}{\partial S} : \text{shares}.$$

The holder of this portfolio is short one derivative and long an amount $\frac{\partial f}{\partial S}$ of shares. Define Π as the value of the portfolio. By definition,

$$(4.43) \quad \Pi = -f + \frac{\partial f}{\partial S} S.$$

The change $\mathcal{J}\Pi$ in the value of the portfolio in the time interval $\mathcal{J}t$ is given by

$$(4.44) \quad \mathcal{J}\Pi = -\mathcal{J}f + \frac{\partial f}{\partial S} \mathcal{J}S.$$

Substituting equations (4.39) and (4.40) into equation (4.44) yields

$$(4.45) \quad \mathcal{J}\Pi = \left(-\frac{\partial f}{\partial t} - \frac{1}{2} \frac{\partial^2 f}{\partial S^2} \sigma^2 S^2 \right) \mathcal{J}t.$$

Because this equation does not involve $\mathcal{J}z$, the portfolio must be riskless during time $\mathcal{J}t$. The assumptions listed in the preceding section imply that the portfolio must instantaneously earn the same rate of return as other short-term risk-free securities. If it earned more than this return, arbitrageurs could make a riskless profit by borrowing money to buy the portfolio; if it earned less, they could make a riskless profit by shorting the portfolio and buying risk-free securities. It follows that

$$(4.46) \quad \mathcal{J}\Pi = r\Pi \mathcal{J}t,$$

where r is the risk-free interest rate. Substituting from equations (4.43) and (4.45), we obtain

$$(4.47) \quad \left(\frac{\partial f}{\partial t} + \frac{1}{2} \frac{\partial^2 f}{\partial S^2} \sigma^2 S^2 \right) \delta t = r \left(f - \frac{\partial f}{\partial S} S \right) \delta t,$$

so that

$$(4.48) \quad \frac{\partial f}{\partial t} + rS \frac{\partial f}{\partial S} + \frac{1}{2} \sigma^2 S^2 \frac{\partial^2 f}{\partial S^2} = rf.$$

Equation (4.48) is the *Black–Scholes–Merton differential equation*. It has many solutions, corresponding to all the different derivatives that can be defined with S as the underlying variable. The particular derivative that is obtained when the equation is solved depends on the *boundary conditions* that are used. These specify the values of the derivative at the boundaries of possible values of S and t . In the case of a European call option, the key boundary condition is

$$(4.49) \quad f = \max(S - K, 0), \quad \text{when } t = T.$$

In the case of a European put option, it is

$$(4.50) \quad f = \max(K - S, 0), \quad \text{when } t = T.$$

One point that should be emphasized is that the portfolio used in the derivation of equation (4.48) is not permanently riskless. It is riskless only for an infinitesimally short period of time. As S and t change, $\frac{\partial f}{\partial S}$ also changes. To keep the portfolio riskless, it is therefore necessary to frequently change the relative proportions of the derivative and stock in the portfolio. (see e.g. Cuthbertson et al. 2001: 454–456; Wilmott, Howison & Dewynne 1995: 41–44.)

4.2.2. Risk–neutral valuation

Risk–neutral valuation arises from one key property of the Black–Scholes–Merton differential equation (4.48). This property is that the equation does not involve any variable that is affected by the risk preferences of investors. The variables that do appear in the equation are the current stock price, time, stock price volatility, and the risk–free rate of interest. All are independent of risk preferences. (Hull 2003: 244–245.)

The Black–Scholes–Merton differential equation would not be independent of risk preferences if it involved the expected return in the stock, μ . This is because the value of μ

does depend on risk preferences. The higher the level of risk aversion by investors, the higher μ will be for any given stock. It is fortunate that μ happens to drop out in the derivation of the differential equation. Because the Black–Scholes–Merton differential equation is independent of risk preferences, an ingenious argument can be used. If risk preferences do not enter the equation, they cannot affect its solution. Any set of risk preferences can, therefore, be used when evaluating f . In particular, the very simple assumption that all investors are risk neutral can be made. (Hull 2003: 245.)

In a world where investors are risk neutral, the expected return on all securities is the risk-free rate of interest, r . The reason is that risk-neutral investors do not require a premium to induce them to take risks. It is also true that the present value of any cash flow in a risk-neutral world can be obtained by discounting its expected value at the risk-free rate. The assumption that the world is risk-neutral, therefore, considerably simplifies the analysis of derivatives. (Hull 2003: 245.)

It is important to appreciate that risk-neutral valuation is merely an artificial device for obtaining solutions to the Black–Scholes–Merton differential equation. The solutions that are obtained are valid in all worlds, not just those where investors are risk neutral. When we move from a risk-neutral world to a risk-averse world, two things happen. The expected growth rate in the stock price and discount rate that must be used for any payoffs from the derivative changes. It happens that these two changes always offset each other exactly. (Hull 2003: 245.)

4.2.3. Black–Scholes pricing formulas

The Black–Scholes pricing formulas for a European call option and a European put option can be derived by solving the Black–Scholes–Merton differential equation (4.48) subject to the boundary conditions presented in the chapter 4.2.1.

The Black–Scholes formulas for the prices at time zero of a European call option on a non-dividend-paying stock and a European put option on a non-dividend-paying stock respectively are

$$(4.51) \quad c = S_0 N(d_1) - Ke^{-rT} N(d_2)$$

and

$$(4.52) \quad p = Ke^{-rT}N(-d_2) - S_0N(-d_1),$$

where

$$d_1 = \frac{\ln(S_0 / K) + (r + \sigma^2 / 2)T}{\sigma\sqrt{T}}$$

and

$$d_2 = \frac{\ln(S_0 / K) + (r - \sigma^2 / 2)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}.$$

The function $N(x)$ is the cumulative probability distribution for a standardized normal distribution. In other words, it is the probability that a variable with a standard normal distribution $\phi(0,1)$ will be less than x . The variables c and p are European call and European put price, S_0 is the stock price at time zero, K is the strike price, r is the continuously compounded risk-free rate, σ is the stock price volatility, and T is the time to maturity of the option. (Black et al. 1973: 644; Neftci 2000: 296–297.)

The equation (4.52) for the price of European put option can also be derived from the *put–call parity*. Put–call parity is a relationship between the price, c , of a European call option on a stock and the price, p , of a European put option on a stock. It shows that the value of a European call with a certain exercise price and exercise date can be deduced from the value of a European put with the same exercise price and exercise date, and vice versa. The put–call parity equation can be written

$$(4.53) \quad c + Ke^{-rT} = p + S_0,$$

where the parameters are the same as in the Black–Scholes pricing formula. (Cuthbertson et al. 2001: 194–195.)

Because the European price equals the American price when there are no dividends, equation (4.51) also gives the value of an American call option on a non-dividend-paying stock. Unfortunately, no exact analytic formula for the value of an American put option on a non-dividend-paying stock has been produced. (Hull 2003: 247.)

4.3. Binomial model

Another useful and very popular technique for pricing a stock option involves constructing a binomial tree. This diagram that represents different possible paths that might be followed by the stock price over the life of the option. This following approach was published in their well known seminar paper by Cox, Ross and Rubinstein in 1979.

4.3.1. One step binomial model

It is assumed that the stock price follows a multiplicative binomial process over discrete periods. The rate of return on the stock over each period can have two possible values: $u - 1$ with probability q , or $d - 1$ with probability $1 - q$. Thus, if the current stock price is S , the stock price at the end of the period will be either uS or dS . We can represent this movement with the following diagram:

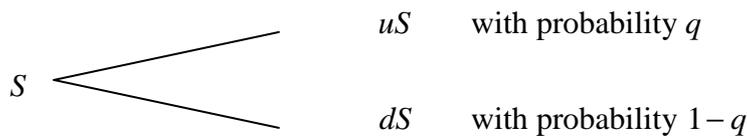


Figure 2. Asset price movement in the binomial model.

It is also assumed that the interest rate is constant. Individuals may borrow or lend as much as they wish at this rate. It is also continued to assume that there are no taxes, transaction costs, or margin requirements. Hence, individuals are allowed to sell short any security and receive full use of the proceeds.

Letter r donates one plus the riskless interest rate over one period, where we require $u > r > d$. If these inequalities did not hold, there would be profitable riskless arbitrage opportunities involving only the stock and riskless borrowing and lending.

The expiration date is just one period away. Let C be the current value of the call, C_u be its value at the end of the period if the stock price goes to uS and C_d be its value at the end of the period if the stock price goes to dS . Since there is now only one period re-

maintaining in the life of the call, we know that the terms of its contract and a rational exercise policy imply that $C_u = \max[0, uS - K]$ and $C_d = \max[0, dS - K]$. Therefore,

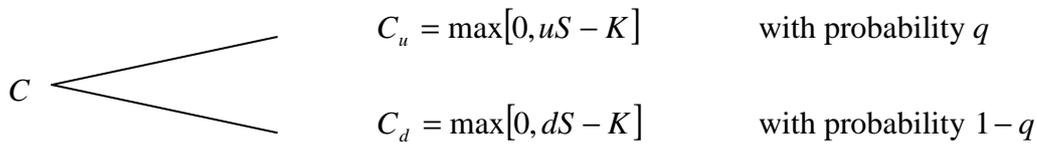


Figure 3. Option price movement in the binomial model.

