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Comparative analysis of technical indicators in international equity markets

Verfasst von / submitted by

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Contents

1 Introduction

There are different forms of the technical analysis. The graphical method tries to identify trends in charts representing price movements. This technique is based purely on visual interpretation of data (Taylor & Allen, 1992, p. 304). In this case it is up to an analyst to decide how prices will develop in the future. In contrast, the mathematical analysis tries to provide us with the best mathematical techniques, algorithms, and indicators to forecast future prices and discover patterns (Wong, Meher, & Boon-Kiat, 2003, p. 543). These indicators try to predict future developments in markets and emit sell or buy signals. On one hand, a sell signal is emitted if a market is expected to show a downward tendency. On the other hand, a buy signal is emitted if the economic situation on a market is expected to be beneficial to an investor (Fifield, Power, & Donald Sinclair, 2005, p. 536).

Technical analysis strives to forecast future trends thus providing useful trading signals for the investors. This is achieved by analyzing past prices (Marshall & Cahan, 2005, p. 384; Kapoor, Dey, & Khurana, 2011, p. 44). Some of the modern technical indicators also combine fundamental data or are based on genetic algorithms (Nunez-Letamendia, 2007, p. 847; Neely, Weller, & Dittmar, 1997, p. 409). The basic notion of all technical indicators underlies the assumption that the past data provide useful information about future trends (Marshall & Cahan, 2005, p. 384). The usability of technical analysis was challenged in some studies and was a subject to a debate (Marshall & Cahan, 2005, p. 385).

We will examine the effectiveness of technical indicators in international stock exchange markets by using the indexes of S&P 500, DAX, FTSE 100, NIKKEI 225, and Euro Stoxx 50 because they belong according to the market capitalization to the most important indexes in the world (see the chapter 3 markets) . The analysis will comprise MACD, Moving Average, RSI and the Gebert indicator as these are the most commonly used indicators with exception of the Gebert indicator (see the chapter 4 technical indicators) . The study will compare the profitability of the technical analysis and the trading signals with the buy and hold strategy. The data set will be divided into sub-periods in order to evaluate the efficiency of the

technical analysis more exactly. We will use the t-test, ANOVA and bootstrapping technique for statistical hypothesis testing.

2 Literature review

2.1 Overview

Simple forms of technical analyses were already used by Charles H. Dow in the 19th century. He was aware that the prices do not merely adhere to financial statements and fundamentals only. Dow noticed that there must be other variables having influence on the stocks' performance. The Dow Theory was one of the first concepts for forecasting future stock prices by using Dow Jones industrial and Transportation averages (Edwards, Magee, & Bassetti, 2007, p. 14). The first studies used simple constructs called the filter rules. An example of a filter rules is: make a purchase in the case the price of the security rose by x % in the previous period (Ghobadi, 2014, p. 335).

The technical analysis was a subject to some controversy in the current literature. It directly opposes the notion of the market efficiency hypothesis (Wong, Meher, & Boon-Kiat, 2003, p. 545; Ghobadi, 2014, p. 335). The market efficiency hypothesis states that the price of stocks encompasses all the information that is available at the current moment (Ghobadi, 2014, p. 335). In this case there should not be any opportunity for achieving excess returns by following the trading rules generated by technical indicators (Malkiel B. G., 2003, p. 59).

Even though the past studies discovered slightly positive returns on technical trading rules these returns disappeared when the transactions cost were introduced or when controlled for dividends (Fama & Blume, Filter rules and stock-market trading, 1966, p. 235). The high forecasting power of technical indicators may also be caused by "trading on trade". That means all the investors act on trading signals generated by technical indicators and reinforce price movements. That could result in a self-predictive power of the indicators (Froot, Scharfstein, & Stein, 1992, p. 1480; Wong, Meher, & Boon-Kiat, 2003, p. 544).

Fama and Bloom performed one of the first analytic studies of mechanical trading rules. The average returns of trading rules were compared to a simple buy and hold strategy which

involved buying shares at the time point t and selling them at t+1 (Fama & Blume, Filter rules and stock-market trading, 1966, p. 226). The results indicate the buy and hold strategy outperforms the mechanical trading rules in all cases when not controlling for dividends. If the dividends are not taken into account then the average returns of the mechanical trading rules increase by 2 %. However, if the dividends are included thereafter the buy and hold strategy is superior to all trading rules and generates on average 5.9 % higher returns (Fama & Blume, Filter rules and stock-market trading, 1966, p. 235).

Current literature shows that technical analysis can be employed to obtain significant returns in several international markets (Wong, Meher, & Boon-Kiat, 2003, p. 550; Ghobadi, 2014, p. 345; Bessembinder & Chan, 1995, p. 283). In addition, Marshal and Cahan (2005) scrutinize the effects of the technical analysis on markets that might be inherently inefficient. They find evidence that an investor can achieve excess returns by following the trading signals emitted by the technical indicators in inefficient markets (Marshall & Cahan, 2005, p. 397).

Chan at al. 1995 analyze the forecasting power of indicators in the Asian market. They found out significant predictive power of the indicators. They ascribed it to the inefficiency in the period taken into account (Bessembinder & Chan, 1995, p. 259). As a consequence, it was possible to achieve significantly positive returns for most indicators. In addition, they found evidence that technical indicators applied to the US market can be used to forecast price movements in the Asian market (Bessembinder & Chan, 1995, p. 283).

The transaction cost reduced the total profits of the stock holders. Nevertheless, they do not remove all the excess returns produced by the technical analysis. The variable moving average and the trading range break rule achieve excess returns up to transaction cost of 1.34 % (Bessembinder & Chan, 1995, p. 283). The performance of the indicators varies with the length of the time period under consideration. That means the time between the buy and sell signals (Bessembinder & Chan, 1995, p. 264).