Suppose we form a portfolio containing Δ shares of stock and the dollar amount B in riskless bonds. This will cost $\Delta S + B$. At the end of the period, the value of this portfolio will be

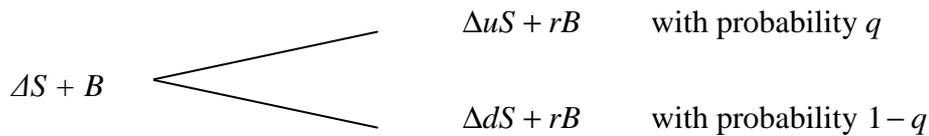


Figure 4. Change on portfolio value in the binomial model.

Since we can select Δ and B in any way we wish, suppose we choose them to equate the end-of-period values of the portfolio and the call for each possible outcome. This requires that

$$(4.54) \quad \Delta uS + rB = C_u$$

and

$$(4.55) \quad \Delta dS + rB = C_d.$$

Solving these equations, we find

$$(4.56) \quad \Delta = \frac{C_u - C_d}{(u - d)S}$$

and

$$(4.57) \quad B = \frac{uC_d - dC_u}{(u-d)r}.$$

With Δ and B chosen in this way, we will call this the hedging portfolio.

If there are to be no riskless arbitrage opportunities, the current value of the call, C , cannot be less than the current value of the hedging portfolio, $\Delta S + B$. If it were, we could make a riskless profit with no net investment by buying the call and selling the portfolio. It cannot also be worth more, since then we would have a riskless arbitrage opportunity by reversing our procedure and selling the call and buying the portfolio.

Suppose that $\Delta S + B < S - K$. If we try to make an arbitrage profit by selling calls for more than $\Delta S + B$, but less than $S - K$, then we will find that we are the source of arbitrage profits rather than the recipient.

Summing up all of this, we conclude that if there are to be no riskless arbitrage opportunities, it must be true that

$$(4.58) \quad \begin{aligned} C &= \Delta S + B \\ &= \frac{C_u - C_d}{u-d} + \frac{uC_d - dC_u}{(u-d)r} \\ &= \left[\left(\frac{r-d}{u-d} \right) C_u + \left(\frac{u-r}{u-d} \right) C_d \right] / r \end{aligned}$$

if this value is greater than $S - K$, and if not, $C = S - K$.

Equation (4.58) can be simplified by defining

$$p \equiv \frac{r-d}{u-d} \quad \text{and} \quad 1-p \equiv \frac{u-r}{u-d},$$

so that we can write

$$(4.59) \quad C = [pC_u + (1-p)C_d] / r.$$

It is easy to see that in the present case, with no dividends, this will always be greater than $S - K$ as long as the interest rate is positive. Hence, (4.59) is the exact formula for the value of a call one period prior to the expiration in terms of S , K , u , d , and r .

4.3.2. Matching volatility with u and d

In practice, when constructing a binomial tree to represent the movements in a stock price, we choose the parameters u and d match the volatility of the stock price. To see how this is done, we suppose that the expected return on a stock is μ and its volatility is σ . The step is of length δt . The stock price either moves up by a proportional amount u or moves down by a proportional amount d . The probability of an up movement is assumed to be q . (Cuthbertson et al. 2001: 212.)

The expected stock price at the end of the first time step is $S_0 e^{\mu \delta t}$. On the tree the expected stock price at this time is

$$(4.60) \quad qS_0u + (1-q)S_0d .$$

In order to match the expected return on the stock with the tree's parameters, we must therefore have

$$(4.61) \quad qS_0u + (1-q)S_0d = S_0 e^{\mu \delta t} ,$$

or

$$(4.62) \quad q = \frac{e^{\mu \delta t} - d}{u - d} .$$

The volatility σ of a stock price is defined so that $\sigma \sqrt{\delta t}$ is the standard deviation of the return on the stock price in a short period of time of length δt . Equivalently, the variance of the return is $\sigma^2 \delta t$. Therefore, the variance of the stock price return can be written as

$$(4.63) \quad qu^2 + (1-q)d^2 - [qu + (1-q)d]^2 .$$

In order to match the stock price volatility with the tree's parameters, we must therefore have

$$(4.64) \quad qu^2 + (1-q)d^2 - [qu + (1-q)d]^2 = \sigma^2 \delta t.$$

Substituting from equation (4.62) into equation (4.64), we get

$$(4.65) \quad e^{\mu\delta t}(u+d) - ud - e^{2\mu\delta t} = \sigma^2 \delta t.$$

When terms in δt^2 and higher power of δt are ignored, one solution to this equation is

$$(4.66) \quad u = e^{\sigma\sqrt{\delta t}},$$

and

$$(4.67) \quad d = e^{-\sigma\sqrt{\delta t}}.$$

These are the values of u and d proposed by Cox, Ross, and Rubinstein (1979) for matching u and d .

4.4. Volatility

Volatility most frequently refers to the standard deviation of the change in value of a financial instrument with a specific time horizon. It is often used to quantify the risk of the instrument over that time period. The volatility of a stock is caused solely by the random arrival of new information about the future returns from the stock and by trading.

For a financial instrument whose price follows a Wiener process, the volatility increases by the square-root of time as time increases. Conceptually, this is because there is an increasing probability that the instrument's price will be farther away from the initial price as time increases. More broadly, volatility refers to the degree of (typically short-term) unpredictable change over time of a certain variable. It may be measured via the standard deviation of a sample, as mentioned above. However, price changes actually do not follow Gaussian distributions. Better distributions used to describe them actually have "fat tails" although their variance remains finite. Therefore, other metrics may be

used to describe the degree of spread of the variable. As such, volatility reflects the degree of risk faced by someone with exposure to that variable. (Hull 2003: 238–240.)

Volatility is essence in option pricing, but why is it so important to an option trader? The option trader, like the futures trader, is interested in the direction of the market. Unlike the futures trader, the option trader is also extremely sensitive to the speed of the market. If the market for a commodity fails to move at a sufficient speed, options on that commodity will have less value because of the reduced likelihood of the market going through an option's exercise price. In a sense, volatility is a measure of the speed of the market. Markets which move slowly are low volatility markets; markets which move quickly are high volatility markets. (Natenberg 1988: 59.)

4.4.1. Implied volatility

Historical volatility is the volatility of a financial instrument based on historical returns. This phrase is used particularly when it is wished to distinguish between the actual volatility of an instrument in the past, and the current volatility implied by the market. The *implied volatility* of a financial instrument is the volatility implied by the market price of a derivative based on a theoretical pricing model. Interestingly the implied volatility of options rarely corresponds to the historical volatility (i.e. the volatility of a historical time series). This is because implied volatility includes future expectations of price movement, which are not reflected in historical volatility.

The option prices obtained from the Black–Scholes pricing framework are functions of five parameters: asset price S , strike price K , interest rate r , time to expiry t , and volatility σ . Except for the volatility parameter, the other four parameters are observable quantities. The difficulties of setting volatility value in the valuation formulas lie in the fact that the model should be the forecast of value over the remaining life of the option rather than an estimate value from the past market data of the asset price. Instead of computing the option price given the volatility value using the Black–Scholes formula, we solve for the volatility value from the observed market option price. The volatility value implied by an observed option price is called the implied volatility, which indicates a consensual view about the volatility level determined by the market. (Kwok 1998: 62.)

Option prices reflect the market's belief about the distribution of the underlying asset's future value. Given rational expectations, the market uses all the information available to form its expectations about future volatility. The market's estimate reflected in option prices, the implied volatility, is the best possible forecast given the currently available information. That is, all information necessary to explain future realized volatility should be subsumed in the implied volatility. (Hansen 2001: 197.)

The hypothesis that implied volatility is an efficient forecast of subsequently realized volatility has been tested in numerous papers. The conclusions are mixed. Some of the first papers in this area, for example Latané and Rendleman (1976) and Chiras and Manaster (1978), concluded that implied volatility is a more accurate predictor than historical volatility measures. They regressed future volatility on the implied volatility across a broad sample of Chicago Board Options Exchange (CBOE) stocks. Jorion (1995) examined currency options and concluded that implied volatility is an efficient estimator of future return volatility in the foreign exchange market.

4.4.2. New information and implied volatility

In this paper is concentrated on 'scheduled news', for which the disclosure date is known in advance, but the information contest is not. In the Black–Scholes (1973) pricing model for European type options, it is assumed that the volatility of the underlying stock is constant over time. However, if volatility is a deterministic function of time, Merton (1973) shows that the Black–Scholes formula still holds if we replace the volatility by the average volatility until expiration. Daily stock price returns are random variables that might be independently and identically distributed on normal days. During scheduled news announcement days, however, a higher volatility is expected. If volatility on a normal day is σ_{normal}^2 and on unexpected news announcement day is equal to σ_{high}^2 , then average volatility AV_x over the remaining life of the option if the announcement has not occurred yet is defined as

$$(4.68) \quad AV_x = \sqrt{\frac{(x-1)}{x} \sigma_{normal}^2 + \frac{1}{x} \sigma_{high}^2},$$

where x is the number of days until the expiration date of the option. After the news announcement day, the average volatility drops to σ_{normal}^2 (assuming there are no other scheduled information releases before expiration). With this simple model of implied

volatility, as a function of the time until and after the expected news announcement, can be described by the function depicted in figure 5. (Donders et al. 1996: 1449–1450.)

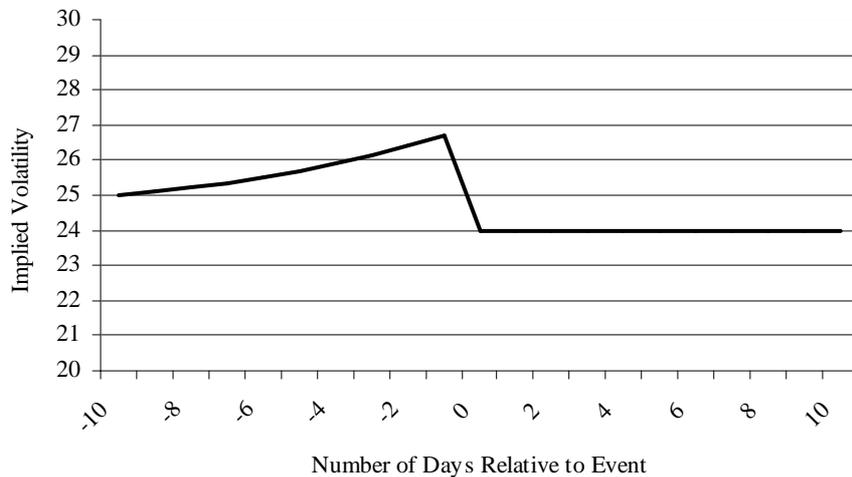


Figure 5. Implied volatility evolvment around scheduled macroeconomic announcement. (Donders et al. 1996: 1450.)

Volatility increases gradually prior to the scheduled announcement and drops after the announcement has been made and the information has been incorporated into the stock prices. It is assumed that the volatility will be constant on nonannouncement days and twice as much as normal on the scheduled announcement day. (Nikkinen et al. 2004: 205.)

Both, the mathematical and the graphical proposal of the behavior of implied volatility around scheduled news announcements are in consensus with the hypothesis that are made earlier in chapter 1.2.

5. DATA AND METHODOLOGY

Scheduled macroeconomic announcements stand out from the steady flow of information, which hits the financial market. Every month, a variety of fundamental macroeconomic releases, such as industrial production, inflation, employment situation etc. are released providing new information concerning the state of the economy. Majority of financial market participants believe that these macroeconomic news announcements have a strong impact on pricing financial assets and thus closely follow the information content of these releases. Previous literature confirms that information arrivals have significant impact on asset pricing and volatility. (See e.g. Ederington et al. (1993); Nikkinen et al. (2001).)

In practice, it is not surprising to observe financial markets responding to news about key indicators of the economic activity. These fundamental macroeconomic news announcements contain information on the overall health of the economy for previous observation period and thus provide important information for investors. Typical for scheduled macroeconomic news announcements is that the timing of the release is known beforehand, but the content of the release is not.

5.1. Data description

This study covers the period May 3rd 2003 through January 25th 2006. The research data includes exactly 752 trading days. The data sample used in the empirical investigation consists of seven major U.S. macroeconomic releases, Federal Open Market Committee releases, and daily closing values of firm-specific option volatilities on Eurex option market. The timing of the U.S. macroeconomic news releases has been collected from Yahoo! website's Economic Calendar. Federal Open Market Committee (FOMC) meetings dates have been obtained from the Federal Reserve's website. Daily closing values for each companies implied volatility in the Eurex futures and options exchange has been obtained from the Datastream-database of the University of Vaasa. Datastream has been used for the source of information, since it is widely recognized as the number one historical financial information provider, offering the highest quality and most comprehensive coverage in the world. Key data sets from both developed and emerging markets - equities, market indices, company accounts, macroeconomics, bonds, foreign exchange, interest rates, commodities and derivatives.

Eurex is the world's leading futures and options exchange and is jointly operated by Deutsche Börse AG and SWX Swiss Exchange. Eurex offers a broad range of international benchmark products and operates the most liquid fixed income markets in the world, featuring open, equal, and low-cost electronic access. With market participants connected from 700 locations worldwide, trading volume at Eurex exceeds 1 billion contracts a year by far. Therefore, Eurex is the market place of choice for the derivatives community worldwide and also one of the focuses of this study. (<http://www.eurexchange.com>.)

5.1.1. Macroeconomic announcements

The sample of scheduled macroeconomic news releases investigated is largely based on the previous literature and on the Bureau of Labor Statistics (BLS) classifications of major economic indicators. Thus, they are selected because of their anticipated importance. This sample consists of the U.S. macroeconomic news releases covering the period between May 2003 and January 2006.

Table 2. Macroeconomic news reports.

Report	Issued	Issuing Office	# of releases
Employment Report	Monthly	Bureau of Labor Statistics	35
Producer Price Index	Monthly	Bureau of Labor statistics	35
Consumer Price Index	Monthly	Bureau of Labor statistics	35
NAPM Manufacturing	Monthly	National Association of Purchasing Management	35
Import and Export Price Indices	Monthly	Bureau of Labor statistics	35
Retail Sales	Monthly	Bureau of the Census	35
Employment Cost In- dex	Quarterly	Bureau of Labor statistics	11
FOMC	Randomly	Federal Reserve	23

In addition to the macroeconomics news announcements, meeting days of the authorities conducting monetary policy in the U.S. are used in the study. The sample therefore includes 23 Federal Open Market Committee (FOMC) meeting days for the US market.

All the reports, the issuing authorities of the information releases, and number of announcements contained in the sample are presented in Table 2.

On the US market, all news announcements are made at 8:30 a.m. Eastern Time (ET), which corresponds to 2:30 p.m. in Germany (GMT +1 h). At the time of news releases the NYSE is not open, whereas the trading hours on the German stock market are 8:00 a.m. to 7:00 p.m. Since releases are made during the trading hours of the Eurex option market, the impact of the releases is incorporated into the closing prices of stocks and their implied volatilities used in the empirical analysis. The FOMC meetings are usually held on Tuesdays and the FOMC issues a statement shortly after the meeting. However, the statement is issued when the European stock markets are not open. Consequently, uncertainty related to the meeting is resolved on the European stock markets on the following day. (See e.g. Nikkinen et al. 2003: 206.)

The Employment Report

The employment report is actually two separate reports which are the results of two separate surveys. The household survey is a survey of roughly 60,000 households. This survey produces the unemployment rate. The establishment survey is a survey of 375,000 businesses. This survey produces the nonfarm payrolls, average workweek, and average hourly earnings figures, to name a few. Both surveys cover the payroll period which includes the 12th of each month.

The reports both measure employment levels, just from different angles. Due to the vastly different size of the survey samples (the establishment survey not only surveys more businesses, but each business employs many individuals), the measures of employment may differ markedly from month to month. The household survey is used only for the unemployment measure - the market focuses primarily on the more comprehensive establishment survey. Together, these two surveys make up the employment report, the most timely and broad indicator of economic activity released each month.

Total payrolls are broken down into sectors such as manufacturing, mining, construction, services, and government. The markets follow these components closely as indicators of the trends in sectors of the economy; the manufacturing sector is watched the most closely as it often leads the business cycle. The data also include breakdowns of hours worked, overtime, and average hourly earnings.

The average workweek (also known as hours worked) is important for two reasons. First, it is a critical determinant of such monthly indicators as industrial production and personal income. Second, it is considered a useful indicator of labor market conditions: a rising workweek early in the business cycle may be the first indication that employers are preparing to boost their payrolls, while late in the cycle a rising workweek may indicate that employers are having difficulty finding qualified applicants for open positions. Average earnings are closely followed as an indicator of potential inflation. Like the price of any good or service, the price of labor reacts to an overly accommodative monetary policy. If the price of labor is rising sharply, it may be an indication that too much money is chasing too few goods, or in this case employees. (<http://biz.yahoo.com>.)

Consumer Price Index

The Consumer Price Index is a measure of the price level of a fixed market basket of goods and services purchased by consumers. CPI is the most widely cited inflation indicator, and it is used to calculate cost of living adjustments for government programs. It has been criticized for overstating inflation, because it does not adjust for substitution effects and because the fixed basket does not reflect price changes in new technology goods which are often declining in price. Despite these criticisms, it remains the benchmark inflation index.

CPI can be greatly influenced in any given month by a movement in volatile food and energy prices. Therefore, it is important to look at CPI excluding food and energy, commonly called the "core rate" of inflation. Within the core rate, some of the more volatile and closely watched components are apparel, tobacco, airfares, and new cars. In addition to tracking the month/month changes in core CPI, the year/year change in core CPI is seen by most economists as the best measure of the underlying inflation rate. (<http://biz.yahoo.com>.)

Retail Sales

The retail sales report is a measure of the total receipts of retail stores. The changes in retail sales are widely followed as the most timely indicator of broad consumer spending patterns. Retail sales are often viewed ex-autos, as auto sales can move sharply from month-to-month. It is also important to keep an eye on the gas and food components, where changes in sales are often a result of price changes rather than shifting consumer demand.

Retail sales can be quite volatile and the advance reports are subject to rather large revisions. Retail sales do not include spending on services, which makes up over half of total consumption. Total personal consumption is not available until the personal income and consumption reports are released, typically two weeks after retail sales. (<http://biz.yahoo.com>.)

Producer Price Index

The Producer Price Index measures prices of goods at the wholesale level. There are three broad subcategories within PPI: crude, intermediate, and finished. The market tracks the finished goods index most closely, as it represents prices for goods that are ready for sale to the end user. Goods prices at the crude and intermediate stages of production often provide an indication of coming (dis)inflationary pressures, but the closer you get to crude goods, the more that these prices track commodity prices which are already available in traded indexes such as the CRB (Commodity Research Bureau).

At all stages of production, the market places more emphasis on the index excluding food and energy, referred to as the core rate. Food and energy prices tend to be quite volatile and obscure trends in the underlying inflation rate. Though the market reaction is determined by the month/month changes, year/year changes are also noted by analysts. The index is not revised on a monthly basis, but annual revisions to seasonal adjustment factors can produce small adjustments to past releases. (<http://biz.yahoo.com>.)