The notion that technical analysis is beneficial was also confirmed in the Singapore stock exchange (Wong, Meher, & Boon-Kiat, 2003, p. 550). The indicators showed that investors can enjoy substantial positive returns by better timing of buying and selling decisions using

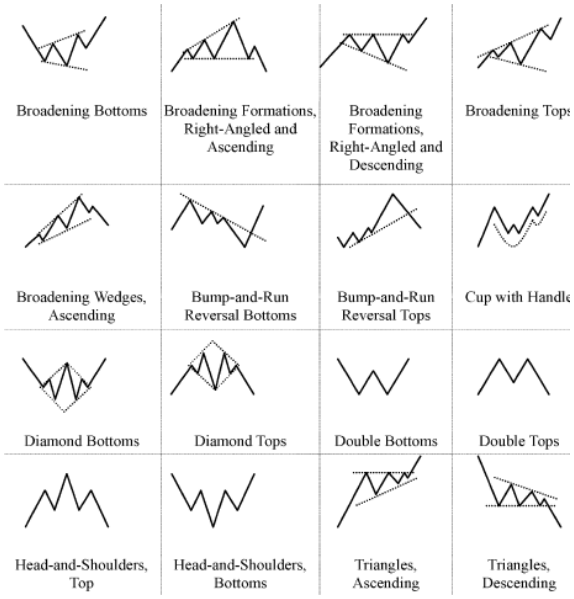
the technical indicators. The moving average test statistic was significant with exception of the 5- and 10-days periods (Wong, Meher, & Boon-Kiat, 2003, p. 547). The t-statistics for RSI displayed significant results using the 50 crossover method. In addition, the results indicate moving averages perform on average better than RSI (Wong, Meher, & Boon-Kiat, 2003, p. 549). The relative strength indicator (RSI) is described in the chapter 4.3 RSI in detail.

Ghobadi (2014) investigated the ability of trading strategies to achieve abnormal returns. His study concentrated on the Teheran stock exchange and international commodity exchanges. He discovered strong evidence that the technical analysis can lead to abnormal returns. He defined the abnormal returns as the differences between actual and expected return. The expected returns were determined on the basis of the London Interbank Offered Rate (Ghobadi, 2014, p. 334).

2.2 Chart analysis

Charting techniques are an important part of the technical analysis. These techniques do not require any mathematical models or knowledge of statistics. It is an approach to identify patterns and predict ups and downs in the prices of indexes. Research indicates that chart analysis has a high forecasting power [10]. Some common pattern formations are broadening formations, triangles and diamonds. Figure 1 shows the most common formations (Liu & Kwong, 2007, p. 1199).

Figure 1 : The patterns in chart analysis



Source: Our own illustration using data from Liu & Kwong (2007), p.1197, Fig.1

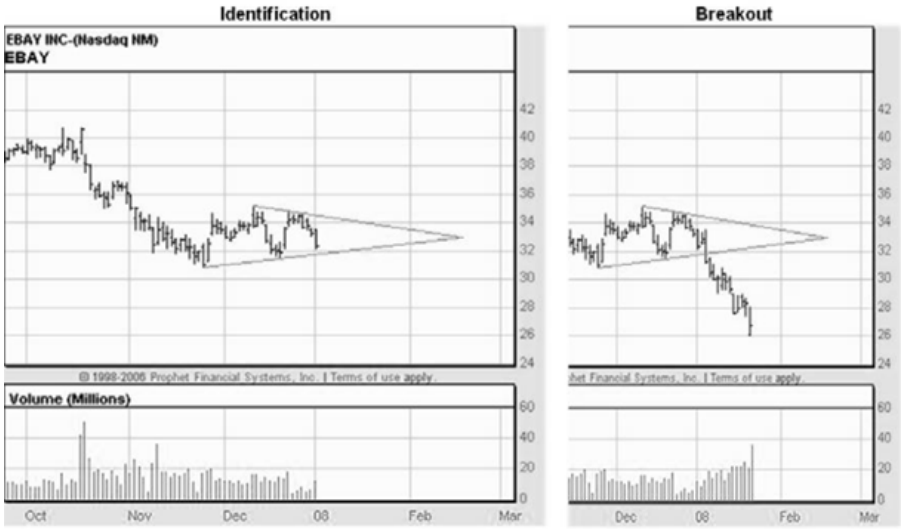
The triangles are patterns that usually signalize a future trend reversal. They appear like two lines that are closing in. We can observe symmetrical triangles in up or down trends. The triangle marks a period of hesitation and indecisiveness among investors. The price cannot go up further because some investors start selling when the stock prices reach a peak. The graph also cannot fall since each try to sell shares is met with other investors buying the shares (Matras, 2016, p. 4).

There can be bullish or bearish triangles (formations). Bullish triangle is created when the triangle is preceded by an upward trend. Bearish triangle is a formation that emerges in a graph with a downward trend. After identifying a triangle, an investors needs to assess it for failures on regular basis. When such a failure occurs and investor will exit the trade (Matras, 2016, p. 5).

In the case of a bullish triangle or all the bullish formations illustrated in Figure 2, a point of failure is drawn when the prices cross the downer line of a triangle. It indicates a discontinuity of the current development and an upcoming downward motion. The opposite applies to the

bearish formations. When the upper line of a bearish formation is crossed it indicates a trend reversal and a possible upward movement (Nison, 1991, p. 39).

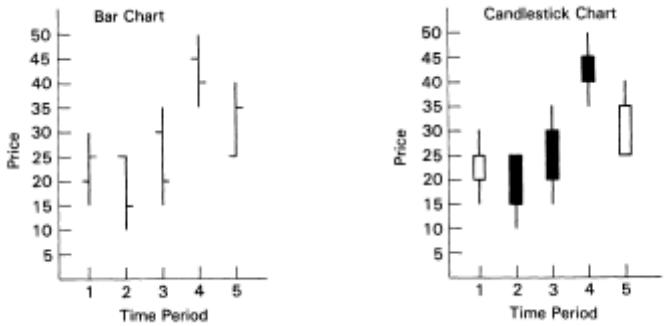
Figure 2 : Symmetrical triangle in a downtrend



Source: Matras (2016), Symmetrical Triangle in a Downtrend (Bullish), p.7

The Japanese charting techniques use candle charts. This system is similar. An investor will identify formations and derive trading rules from them.The advantage of candle stick charts is that they incorporate more information and an investor can perform more detailed analysis of the charts (Nison, 1991, p. 8).We can see examples of the candle sticks on Figure 3.

Figure 3 : Candlesticks

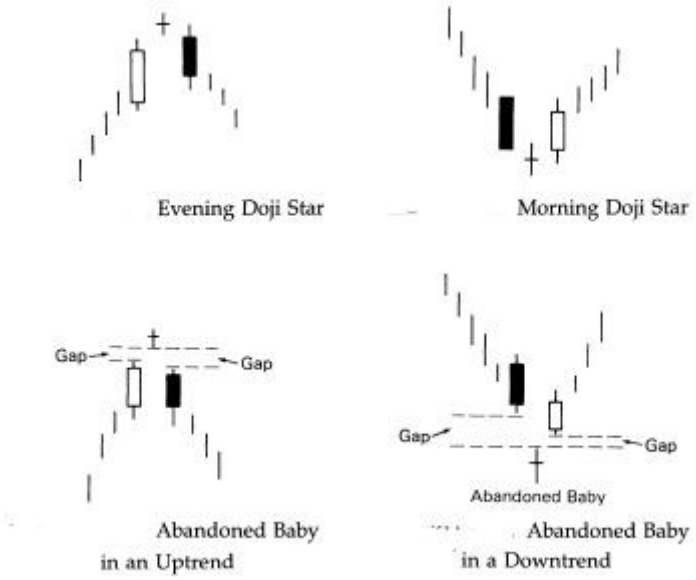


Source: Nison (1991), Exhibit 3.3, Bar Chart and Candlestick Chart, p.23

The candle stick chart has two different parts, the body and the shadows. The thicker part of the chart is the body depicting the close and open prices. The shadows are the thin lines coming out of the body. It is black when the prices went down or when the closing price was lower than the opening price. If the body is white it indicates that the prices rose and the closing price was higher than the opening price. The thin lines represent the extreme values, daily maximum and minimum (Nison, 1991, p. 23).

There are many different patterns and various imaginative and original names given to the formations as we can see in Figure 4. Usually when there is a candle stick with white body succeeded by a candle stick with small and black body it signals a trend reversal. In that case the prices are supposed to decline. On the contrary, candle stick with black body, followed by a candle stick with a small body and a white candle stick signal ascending trend (Nison, 1991, pp. 66-67).

Figure 4 : Exotic candle stick signals



Source: Nison (1991), Stars, p. 65

Although charting can be done just with a pencil and paper, there is charting software available that can do much of the work for investors. Specialized software can do the job for

the investors much easier since they would spend a lot of time on analyzing the shares in a newspaper (Kahn, 2008, p. 214). Just a basic system can be very helpful for semi-professional and professional investors. It is indispensable for the software to know how to draw price charts, line charts, uses flexible time frames and includes all the major technical indicators (Kahn, 2008, p. 2015). There are a number of algorithms used by the software. Each of them has a different method for recognizing patterns. The PXtract algorithm shows most promising results with its combination of neural networks, multi-resolution analysis and radial basis function (Liu & Kwong, 2007, p. 1197).

2.3 Fundamental analysis

The fundamental analysis incorporates the analysis of financial statements (fundamentals) of a company. An investor tries to calculate the intrinsic value of a company by forecasting the financial performance after a thorough analysis of the balance sheet, the income and cash-flow statements. The fundamental analysis shares some common ground with the technical analysis. When we analyze the advantages and disadvantages of fundamental analysis we find out that there is not a superior type of an analysis. The best strategy is to use both technical analysis and fundamental analysis complementary and try to interpret the signals. The interpretation requires some experience (Lim, 2016, p. 3).

Fundamental analysis is important when the investors try to determine the direction of the future development of a market. It is a very good tool that can be used for long-term forecasts. Nevertheless, the lower the period of time the more important it will be to use the technical analysis. The technical analysis produces better results when applied to shorter timeframes (Lim, 2016, p. 40). In addition, a fundamental analysis does not tell the investor when exactly he or she should purchase or sell shares (Lim, 2016, p. 14).

Furthermore, fundamental analysis does not give the investor any graphical representation of the share prices in the stock markets. This is in contrast to the technical analysis in which case the chart analysis is one of its components. In addition, fundamental analysis is market specific and makes use of different variables in each market. On the contrary, we use technical indicators in the course of the technical analysis that are standardized and can be applied to all financial markets (Lim, 2016, p. 13).

One disadvantage of the fundamental analysis is also the fact that it is based on cash-flows, earnings, sales, financial data that can be easily manipulated. The market share prices are real and nowadays it is more difficult to manipulate them. The advantage of the fundamental analysis is that less false signals are generated. When conducting the fundamental analysis an investors needs to think how the company and the market will develop in the future. However, the studies showed that fundamentalists' forecasts are very imprecise with 54 % average error for the next year and it is necessary to predict the earning 10 years and more in future (Edwards, Magee, & W.H.C., 2012, p. 530).

2.4 Efficient market hypothesis

The technical analysis opposes the notion of the market efficiency hypothesis (Wong, Meher, & Boon-Kiat, 2003, p. 545; Ghobadi, 2014, p. 335). If the market were perfect there should not be any opportunity for achieving excess returns by following the trading rules generated by technical indicators (Malkiel B. G., 2003, p. 59). Fama (1970) divides the market efficiency in three different sub-types.

Weak form of EMH

It says that markets are efficient and it is not possible to determine future share prices based on the past prices. This form of EMH is based on the principles of the random walk theory and stipulates that past prices have not predictive power. However, the weak form of EMH also implies that it is possible to forecast future prices based on public or private information that was not included in the current prices. As a consequence, a certain kind of fundamental analysis is possible to be used in determination of future share prices (Garg, 2014, p. 1; Timmermann & Granger, 2004, p. 16).

Semi strong form of EMH

The semi strong form of market efficiency hypothesis does not only suggest that the current share prices incorporate all the available information. In addition, it stipulates that all public information about the companies is already included in the current share prices. Consequently, an investor cannot use fundamental analysis to determine future prices anymore (Garg, 2014, p. 1).

Strong form of EMH

The strong form of EMH is a combination of the weak and semi-strong form and says that current share prices include all available public and private information. Therefore neither fundamental nor technical analyses are able to forecast future prices. Current market prices reflect efficiently all the past, public and insider information (Garg, 2014, p. 1; Malkiel & Fama, 1970, p. 383).

The efficient market hypothesis should always apply at least in its weakest form due to the rule of self-destruction of the investment opportunities. It implies that if there is any investment opportunity the investors will exploit it and it disappears from existence (Timmermann & Granger, 2004, p. 22). An evidence of this phenomenon has been found also in the news studies on the calendar effects.

Some studies suggest that there can be forecasting techniques that actually work. Such indicators or techniques need to be able to choose the most suitable forecasting methods, learn from the past and adapt quickly. Nevertheless, there are periods when the effects of forecasting techniques are reversed due to the investors trying to exploit the investment opportunities and these opportunities will disappear (Timmermann & Granger, 2004, p. 24).

Malkiel (2003) claims that it is possible to find efficient market behavior also in the time of crisis. The crisis are unpredictable because in the other case an investor could exploit it and earn superior returns. The share prices also could change rationally based on exogenous influences (Malkiel B. G., 2003, pp. 58-59).