International Trade

The trade report is most widely watched for trends in the overall trade balance. But trends in both exports and imports of goods and services bear watching as well. The export data in particular are important to watch for indications that a strengthening competitive position at home and/or strengthening economies overseas are boosting U.S. growth. Imports provide an indication of domestic demand, but given the severe lag of this report relative to other consumption indicators, it is not particularly valuable for this purpose.

The volatility in the monthly trade balance can play an important role in GDP forecasts. Net exports are a relatively volatile component of GDP, and the trade report provides the only early clues to the net export performance each quarter. (<http://biz.yahoo.com>.)

NAPM Manufacturing

The NAPM Manufacturing (National Association of Purchasing Management), is a measure of the health of the manufacturing sector, and more generally the overall economy, calculated by surveying purchasing managers for data about new orders, production, employment, deliveries, and inventory, in descending order of importance. It is based on a survey of over 250 companies within twenty-one industries covering all 50 states, and it is released on the first business day of the month at 10 am EST and reflects the previous month's data. A reading over 50% indicates that manufacturing is growing, while a reading below 50% means it is shrinking. The NAPM index is also thought to be an early indicator of inflationary pressures. (<http://biz.yahoo.com>.)

Employment Cost Index

The U.S. Department of Labor's quarterly Employment Cost Index measures the rate of change in employee compensation. Like the average hourly earnings data, it allows economists to keep a beat on wage inflation, which is often seen as a catalyst to overall inflation.

The Employment Cost Index (ECI) depicts both wage and total compensation costs. It has been monitored closely by the financial markets since being mentioned by Fed Chairman Alan Greenspan in July 1996. The release comes near the end of the first month of each quarter, providing results from the prior quarter. Wages aren't the only cost paid by businesses for labor; compensation costs, such as insurance, also need to be factored into the cost of labor.

Wages may increase without raising overall employment costs if benefit costs are being reduced. Likewise, declining wages may not reduce employer costs when benefit costs are escalating.

Because both wage and benefit costs are taken into account in the ECI measure, it is seen as a superior wage cost indicator. Its major flaw is timeliness, since it is released quarterly. The ECI does allow analysts to better evaluate whether employment costs are igniting inflationary pressures, thereby serving as a complement to more timely wage indicators. (<http://www.businessweek.com>.)

Federal Open Market Committee

The term "monetary policy" refers to the actions undertaken by a central bank, such as the Federal Reserve, to influence the availability and cost of money and credit to help promote national economic goals. The Federal Reserve Act of 1913 gave the Federal Reserve responsibility for setting monetary policy in the U.S.

The Federal Reserve controls the three tools of monetary policy: open market operations, the discount rate, and reserve requirements. The Board of Governors of the Federal Reserve System is responsible for the discount rate and reserve requirements, and the Federal Open Market Committee is responsible for open market operations. Using the three tools, the Federal Reserve influences the demand for, and supply of, balances that depository institutions hold at Federal Reserve Banks and in this way alters the federal funds rate. The federal funds rate is the interest rate at which depository institutions lend balances at the Federal Reserve to other depository institutions overnight.

Changes in the federal funds rate trigger a chain of events that affect other short-term interest rates, foreign exchange rates, long-term interest rates, the amount of money and credit, and, ultimately, a range of economic variables, including employment, output, and prices of goods and services.

The FOMC holds eight regularly scheduled meetings per year. At these meetings, the Committee reviews economic and financial conditions, determines the appropriate stance of monetary policy, and assesses the risks to its long-run goals of price stability and sustainable economic growth. (<http://www.federalreserve.gov/FOMC/>.)

5.1.2. Calculation of implied volatility

Calculating an option's implied volatility is somewhat complicated process that uses option pricing models to assume the future price movement of the underlying instrument. Instead of inputting volatility into an option model to determine an option's fair value, the calculation can be rotated, where the actual current option price is the input and the volatility is the output. Unfortunately, the Black–Scholes option pricing formula cannot be inverted analytically to solve for implied volatility. Nonetheless, the formula can be quickly solved with numerical techniques to obtain a good approximation. A Newton–Rhapson search, conveniently finds the implied volatility by converting a close

approximation of the volatility to the true market price of the option. (Cox and Rubinstein 1985: 278.)

The popularity of the Newton–Rhapson method is due to its efficiency in finding the implied volatility. It produces a result quickly as it converges to the implied volatility usually in no more than three iterations. The Newton–Rhapson iterative scheme is given by

$$(5.1) \quad \sigma_{i+1} = \sigma_i - \frac{c(\sigma_i) - c_m}{\frac{\partial c}{\partial \sigma_i}},$$

where σ_{i+1} is the implied volatility of an option, c_m is the market price of an option, $c(\sigma_i)$ is the theoretical option price with volatility σ_i , and $\frac{\partial c}{\partial \sigma_i}$ the vega of an option evaluated at σ_i . The iteration procedure is then continued until the desired degree of accuracy in the difference between $c(\sigma_i)$ and c_m is reached. (Kwok 1998: 62–64.)

5.1.3. Market portfolio companies

Eight most liquid firms, excluding banks, from the EUREX option market are chosen to represent the market portfolio. According to the monthly stats of February 2006, the eight most liquid firms, excluding banks, of the EUREX are BASF, Daimler–Chrysler, E. ON, Nokia, RWE, SAP, Siemens, and Total. The portfolio is equally weighted. This means that the sizes of the companies nor the trading volumes have not been taking into account. Table 3 provides descriptive statistics of implied volatilities for the market portfolio covering the period between March 2003 and January 2006. In addition to this, figure 6 illustrates the behavior of the implied volatility of the market portfolio for the same time period.

BASF

In its five business segments, Chemicals, Plastics, Performance Products, Agricultural Products & Nutrition, and Oil & Gas, BASF posted sales of €42.7 billion in 2005. BASF’s strategic goal is to continue to grow profitably. Around 94,000 employees on five continents are the key to BASF’s success. (<http://www.basf.com>.)

Table 3. Descriptive statistics of the market portfolio's implied volatility from March 2003 to January 2006.

Statistics	Level	Change
Mean	0.25	0.00
Median	0.23	0.00
Maximum	0.91	1.24
Minimum	0.08	-1.25
Std. Dev.	0.09	0.07
Skewness	1.29	2.46
Kurtosis	5.00	87.43
Observations	6016	6016

Notes: Change: $\ln\left(\frac{\sigma_t}{\sigma_{t-1}}\right)$, where σ_t is implied volatility at day t .

DaimlerChrysler

DaimlerChrysler was created in November 1998 through the merger of Daimler-Benz AG and Chrysler Corporation. The Group can look back on a tradition that stretches back over more than a hundred years and its market by the pioneering achievements of both predecessor companies. Today, DaimlerChrysler is a leading supplier of superior passenger cars, SUVs, sports tourers, minivans and pickups, as well as the world's largest manufacturer of commercial vehicles. (<http://www.daimlerchrysler.com>.)

E.ON

E.ON is on track to becoming the world's leading power and gas company. With annual sales of more than EUR56 billion and around 80,000 employees, E.ON is already the world's largest investor-owned energy service provider. (<http://www.eon.com>.)

Nokia

Nokia is the world's largest manufacturer of mobile devices; a leader in equipment, services and solutions for network operators; and a driving force in bringing mobility to businesses. In 2005, Nokia's net sales totaled EUR 34.2 billion. The company has 15 manufacturing facilities in nine countries and research and development centers in 11

countries. At the end of 2005, Nokia employed approximately 58,900 people. Nokia is a broadly held company with listings on the Helsinki, Stockholm, Frankfurt and New York stock exchanges. (<http://www.nokia.com>.)

RWE

RWE Energy is the RWE Group's sales and grid company for Continental Europe. In a total of 12 regions, including six abroad, RWE Energy offers electricity, gas, water and related services from a one-stop shop. Customers include residential households, commercial operations, business and industrial customers as well as municipal and regional utilities. Supraregional electricity and gas grid operations as well as the storage of gas are handled by independent companies. Together with its subsidiaries and affiliates, RWE Energy supplies 15.8 million customers with electricity and 8.3 million customers with gas. In 2005, sales totaled 150.6 billion kilowatt-hours of electricity, 288.8 billion kilowatt-hours of gas and 109 million cubic meters of water. With its 37,598 employees, RWE Energy generated revenues of € 25.2 billion in 2005, which makes it one of the leading utility companies in Europe. (<http://www.rwe.com>.)

SAP

Founded in 1972 as Systems Applications and Products (SAP) in Data Processing, SAP is the recognized leader in providing collaborative business solutions for all types of industries and for every major market. Serving more than 36,200 customers worldwide, SAP is the world's largest business software company and the world's third-largest independent software provider overall. SAP has a rich history of innovation and growth that has made them a true industry leader. Today, SAP employs more than 38,400 people in more than 50 countries. (<http://www.sap.com>.)

Siemens

Siemens, headquartered in Berlin and Munich, is one of the world's largest electrical engineering and electronics companies. Siemens provides innovative technologies and comprehensive know-how to benefit customers in 190 countries. Founded more than 150 years ago, the company is active in the areas of Information and Communications, Automation and Control, Power, Transportation, Medical, and Lighting. (<http://www.siemens.com>.)

Total

Total is a multinational energy company committed to leveraging innovation and initiative to provide a sustainable response to humankind's energy requirements. The fourth largest publicly-traded integrated oil and gas company and a world-class chemicals manufacturer, Total operates in more than 130 countries and has over 95, 000 employees. (<http://www.total.com>.)

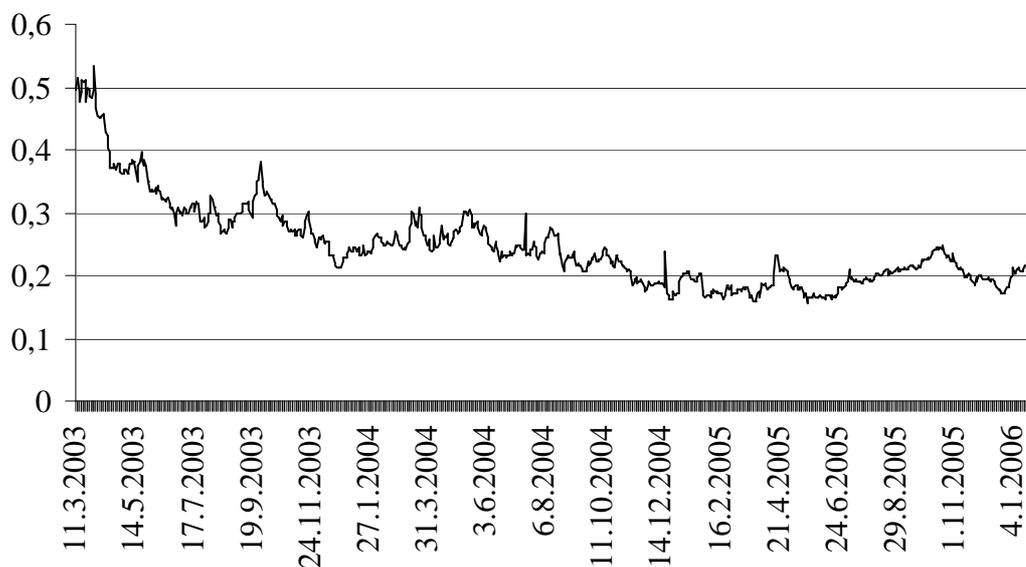


Figure 6. Behavior of the market portfolio's implied volatility from March 2003 to January 2006.

5.1.4. Bank portfolio companies

Much has changed in the banking landscape during the last couple decades. Significant increases in international capital flows among bank and non-bank entities, in addition to a broad range of specialized financial instruments mean banks can no longer be considered the only source of transaction accounts. Except for their access to the Federal Reserve discount window, banks are no longer the dominant provider of liquidity for other financial industries. But banks remain the key access point to the dominant wholesale payments network, and they still provide federally insured checking and savings deposits. With the rise of new financial services, products, and techniques, moreover, banks

have expanded their role in providing liquidity in more indirect ways, for example, through securitization of loans and backup commitments to securitization vehicles and other capital-markets instruments. Even when banks may not be special or unique providers in a particular market, banks have proven themselves to be formidable competitors and innovators--which only reinforce banks' importance in the proper functioning of every economy's financial system. In short, the public's trust and confidence in banking continue to be vital to economy's financial well-being (<http://www.federalreserve.gov/>). Due to these special characteristics of the banking sector, it is reasonable to believe that it might response differently to the macroeconomic news announcements compared to the market reaction, which ultimately leads to the motivation of this study.

Table 4. Descriptive statistics of the bank portfolio's implied volatility from March 2003 to January 2006.

Statistics	Level	Change
Mean	0.24	0.00
Median	0.22	0.00
Maximum	0.81	1.10
Minimum	0.10	-0.62
Std. Dev.	0.09	0.06
Skewness	1.99	3.17
Kurtosis	9.03	60.34
Observations	5264	5264

Notes: Change: $\ln\left(\frac{\sigma_t}{\sigma_{t-1}}\right)$, where σ_t is implied volatility at day t .

Since the study uses a banking sector approach, a portfolio of seven banks from the EUREX option market are chosen to represent banking industry. These seven banks are Allianz, BNP Paribas, Credit Suisse, Credit Agricole, Deutsche Bank, Societe Generale, and UBS. Like in the case of the market portfolio, the bank portfolio is equally weighted as well. This means that the sizes of the companies nor the trading volumes have not been taking into account. Table 4 provides descriptive statistics of implied volatilities for the bank portfolio covering the period between March 2003 and January 2006. In addition to this, figure 7 illustrates the behavior of the implied volatility of the bank portfolio for the same time period.

Allianz

Allianz Group is one of the world's leading insurers and financial services providers. Founded in 1890 in Berlin, Allianz is now present in more than 70 countries with over 177,000 employees. At the top of the international group is the holding company, Allianz SE, with its head office in Munich. Allianz Group provides its more than 60 million customers worldwide with a comprehensive range of services in the areas of property and casualty insurance, life and health insurance, asset management and banking. In fiscal year 2005, Allianz's total revenues amounted to some 100.9 billion euros. At the end of 2005 Allianz Group had more than 1.26 trillion euros in assets under management. Of this, 743 billion euros were assets managed for third parties. (<http://www.allianz.com>.)

BNP Paribas

With a presence in more than 85 countries, including all the main international financial markets, BNP Paribas can boast one of the most extensive global banking networks. The mutually complementary nature of its commercial and financial activities also enables BNP Paribas to play an outstanding role in the provision of finance, investment banking, international private banking and asset management. BNP Paribas has 138,000 employees worldwide including 51,600 in Europe - among whom 20,400 in Italy, 56,100 in France and in the Overseas Departments, 15,100 in North America and 5,200 in Asia. (<http://www.bnpparibas.com>.)

Crédit Agricole

Crédit Agricole is the largest high-street banking group in France, with 41 Regional Banks all strongly anchored in their respective geographical areas. With the acquisition of Crédit Lyonnais (now LCL) in 2003, the Group strengthened its positions in all its business lines. Its key qualities are a mutual banking group, high-street presence, and global reach. (<http://www.credit-agricole.fr>.)

Credit Suisse

Credit Suisse is a world-leading financial services company, advising clients in all aspects of finance, around the world, around the clock. Credit Suisse's core business

areas are in investment banking, private banking and asset management. (<http://www.credit-suisse.com>.)

Deutsche Bank

Founded in Berlin in 1870 to support the internationalization of business and to promote and facilitate trade relations between Germany, other European countries, and overseas markets, Deutsche Bank has developed into a leading global provider of financial services. Today Deutsche Bank is a leading global investment bank with a strong and profitable private clients franchise. Deutsche Bank comprises three Group Divisions: Corporate and Investment Bank (CIB), Private Clients and Asset Management (PCAM), and Corporate Investments (CI). Deutsche Bank has € 1,07 billion in assets. It has Unparalleled financial services in 73 countries and 67,474 employees from 130 nations. A leader in Germany and Europe, Deutsche Bank is continuously growing in North America, Asia, and key emerging markets. (<http://www.deutsche-bank.com>.)

Société Générale

Société Générale Group is the 7th largest French company by market capitalization and one of the leading financial services groups in the Euro zone. It employs over 103,000 people worldwide. Its business mix is structured around three core businesses: Retail Banking & Financial Services; Global Investment Management & Services and Corporate and Investment Banking. (<http://www.socgen.com>.)

UBS

UBS is the world's largest wealth manager, a top tier investment banking and securities firm, and one of the largest global asset managers. In Switzerland, UBS is the market leader in retail and commercial banking. Headquartered in Zurich and Basel, UBS is present in all major financial centers worldwide. UBS's financial businesses employ over 75,000 people worldwide. (<http://www.ubs.com>.)

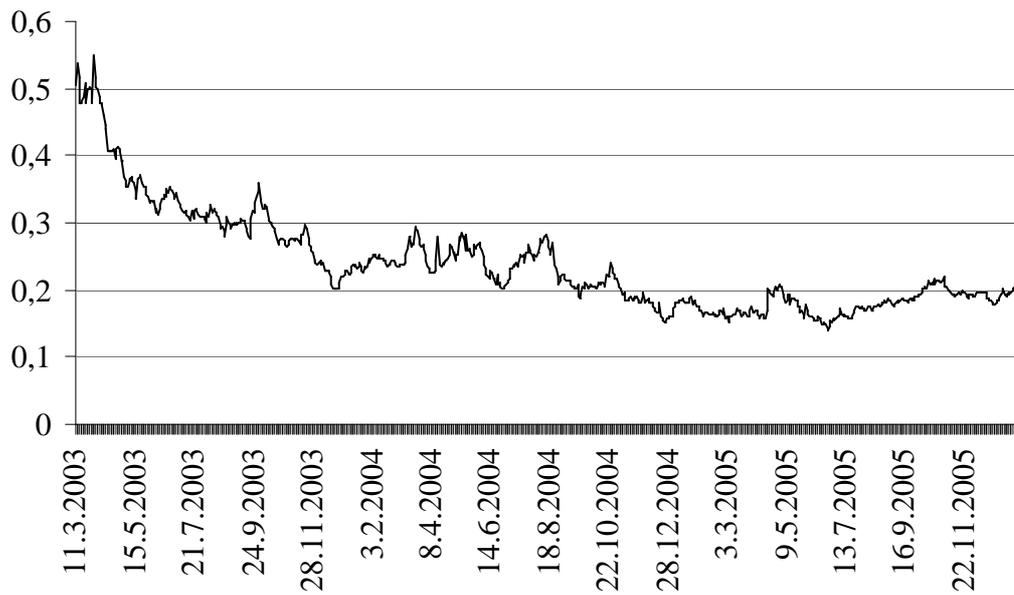


Figure 7. Behavior of the bank portfolio's implied volatility from March 2003 to January 2006.