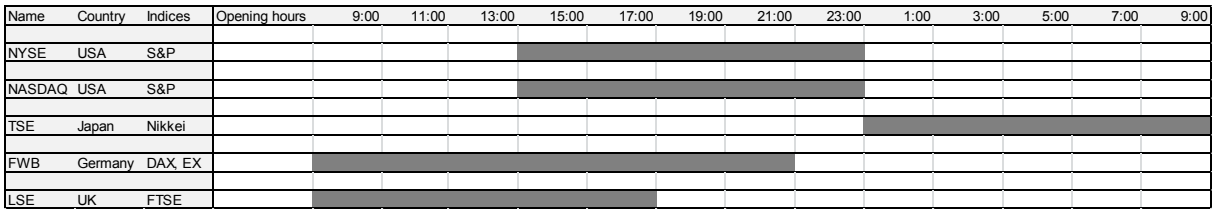
3 Markets

3.1 Trading hours

The number of observations in my project is influenced by the opening sessions of the stock exchanges. Each stock exchange has specific opening hours and is closed on different dates since the holidays are on a different date in each country. The NYSE is open every day from Monday to Friday from 9:30 am to 4:00 pm. The stock exchange was closed on 10 days in the year 2016 [12].

We can see the standard opening hours in Figure 5. The opening times are the CET (Central European Time) equivalents. We can easily notice that the Frankfurter Exchange has the longest opening hours from 9 am until 8 pm. The Japanese stock exchange has the shortest opening hours because there is lunch break from 11:30 to 12:30 for the specialists [18].

Figure 5 : Trading hours



Source: Own illustration using data from NYSE, NASDAQ, World time zone

Although the stock exchanges are closed on holidays there are also special closing days called emergency closures. One example of an unexpected closure was the terrorist attack of 9/11 but the stock exchanges can announce closures in the case of the maintenance or update of the electronic trading system or for any other reason [18].

3.2 DAX

The stocks of the DAX companies are traded in the prime market on the Frankfurt stock exchange. The history of the Frankfurter stock exchange dates back to the middle ages. At the beginning Frankfurt's attention concentrated merely on trading US government debt securities and international stocks. Nevertheless, fierce competition from the Berliner stock exchange had compelled it to distinguish itself and the Frankfurter stock exchange offered some trading ground for South German companies. It has propelled the rise of its dominance and it is currently part of Deutsche Börse AG [4].

DAX is a German stock index, which tracks the performance of 30 German companies with the largest market capitalization displayed in Figure 6. The DAX has been calculated since 1988 by German Stock Exchange (Deutsch Börse AG) and represents 75 % of the total nominal share capital and 85 % of the total equity revenues in the country. The shares are

weighted according to the volume and market capitalization of the free float. The change in the composition of the index is made annually in September [4].

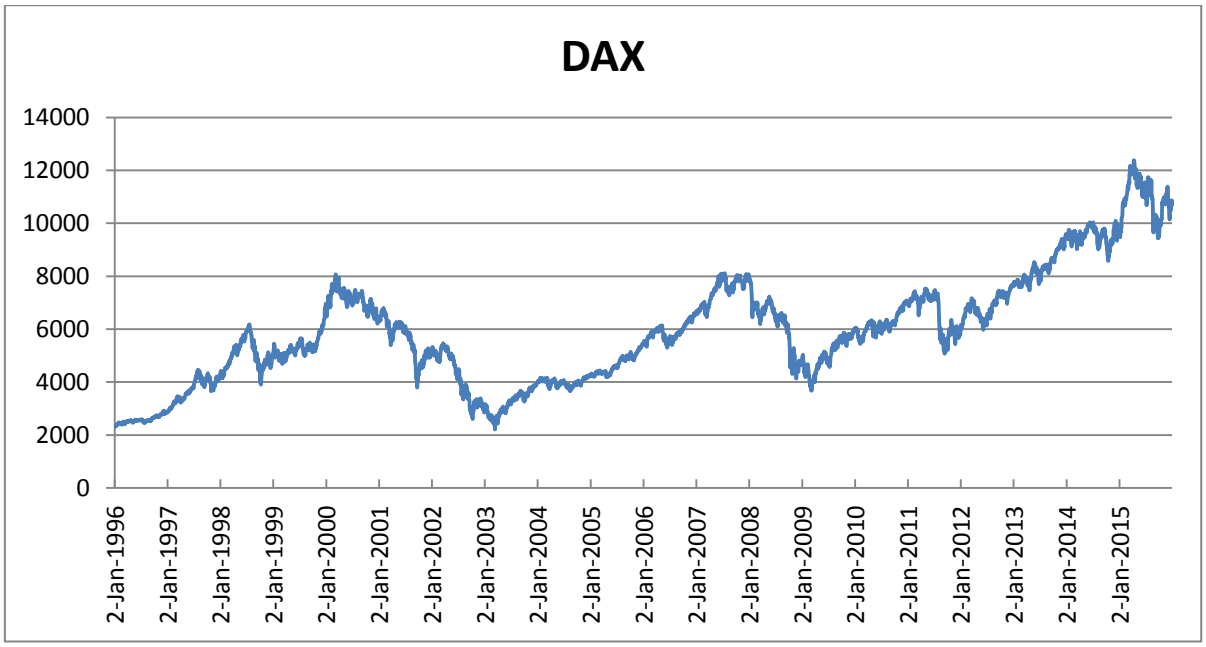
Figure 6 : Dax all companies

DAX Companies							
Name	**Sector**	**Last Value (May 22th)**	**Volume**	**Name**	**Sector**	**Last Value (May 22th)**	**Volume**
Adidas AG	Clothing	113,10	962.446	Fresenius SE & Co	Pharmaceutical	64,99	1.147.976
Allianz SE	Insurance	137,75	1.546.905	HeidelbergCement	Construction	74,88	465.619
BASF SE	Petrochemicals	67,29	2.512.107	Henkel AG & Co.	Chemicals	102,35	517.749
Bayer AG	Pharmaceutical	89,54	4.763.515	Infineon	Semiconductors	12,48	3.684.313
Beiersdorf AG	Chemicals	79,21	202.52	Deutsche Lufthansa	Aviation	12,35	3.242.451
BMW	Automotive	71,70	1.889.879	Linde	Industrial Gases	127,60	288.466
Commerzbank AG	Banking	7,32	8.384.599	Merck KGaA	Pharmaceutical	87,23	671.494
Continental	Automotive	185,05	798.032	Münchener	Insurance	159,75	817.198
Daimler AG	Automotive	57,83	4.501.447	ProSiebenSat 1	Media	45,08	924.287
Deutsche Boerse AG	Financial	76,66	401.784	RWE AG	Energy	11,49	3.088.472
Deutsche Bank AG	Banking	15,14	7.413.579	SAP SE	Software	69,44	2.399.378
Deutsche Post AG	Logistics	25,87	3.494.888	Siemens	Technology	94,00	2.316.865
Deutsche Telekom AG	Communication	15,90	9.404.608	ThyssenKrupp AG	Manufacturing	18,53	1.710.968
EON	Energy	8,32	8.008.115	Vonovia	Real estate	30,26	973.571
Fresenius Medical	Pharmaceutical	74,75	541.688	Volkswagen AG	Automotive	129,65	1.180.553

Source: Our own table using data from yahoo, https://de.finance.yahoo.com/q/cp?s=^GDAXI

The index in Figure 7 displays a general upward tendency reaching its lowest point during the primer mortgage crisis on March the 9th 2009. Thereafter the DAX index began a recovery despite the European automotive crisis which did not have such a strong impact on DAX. The next low occurred during the renegotiations of the Greek debt in June 2012 as the uncertainty rose among the investors [13]. The DAX followed other worldwide indexes in their plunge after the China stock Crash in August 2015. The outcome in 2016 is uncertain with DAX displaying a downward trend because of preoccupation about the growth of the global economy [3].