5.2. Research methodology

In the literature, two different methodologies have been used when investigating the effects of scheduled news on implied volatility. The first is used by Donders et al. (1996) to investigate the impact of earnings announcements on implied volatility and the second one is first adopted by Ederington et al. (1996) to investigate the impact of macroeconomic news announcements. In this study the methodology of Ederington et al. (1996) is applied. The reason for this choice is that while earnings announcements occur on average every 3 months, there are several macroeconomic news announcements every month. Therefore, it is not possible to calculate a mean value for implied volatility not containing macroeconomic news announcements as required in the methodology of Donders et al. (1996).

Based on option pricing theory, implied volatility is hypothesized to gradually increase prior to the news announcements containing relevant information on underlying asset pricing. Moreover, the most important news has the greatest impact on implied volatility. After the news announcement implied volatility is hypothesized to revert to its nonannouncement day level. The following regression model is estimated to examine the impact of the macroeconomic news releases on implied volatility:

$$(5.2) \quad \ln\left(\frac{\sigma_t}{\sigma_{t-1}}\right) = \alpha + \sum_{i=1}^7 \beta_i D_{i,t}^{MacroNews} + \delta D_t^{FOMC} + \varepsilon_t,$$

where σ_t is the implied volatility value at day t and index i refers to a particular macroeconomic news announcement. The dummy $D_{i,t}^{MacroNews}$ has a value of one on a particular macroeconomic news announcement day and otherwise zero. D_t^{FOMC} is a similarly defined dummy variable for the Federal Open Market Committee (FOMC) announcements. It is included in the model since, as a scheduled announcement followed by market participants, it may have an effect on implied volatility as shown by Nikkinen et al. (2003). Based on the theory presented in the chapter 4.4.3, it is hypothesized that $\alpha > 0$, since on days with no scheduled news releases implied volatility is expected to increase.

A closer look at the data used in the study shows that significant first-order autocorrelation is present. Thus, an AR(1) term is added to the model. Moreover, the Lagrange Multiplier (LM) test for the ARCH indicates conditional heteroskedasticity in error terms. Therefore, GARCH (1) is fitted. The coefficients of the GARCH equation in the case of the bank portfolio are statistically significant and the LM test shows that the specification is adequate.

6. RESULTS

This study explores the impact of important U.S. macroeconomic and Federal Reserve's FOMC news announcements on the Eurex stock options' implied volatilities on industry level. To be more exact, the study takes a banking sector approach by constructing a banking sector portfolio and compares its implied volatility behavior to the market reaction. A regression framework is utilized in order to explore the impact of these scheduled announcements. The regression analysis results are obtained by using the EViews 5 Econometrics software package. The importance of each news announcement is determined by its impact on the change of the logarithmic return of both portfolios' implied volatility. Returns for each trading day are calculated by the following equation:

$$(6.1) \quad \ln\left(\frac{\sigma_t}{\sigma_{t-1}}\right).$$

Figures 8 and 9 reveal how these logarithmic returns for both portfolios have varied over the research period May 3rd 2003 through January 25th 2006.

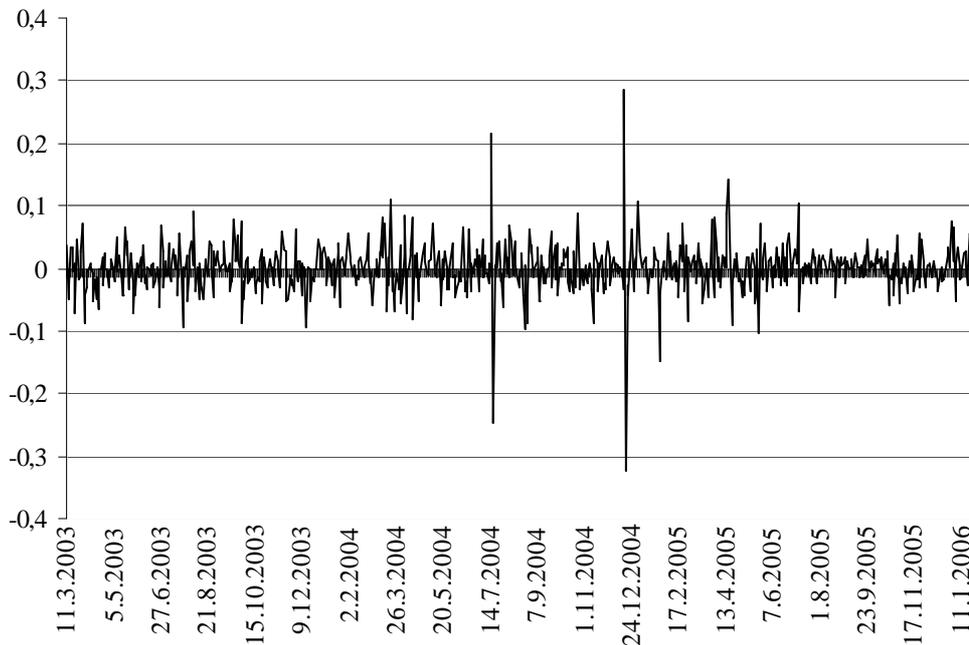


Figure 8. Logarithmic change in the market portfolio's implied volatility during the period May 3rd 2003 through January 25th 2006.

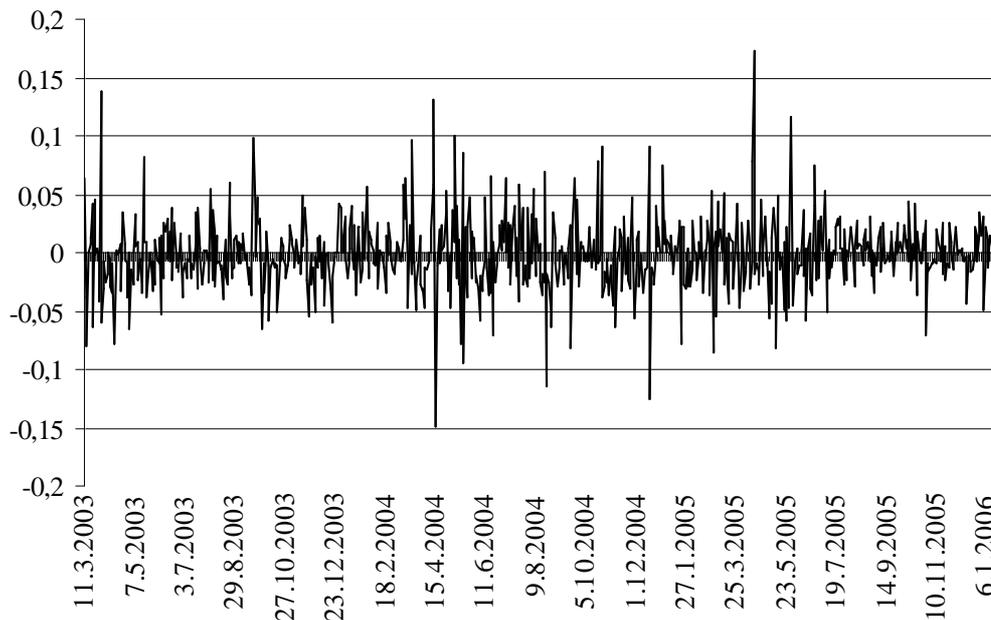


Figure 9. Logarithmic change in the bank portfolio's implied volatility during the period May 3rd 2003 through January 25th 2006.

The results of equation (5.2) are reported in the Tables 5 and 6 for the market portfolio and in the Tables 7 and 8 for the bank portfolio. The results of the regression suggest a differing impact of the announcements on stock valuation. In addition, different announcements seem to be relevant for different portfolios.

6.1. Market portfolio's volatility reaction

Previous literature on volatility reactions generally suggests that implied volatility tends to increase on days with no important news announcements. Following this, the first hypothesis of the study stated that the implied volatility of both portfolios will increase on days with no scheduled macroeconomic news releases. The intercept term, as shown in the Table 5, is positive but does not have any statistical significance. This suggests that the first hypothesis of this study does not hold in the case of the market portfolio, and therefore it is rejected.

For the market portfolio, two out of seven macroeconomic announcements exert a significant influence in stock valuation. These two macroeconomic news releases are found to be of importance in stock valuation, both having significant negative slope coefficients. Similarly, the coefficient of FOMC is negative and significant with a 1 percent level.

The significance level indicates the relative importance of the associated variable. The results from the regression analysis for the market portfolio indicate that the Consumer Price Index and FOMC exert the greatest impact on stock valuation (significance at 1 percent level). Furthermore, the results suggest that the Import and Export Price Indexes has a significant effect on implied volatility at the 5 percent significance level.

Table 5. Regression results of the market portfolio.

Coefficient	Estimate	Prob. of t-stat.
Intercept: No Releases	0.0008	0.357
NAPM: Manufacturing	0.0000	0.993
Employment Report	0.0120	0.000
Consumer Price Index	-0.0207	0.003
Producer Price Index	0.0007	0.894
Retail Sales	0.0037	0.208
Import and Export Price Indexes	-0.0088	0.016
Employment Cost Index	0.0021	0.731
FOMC	-0.0120	0.000
AR(1)	-0.2085	0.000
ARCH(1)	0.4823	0.000
GARCH(1)	-0.0093	0.271
Number of observations	6016	
Ajd. R-squared	0.048	
F-statistics	34.505	
Prob. of F-stat.	0.000	

The NAPM Manufacturing, the Employment Report, the Producer Price Index, Retail Sales, and the Employment Cost Index do not appear to have any statistically significant influence on the market portfolio's implied volatility. In other words, the information

content of these news releases does not cause a decrease in implied volatility after the release. This may be surprising given that the information content of these variables reveals important details of the U.S. economy. Following Graham et al. (2003), the reason why these releases do not have statistically significant impact on volatility might be the fact that market participants have already drawn informed inferences regarding these news releases as a result of previous macroeconomic news releases during the same month. Hence, it may be the case that some crucial elements of the information releases may have already been reflected in stock valuation.

First order autocorrelation can be observed by looking at the slope coefficient of the AR(1) term in the regression result table. Table 5 reveals that the market portfolio's implied volatility is negatively autocorrelated (-20.9 percent) over the research period. This finding is statistically significant at 1 percent level.

Table 6. Regression results of the market portfolio without the autocorrelation terms.

Coefficient	Estimate	Prob. of t-stat.
Intercept: No Releases	0.0004	0.665
NAPM: Manufacturing	0.0015	0.602
Employment Report	0.0131	0.000
Consumer Price Index	-0.0184	0.017
Producer Price Index	0.0047	0.425
Retail Sales	0.0012	0.667
Import and Export Price Indices	-0.0076	0.035
Employment Cost Index	0.0043	0.485
FOMC	-0.0098	0.004
Number of observations	6016	
Ajd. R-squared	0.005	
F-statistics	4.668	
Prob. of F-stat.	0.000	

Table 6 provides regression results for the market portfolio without the autocorrelation terms AR(1), ARCH(1), and GARCH(1). The Newey–West test has been added to the regression model. The results are consistent with the results reported in the Table 5, and confirm the earlier findings. The Consumer Price Index, the Import and Export Price

Indexes, and the FOMC have statistical significance in stock valuation, whereas the rest of the news announcements do not appear to have any statistically significant influence on the market portfolio's implied volatility.

6.2. Bank portfolio's volatility reaction

In the case of the bank portfolio, as shown in the Table 7, from the seven macroeconomic news announcements only NAPM Manufacturing exerts a significant influence on stock valuation with a negative slope coefficient (significance at 1 percent level). Similarly, the coefficient of FOMC is negative and significant with a 1 percent level. All the other six macroeconomic releases, the Employment Report, the Consumer Price Index, the Producer Price Index, Retail Sales, Import and Export Price Indexes, and the Employment Cost Index, do not appear to exert any measurable influence in stock valuation. This can be explained by the fact that market participants have already drawn informed inference from the earlier information, like in the case of the market portfolio. In addition, the intercept term of the bank portfolio is positive but does not have any statistical significance. This suggests that the first hypothesis of this study does not hold in the case of the bank portfolio as well, and therefore it is rejected.

However, the results of the bank portfolio vary significantly from the market reaction. The two portfolios seem to react with a significant level to different macroeconomic news announcements. Whereas the Consumer Price Index and the Import and Export Price Indexes have significance in the stock valuation of the market portfolio, only the NAPM Manufacturing exerts this level in the case of the bank portfolio. These findings are very interesting and crucial in the investment decision making. The differences between the behaviors of the implied volatilities of these two portfolios' can be explained with the banking sector's unique features as mentioned in the chapter 5.1.4. In addition, Federal Reserve's FOMC news announcements have significant influence on both portfolios' stock valuation.

Table 7 shows also that the bank portfolio's implied volatility is negatively autocorrelated (-19.7 percent) over the research period. This finding is statistically significant at 1 percent level.

Table 7. Regression results of the bank portfolio.

Coefficient	Estimate	Prob. of t-stat.
Intercept: No Releases	0.0005	0.553
NAPM: Manufacturing	-0.0080	0.002
Employment Report	0.0065	0.016
Consumer Price Index	-0.0055	0.282
Producer Price Index	-0.0032	0.368
Retail Sales	0.0029	0.456
Import and Export Price Indexes	-0.0019	0.609
Employment Cost Index	-0.0076	0.178
FOMC	-0.0065	0.067
AR(1)	-0.1974	0.000
ARCH(1)	0.1786	0.000
GARCH(1)	0.3112	0.000
Number of observations	5264	
Ajd. R-squared	0.039	
F-statistics	24.527	
Prob. of F-stat.	0.000	

Table 8 provides regression results for the bank portfolio without the autocorrelation terms AR(1), ARCH(1), and GARCH(1). The Newey–West test has been added to the regression model. The results are somewhat consistent with the results reported in the Table 7. The NAPM Manufacturing exerts the significance level, but the FOMC does not have significance influence in stock valuation. All the other six macroeconomic releases, the Employment Report, the Consumer Price Index, the Producer Price Index, Retail Sales, Import and Export Price Indexes, and the Employment Cost Index, do not appear to have any statistically significant influence on the bank portfolio’s implied volatility.

Table 8. Regression results of the bank portfolio without the autocorrelation terms.

Coefficient	Estimate	Prob. of t-stat.
Intercept: No Releases	-0.0002	0.805
NAPM: Manufacturing	-0.0042	0.093
Employment Report	0.0096	0.001
Consumer Price Index	-0.0035	0.545
Producer Price Index	0.0020	0.586
Retail Sales	0.0034	0.399
Import and Export Price In- dexes	-0.0015	0.684
Employment Cost Index	-0.0090	0.146
FOMC	-0.0043	0.240
Number of observations	5264	
Ajd. R-squared	0.001	
F-statistics	1.345	
Prob. of F-stat.	0.216	

7. SUMMARY AND CONCLUSIONS

This thesis investigates how scheduled macroeconomic news releases affect stock market uncertainty on industry level. More specifically, the study takes a banking sector approach to inspect whether banks react differently to new information compared to the entire market. The study focuses on seven U.S. macroeconomic and Federal Reserve's FOMC news announcements, which are selected based on the previous literature and the Bureau of Labor Statistics classifications of major economic indicators. Thus, they are selected because of their anticipated importance. The macroeconomic news releases are the NAPM: Manufacturing, the Employment Report, the Consumer Price Index, the Producer Price Index, the Retail Sales, the Import and Export Price Indexes, and the Employment Cost Index. Data from the Eurex option market covering the period between May 2003 and January 2006 are used in the analyses.

To examine the industry level reaction to important economic news announcements, two portfolios has been constructed, one representing the banking sector and the other the entire market. To assess the importance of scheduled U.S. macroeconomic news announcements, the behavior of both portfolios' implied volatilities are examined. A dummy regression framework has been used to reveal the outcomes of the study. The results convey that the banking sector reacts differently compared to the market reaction. Out of the seven macroeconomic news announcements the Consumer Price Index and the Import and Export Price Indexes seems to have statistical significance in the case of the market portfolio, whereas the bank portfolio reacts only to the NAPM: Manufacturing release with a statistical significance. In addition, Federal Reserve's FOMC news announcements have significant influence on both portfolios' stock valuation.

The empirical results of the study are somewhat in accordance with the theoretical hypothesis. The intercept terms (non-announcement days) observed in the both portfolios are positive, but they do not have any statistical influence to the stock valuation. Therefore, the first hypothesis, which states that both portfolios' implied volatility should increase on the days with no macroeconomic news announcement, is rejected. On the other hand, the second hypothesis, which claims that both portfolios' implied volatility should decrease on days with macroeconomic news announcements, is supported by the empirical results. The volatility of both portfolios' drops after important economic news announcements or the Federal Reserve's FOMC news announcements. Furthermore, the

banking sector seems to react to different macroeconomic news announcements compared to the market reaction.

In general, the results of this thesis show that the U.S. macroeconomic news announcements and FOMC releases have an important and significant role in financial asset pricing. Whereas the earlier studies of this field have been concentrated to index level investigations, these new findings concerning industry level behavior of implied volatilities adds a scientific contribution to this thesis.

REFERENCES

- Allianz (2006). [online] [cited 15 Dec 2006]. Available from Internet:
 <URL: <http://www.allianz.com/en/index.html>>
- Ball, R & P. Brown (1968). An empirical evaluation of accounting income numbers. *Journal of Accounting Research* 6, 159–178.
- Ball, R. (1978). Anomalies in relationships between securities' yields and yield-surrogates. *Journal of Financial Economics* 6, 103–126.
- Bamber, L. S. (1986). The information content of annual earnings releases: A trading volume approach. *Journal of Accounting Research* 24, 40–56.
- BASF (2006). [online] [cited 15 Dec 2006]. Available from Internet:
 <URL:http://www.corporate.basf.com/en/?id=V00-QbKNh9p9Fbcp._g>
- Black, F. & M. Scholes (1973). The pricing of option and corporate liabilities. *Journal of Political Economy* 81, 637–654.
- Black, F. (1975). Fact and fantasy in the use of options. *Financial Analysts Journal* 31: 36–41, 61–72.
- Blake, D. (2000). *Financial market analysis*, 2nd ed. Chichester: John Wiley & Sons, Inc.
- BNP Paribas (2006). [online] [cited 15 Dec 2006]. Available from Internet:
 <URL: <http://www.bnpparibas.com/>>
- Bodie, Z., A. Kane & A.J. Marcus (2002). *Investments*, 5th ed. New York: McGraw–Hill Inc.
- Business Week (2006). [online] [cited 15 Dec 2006]. Available from Internet:
 <URL: <http://www.businessweek.com/>>