Figure 7 : DAX index graph



Source: Our own illustration used data from https://finance.yahoo.com/quote/DAX/?p=DAX

3.3 Eurostoxx

The Eurostoxx index captures the performance of 50 European companies with the highest market capitalization. First, all the companies in the Eurozone are assessed according to their free-float market capitalization and selected from the 19 EURO STOXX super sector index. Thereafter the 50 leaders of the list are added into the index until reaching at least of 60 % of the total market capitalization. They need to meet minimum liquidity criteria of daily trading volume of at least 1 million EUR. It comprises companies from 19 different economic sectors and from 12 European countries. We can see the country weights in Figure 8 [15].

Figure 8 : Eurostoxx all companies

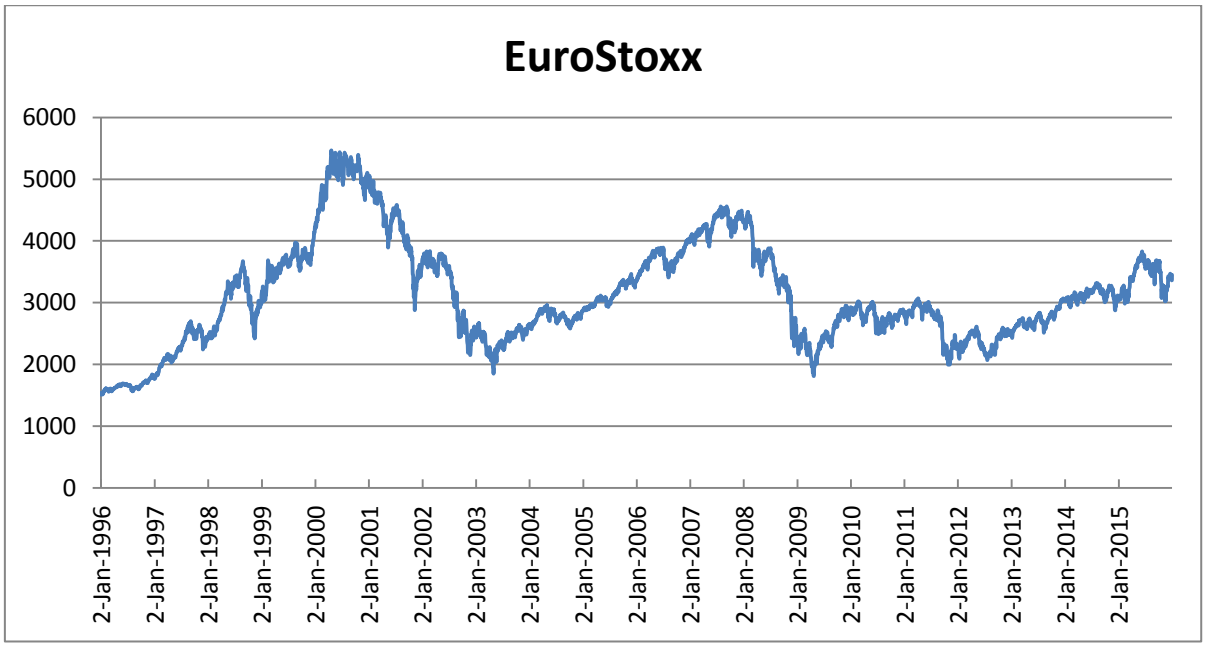
Eurostoxx Companies							
Name	**Country**	**Last Value**	**Volume**	**Name**	**Country**	**Last Value**	**Volume**
Anheuser-Busch	Belgium	109,30	1.614.891	Assicurazioni Generali	Italy	12,75	8.433.743
Air Liquide SA	France	97,17	1.044.286	Societe Generale Group	France	34,67	4.225.016
Airbus	Netherlands	54,41	2.114.660	Iberdrola	Spain	60,760	12.114.93
Allianz SE	Germany	137,75	1.546.905	ING Group	Netherlands	10,49	16.195.40
ASML HLDG	Netherlands	85,18	1.416.359	Intesa Sanpaolo S.p.A.	Italy	23,140	136.096.9
BASF SE	Germany	67,29	2.512.107	Inditex	Spain	28,80	3.511.684
Bayer AG	Germany	89,54	4.763.515	LVMH Moët Hennessy	France	144,20	1.004.386
BBVA	Spain	56,330	34.929.71	Münchener	Germany	159,75	817.198
BMW	Germany	71,70	1.889.879	NOKIA	Finland	46,480	22.297.78
Danone	France	60,35	2.128.033	L'Oreal SA	France	160,65	790.604
BNP Paribas SA	France	45,72	4.395.458	Orange	France	15,20	7.274.638
Carrefour SA	France	24,40	3.745.352	ROY.PHILIPS	Netherlands	23,00	3.392.646
AXA Group	France	21,24	7.010.249	Safran SA	France	59,98	1.205.950
Daimler AG	Germany	57,83	4.501.447	Banco Santander	Spain	41,450	59.786.22
Deutsche Bank AG	Germany	15,14	7.413.579	Sanofi	France	71,18	4.662.089
Vinci	France	66,01	2.293.771	SAP SE	Germany	69,44	2.399.378
Deutsche Post AG	Germany	25,87	3.494.888	Compagnie de Saint-	France	38,78	2.102.201
Deutsche Telekom	Germany	15,90	9.404.608	Siemens	Germany	94,00	2.316.865
Essilor International	France	114,55	695.217	Schneider Electric SE	France	56,25	1.654.935
Enel SpA	Italy	3,99	27.843.66	Telefonica	Spain	9,19	48.150.07
ENGIE	France	13,30	4.618.231	UniCredit S.p.A.	Italy	30,040	197.496.6
Eni SpA	Italy	13,40	16.957.54	Rodamco	France	235,70	311.318
E.ON SE	Germany	8,32	8.008.115	Unilever	Netherlands	38,99	4.014.793
Total	France	43,01	6.867.101	Vivendi SA	France	17,32	5.074.199
Fresenius SE & Co	Germany	64,99	1.147.976	Volkswagen AG	Germany	129,65	1.180.553

Source: Our own table using data from yahoo, https://de.finance.yahoo.com/q/cp?s=^GDAXI

The Eurex exchange in Germany is responsible for the benchmarking services related to the Euro Stoxx 50. The Eurex stock exchange is based in Frankfurt and like the Frankfurter Stock Exchange owned by Deutsche Boerse AG. It is mostly known for its indexing services. In addition, it belongs to one of the largest derivatives exchanges worldwide [15].

The index in Figure 9 reached a peak at the beginning of the millennium with a boom of internet and software companies. However, the political and economic situation in some European countries led to the fact that the Euro Stoxx 50 never fully recovered after the prime mortgage crisis. In comparison to DAX the index displays lower values than before the crisis and is affected by stagnation in the long run. The index reached a peak at the beginning of the millennium with a boom of internet and software companies.

Figure 9 : Eurostoxx index graph



Source: Our own illustration with data from https://www.stoxx.com/index-details?symbol=sx5e

3.4 FTSE

The London Stock Exchange is one of the oldest stock exchanges in Europe which is situated in the United Kingdom in the city of London. The stock market is with its 6 trillion dollars the third largest market in the world by market capitalization. The stock exchange was founded in 1801 and its current offices are located in Paternoster Square London. The exchange is a part of the London Stock Exchange group [9].

The FTSE index is the most important stock index in the UK. The name FTSE is equivalent of Financial Times Stock Exchange. It shows the status of the British share prices of 100 largest and most actively traded companies some of these presented in Figure 10. It thus reflects the performance of the segment of the British Blue Chips and it is the leading index for all British companies. The index value is calculated by the FTSE Group which emerged for a collaboration of the London Stock Exchange with the financial times [6].

Figure 10 : FTSE selected companies

FTSE 100 Selected companies							
Name	Sector	Last Value (May 22th)	Volume	Name	Sector	Last Value (May 22th)	Volume
British American Tobacco	Retail	4.170,50	2.239.685	Pearson plc	Education	814,50	2.307.975
Carnival plc	Leisure	3.584,00	539.79	Royal Dutch Shell	Oil industry	1.655,00	6.040.563
Direct Line Insurance	Insurance	373,90	3.910.557	Rolls Royce	Manufacturing	638,50	3.104.075
EasyJet plc	Travel	1.519,00	2.038.595	SABMiller plc	Beverages	4.262,50	1.885.408
Fresnillo PLC	Mining	1.041,00	1.342.517	Tesco PLC	Retail	171,00	36.995.57
International Consolidated	Travel	531,50	5.977.257	TUI AG	Travel	1.058,00	886.041
Vodafone Group Plc	Communication	226,70	49.970.47(	Unilever PLC	Retail	3.113,50	1.874.775

Source: Our own table using data from yahoo, https://de.finance.yahoo.com/q/cp?s=^GDAXI

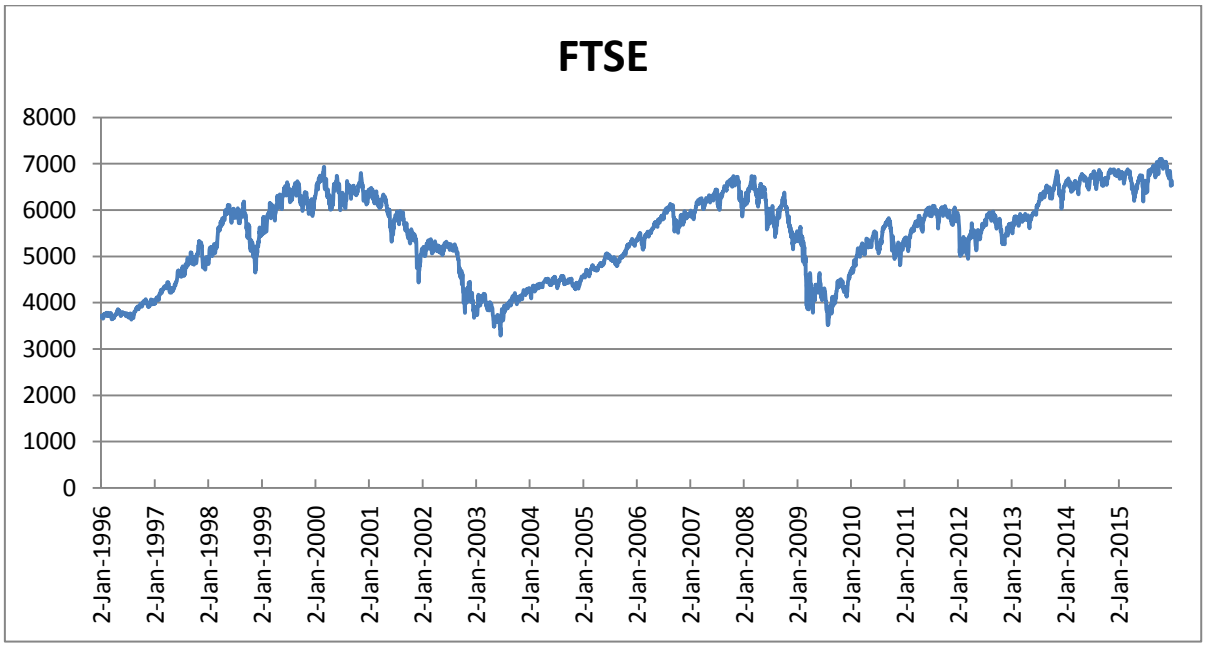
The FT and Russell Index as the predecessors of the FTSE index were calculated already from 1962. The FTSE was established in 1995 as an index weighted by market capitalization and shares traded on the London stock exchange. Apart from the FTSE 100 index there are indexes derived from the original index: the FTSE 250, FTSE Small Cap, All-share and Fledgling [6].

The FTSE index illustrated in Figure 11 experienced a remarkable growth since 1996. The index value more than doubled in Dec 1999 and it reached a peak at 6930 points. The main reasons for hitting the all-time high in Dec 1999 was optimism among the investors about the resolution of the Greek crisis and that the Fed decided to raise the interest rates. Thereafter the index declined steadily until it plunged in March 2003 amid rising concerns about the global economic performance due to war in Iraq and rising oil prices. However, it rebounded again and rose up to 6700 points. Nevertheless the prime mortgage crisis caused the index to drop to 3830 points [1].