- Chiras, D. P. & S. Manaster (1978). The information content of prices and a test of market efficiency. *Journal of Financial Economics* 6, 213-234.
- Christie-David, R., M. Chaudhry & T. W. Koch (2000). Do macroeconomic news releases affect gold and silver prices? *Journal of Economics and Business* 52, 405-421.
- Cox, J. C., S. A. Ross & M. Rubinstein (1979). Option pricing: A simplified approach. *Journal of Financial Economics*. 7: 3, 229-263.
- Cox, J. & M. Rubinstein (1985). *Option Markets*, 2nd ed. New Jersey: Prentice Hall Inc.
- Credit Agricole (2006). [online] [cited 15 Dec 2006]. Available from Internet:
<URL: <http://www.credit-agricole.fr/>>
- Credit Suisse (2006). [online] [cited 15 Dec 2006]. Available from Internet:
<URL: http://www.credit-suisse.com/country_selection/en/index.html>
- Cuthbertson, K. & D. Nitzsche (2001). *Financial Engineering: Derivatives and risk management*. Chichester: John Wiley & Sons, Inc.
- DaimlerChrysler (2006). [online] [cited 15 Dec 2006]. Available from Internet:
<URL: <http://www.daimlerchrysler.com/>>
- Datta, S. & U. S. Dhillon (1993). Bond and stock market response to unexpected earnings announcements, *Journal of Financial and Quantitative Analysis* 28, 565-577.
- Deutsche Bank (2006). [online] [cited 15 Dec 2006]. Available from Internet:
<URL: http://www.deutsche-bank.de/index_e.htm?ghpmeta=DEU_english>
- Dodd, P. (1981). The effect on market value of transactions in the market for corporate control. *Proceedings of Seminar on the Analysis of Security Prices, CRSP*. University of Chicago, Chicago.
- Donders, M. & T. Vorst (1996). The impact of firm specific news on implied volatilities. *Journal of Banking and Finance* 20, 1447-1461.

- Ederington, L. H. & J. H. Lee (1993). How market process information: News releases and volatility. *Journal of Finance* 48:4, 1161–1191.
- Ederington, L. H. & J. H. Lee (1995). The short–run dynamics of the price adjustment to new information. *Journal of Financial and Quantitative Analysis* 30:1, 117–134.
- Ederington, L. H. & J. H. Lee (1996). The creation and resolution of market uncertainty: The impact of information releases on implied volatility. *Journal of Financial and Quantitative Analysis* 31:4, 513–539.
- Eurex (2006). [online] [cited 15 Dec 2006]. Available from Internet:
<URL:<http://www.eurexchange.com/index.html>
- E.ON (2006). [online] [cited 15 Dec 2006]. Available from Internet:
<URL: <http://www.eon.com/>>
- Fama, E. F. (1970). Efficient capital market: review of theory and empirical work. *Journal of Finance* 25:2, 383–432.
- Fama, E. F., L. Fisher, M. Jensen & R. Roll (1969). The adjustment of stock price to new information. *International Economic Review* 10, 1–21.
- Fleming, M. J. & E. M. Remolona (1999). Price formation and liquidity in the U.S. treasury market: The response to public information. *Journal of Finance* 54, 1901–1915.
- Friend, I., F. Brown, E. Herman & D. Vickers (1962). A study of mutual funds. *US Government Printing Office*, Washington, DC.
- Graham, M., J. Nikkinen & P. Sahlström (2003). Relative importance of scheduled macroeconomic news for stock market investors. *Journal of Economics and Finance* 27:2, 153–165.
- Hansen, C. S. (2001). The relationship between implied and realized volatility in the Danish option and equity markets. *Accounting and Finance* 41:3, 197–228.

- Harvey, C. R. & R. D. Huang (1991). Volatility in the foreign currency futures market. *Review of Financial Studies* 4, 543–569.
- Hull, J. C. (2003). *Options, Futures, and Other Derivatives*, 5th ed. New Jersey: Prentice–Hall Inc.
- Jaffe, J. (1974). The effect of regulation changes on insider trading. *Bell Journal of Economics and Management Science* 5, 93–121.
- Jensen, M. (1969). Risk, the pricing of capital assets, and the evaluation of investment portfolios. *Journal of Business* 42, 167–247.
- Jensen, M. (1978). Some anomalous evidence regarding market efficiency. *Journal of Financial Economics* 6, 95–101.
- Jorion, P. (1995). Predicting volatility in the foreign exchange market. *Journal of Finance* 50, 507–528.
- Kleidon, A. (1986). Variance bounds, tests and stock price valuation models. *Journal of Political Economy* 94, 953–1001.
- Kwok, Y. K. (1998). *Mathematical Models of Financial Derivatives*. Singapore: Springer–Verlag Singapore Pte, Ltd.
- Latané, H. & R. Rendleman (1976). Standard deviation of stock price ratios implied in option prices. *Journal of Finance* 31, 369–381.
- Malkiel, B. (1989). Efficient market hypothesis. In: Eatwell, J., M. Milgate & P. Newman (Eds.), *The Palgrave Finance*. W.W. Norton and Co., New York, 127–134.
- Mandelbrot, B. (1966). Forecasts of future prices, unbiased markets, and martingale models. *Security Prices: A Supplement, Journal of Business* 39, 242–255.
- Marsh, T. & R. Merton (1983). Aggregate dividend behavior and its implications for tests of stock market rationality. Working paper. Sloan School of Management.
- Mayhew, S. (1995). Implied volatility. *Financial Analysts Journal* 51, 8–20.

- McDonald, R. L. (2006). *Derivatives Markets*, 2nd edition. Boston: Pearson Education Inc.
- Merton, R. C. (1973). Theory of rational option pricing. *Bell Journal of Economics and Management Science* 4, 141–183.
- Merton, R. C. (1976). The impact on option pricing of specification error in the underlying stock price returns. *Journal of Finance* 31, 333–350.
- Merton, R. (1980). On estimating the expected return on the market: an exploratory investigation. *Journal of Financial Economics* 8, 323–361.
- Natenberg, S. (1988). *Option volatility and pricing strategies: advanced trading techniques for professionals*. Chicago: Probus Publishing Company.
- Neftci, S. N. (2000). *An introduction to the mathematics of financial derivatives*: 2nd edition. San Diego: Academic Press.
- Nikkinen, J. & P. Sahlström (2001). Impact of scheduled U.S. macroeconomic news on stock market uncertainty: A multinational perspective. *Multinational Finance Journal* 5:2, 129–148.
- Nikkinen, J. & P. Sahlström (2003). Impact of the federal open market committee's meetings and scheduled macroeconomic news on stock market uncertainty. *International Review of Financial Analysis* 13, 1–12.
- Nikkinen, J. & P. Sahlström (2004). Scheduled domestic and U.S. macroeconomic news and stock valuation in Europe. *Journal of Multinational Financial Management* 14, 201–215.
- Nikkinen, J., M. Omran, P. Sahlström & J. Äijö (2006). Global stock market reactions to scheduled U.S. macroeconomic news announcements. Forthcoming.
- Nofsinger, J. R. & B. Prucyk (2003). Option volume and volatility response to scheduled economic news releases. *The Journal of Futures Markets* 23:4, 315–345.

- Nokia (2006). [online] [cited 15 Dec 2006]. Available from Internet:
<URL: <http://www.nokia.com/>>
- Patell, J. & M. Wolfson (1981). The ex ante and ex post price effects of quarterly earnings announcements reflected in option and stock prices. *Journal of Accounting Research* 19:2, 434–458.
- Pearce, D. K. & V. V. Roley (1983). The reaction of stock prices to unanticipated changes in money: A note. *Journal of Finance* 38, 1323–1333.
- Rendleman, R., C. Jones & H. Lataté (1982). Empirical anomalies based on unexpected earnings and the importance of risk adjustments. *Journal of Financial Economics* 10, 269–287.
- RWE (2006). [online] [cited 15 Dec 2006]. Available from Internet:
<URL: <http://www.rwe.com/generator.aspx/language=de/id=450/home.html>>
- Samuelson, P. A. (1965). Proof that properly anticipated prices fluctuate randomly. *Industrial Management Review* 6, 41–49.
- SAP (2006). [online] [cited 15 Dec 2006]. Available from Internet:
<URL: <http://www.sap.com/index.epx>>
- Shiller, R. J. (1981). Do stock prices move too much to be justified by subsequent changes in dividends? *American Economic Review* 71, 421–436.
- Siemens (2006). [online] [cited 15 Dec 2006]. Available from Internet:
<URL: <http://www.siemens.com/index.jsp>>
- Société Générale (2006). [online] [cited 15 Dec 2006]. Available from Internet:
<URL: <http://www.societegenerale.fr/>>
- The Federal Reserve (2006). [online] [cited 15 Dec 2006]. Available from Internet:
<URL: <http://www.federalreserve.gov/FOMC/>>
- Total (2006). [online] [cited 15 Dec 2006]. Available from Internet:
<URL: <http://www.total.com/>>

UBS (2006). [online] [cited 15 Dec 2006]. Available from Internet:

<URL: <http://www.ubs.com/>>

Watts, R. (1978). Systematic 'abnormal' returns after quarterly earnings announcements. *Journal of Financial Economics* 6, 127–150.

Wilmott, P., S. Howison & J. Dewynne (1995). *Mathematics of Financial Derivatives: A Student Introduction*, Cambridge: Cambridge University Press.

Yahoo! Finance (2006). [online] [cited 15 Dec 2006]. Available from Internet:

<URL: <http://biz.yahoo.com/>>