Thereon a slow recovery began, since then more than 50 companies have left the FTSE due to mergers and bankruptcies. Some of the largest and best known companies that were not present in the index in 2015 include British Airways, Cadbury Schweppes and Hilton. British Airways and Cadbury Schweppes became a part of the International Airport Group. Hilton's

liquidity dropped after the last stock market crash and disqualified it from participating in the FTSE 100 [4].

Figure 11 : FTSE index graph



Source: Our illustration data from https://finance.yahoo.com/quote/%5EFTSE/news?p=^FTSE

3.5 NIKKEI

The classical floor trading attracted the attention of investors in Japan since 120 years. That gave a rise of the Tokyo stock exchange as the favorite place for Japanese equity investors. The classical floor trading began in 30 April 1878 and continued until 1999 when the stock exchange was equipped with modern digital trading systems. The indexes traded on the stock exchange are Nikkei 225 and Topix. The stock exchange reached the volume of 4 trillion USD [17].

Figure 12 : Nikkei selected companies

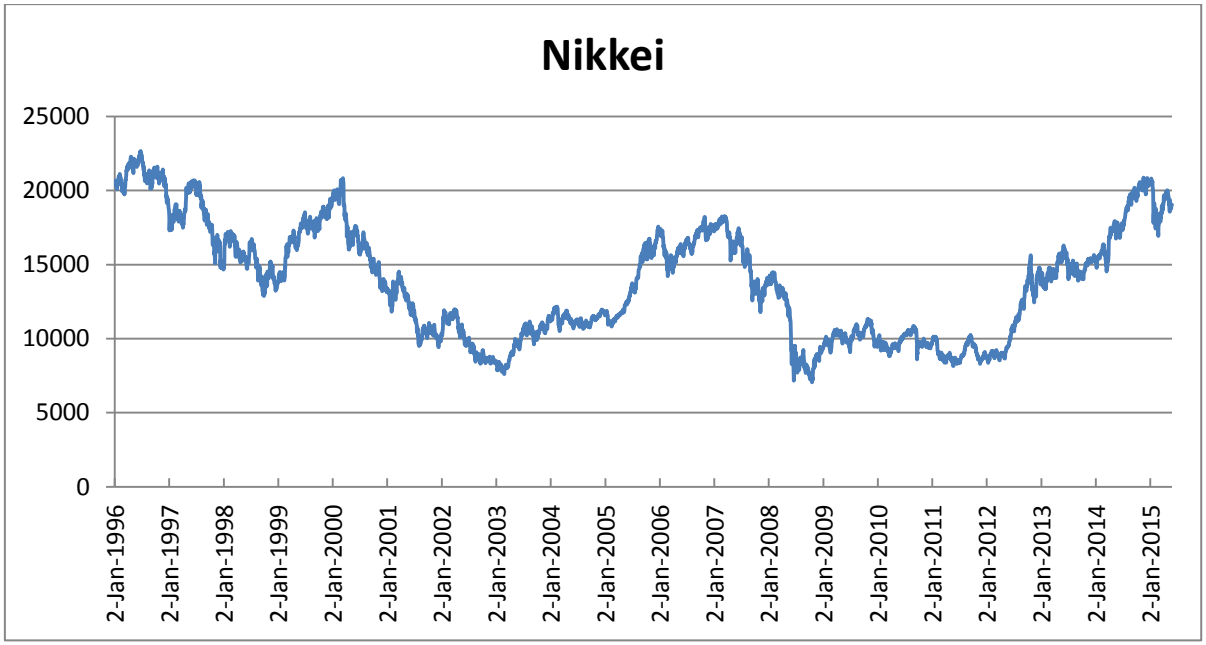
Nikkei 225 Selected companies					
Name	**Sector**	**Last Value (May 22th)**	**Name**	**Sector**	**Last Value (May 22th)**
Bridgstone	Industrie	28,94	Olympus Corp	Technological	35,4
Fuji	Technolog.	3,48	Panasonic	Technological	7,64
Honda Motors	Automobile	24,00	Sharp	Technological	1,1
Isuzu Motors	Automobile	10,02	Sony	Technological	24,7
Kawasaki	Transport	1,80	toshiba	Technological	1,83
Mazda Motors	Automotive	14,38	Toyota	Automotive	45,25
Mitsubishi	Transport	11,84	Yamaha	Transportation	25,7

Source: Own table using data from http://index.finanztreff.de/

Similarly to FTSE the Nikkei index was created by Nihon Keizai Shimbun Corporation an important Japanese financial newspaper company which is the parent company of National Geographic and Financial Times. The Nikkei consists of 225 blue chips which are stocks with the highest liquidity, some of these stocks are presented in Figure 12. It has been calculated and published by the Nikkei Inc. media company since 1950. The prices are adjusted and then aggregated. Thereafter a quotient between the sums of adjusted priced and a divisor is calculated according to a specific formula [17].

Nikkei peaked as high as 38560 in Dec 1988 then the index displayed a general downward tendency and the graph in Figure 13 is marked by periods of low performance never reaching its original values in 1988. The current index value is 16736 points. The decline of the index can be attributed to the disappointing performance of the Japanese economy since the late 1980's. Apart from that, demographic changes made also a major contribution to the adverse situation on the Japanese stock markets. Low population growth and aging, higher unemployment and stiff organizational structure are some factors that had an influence on Nikkei never reaching its previous values [14].

Figure 13 : Nikkei index graph



Source: Own graph data from https://finance.yahoo.com/quote/%5EN225/news?p=^N225

3.6 S&P 500

The history of the index starts in 1957 and it is considered to be a large-cap index that bests represents the performance of the US economy. It includes 500 companies with assets that exceed 2.2 trillion USD thus representing 80 % of the total market capitalization of listed companies. The index is weighted according to the market capitalization of its companies [11].

The conditions to be admitted into the index are minimal market capitalization of UDS 5.3 billion; the companies need to show positive revenues in the last quarter. In addition, the sum of the revenues in last 4 quarters must be positive. The index remains exclusive for the US American companies that are presented in Figure 14. The index includes ten main GICS sectors [11].

Figure 14 : S&P selected companies

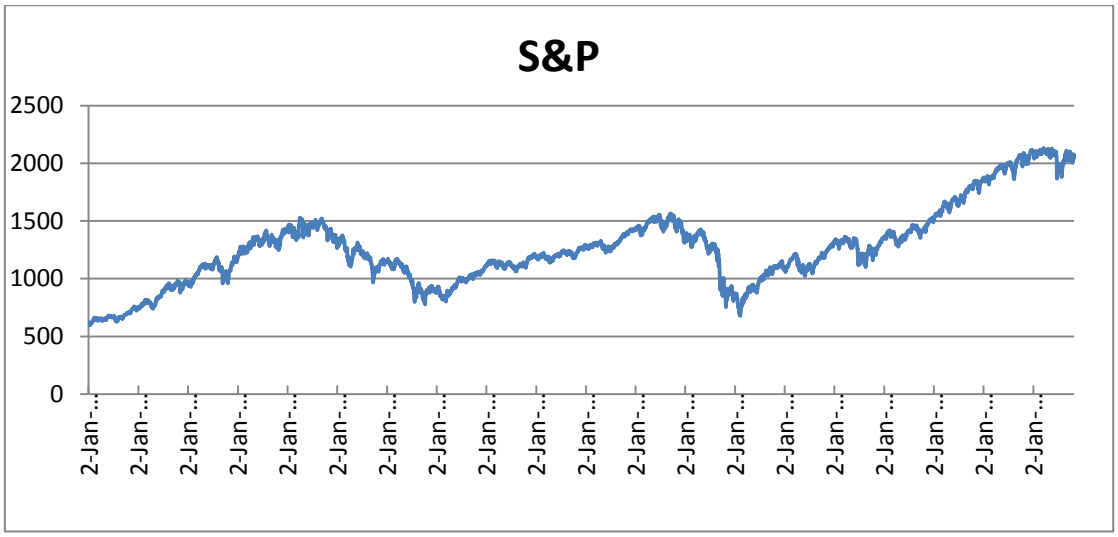
S&P 500 Selected Companies							
Name	Sector	Last Value (May 22th)	Volume	Name	Sector	Last Value (May 22th)	Volume
Apple Inc.	Electronics	97,76	23.325.99	Johnson & Johnson	Pharmaceuticals	112,75	3.451.532
American Express Company	Finance	64,94	2.363.751	JPMorgan Chase & Co.	Banking	64,38	8.630.728
The Boeing Company	Aviation	126,78	3.366.821	The Coca-Cola Company	Beverages	44,26	7.911.765
Caterpillar Inc.	Equipment	71,07	2.161.988	McDonald's Corp.	Fast food	124,00	2.997.626
Cisco Systems, Inc.	Computer	28,51	15.977.61	3M Company	Conglomerate	168,13	751.3
Chevron Corporation	Oil and Gas	100,16	2.548.962	Merck & Co. Inc.	Pharmaceuticals	55,69	3.231.394
E. I. du Pont	Chemicals	67,84	3.442.903	Microsoft Corporation	Software	51,52	21.884.00
The Walt Disney Company	Entertainment	99,70	3.024.630	NIKE, Inc.	Sport goods	56,68	6.833.991
General Electric Company	Conglomerate	29,89	13.210.09	Pfizer Inc.	Pharmaceuticals	34,01	13.173.39
The Goldman Sachs Group, Inc.	Banking	157,18	2.128.387	The Procter & Gamble	Consumer goods	81,10	3.648.154
The Home Depot, Inc.	Retail	133,56	3.043.478	The Travelers Companies	Insurance	113,14	724.705
International Business Machines	Retail	147,93	1.336.689	UnitedHealth Group	Health Care	132,30	1.284.022
Intel Corporation	Semiconductors	31,02	13.759.93	United Technologies	Conglomerate	100,01	1.598.657

Source: Our own table, data from http://finance.yahoo.com/q/hp?s=^GSPC+Historical+Prices

The indexes are calculated and maintained by S&P Dow Jones indexes LLC a subsidiary of McGraw Hill Financial. Generally S&P shares are traded on NASDAQ and NYSE both located in New York, United States. The main differences between these two exchanges are in their operations. NASDAQ trading is automated and independent of any human intervention. NYSE operations are overlooked by specialists. The NYSE is largest stock exchange by market capitalization NASDAQ is the second largest stock exchange in the world according to the market capitalization [2].

The S&P index in Figure 15 shows similar features to the FTSE 100. The index was hit equally hit hard by the prime mortgage crisis However, the index experienced an impressive surge and the upward tendency is likely to continue. S&P is the only index that exceeded its all-time high and it is still breaking all records this year. The impressive surge began after the end of the prime mortgage crisis. Then the index more than doubled from 799 in Jan 2009 to the current high of 2099 points.

Figure 15 : S&P index graph

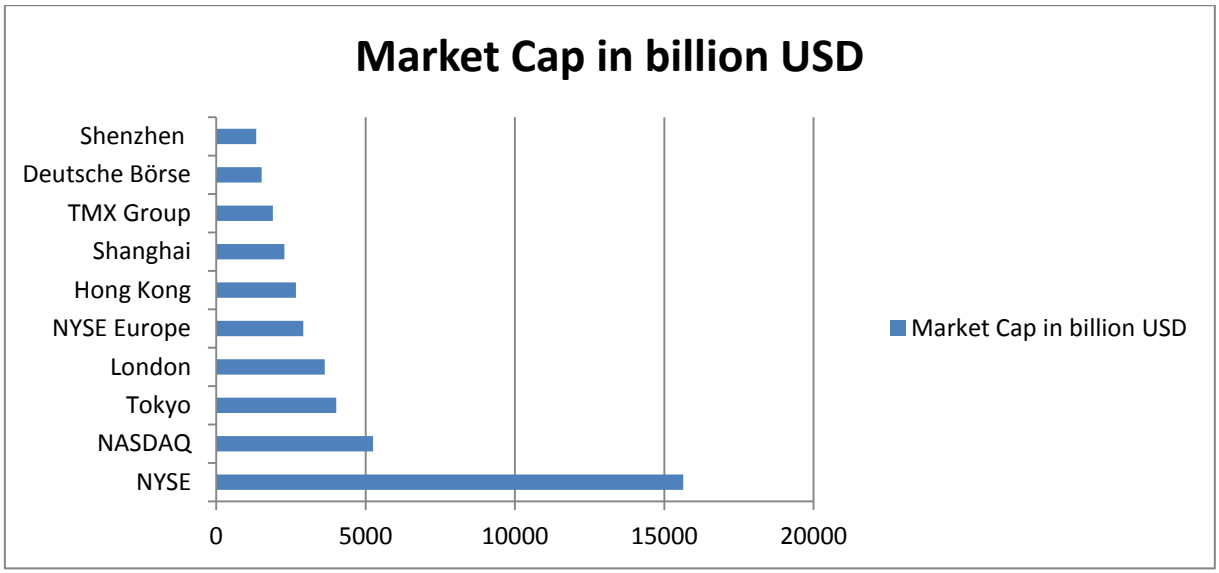


Source: Our own illustration using data from https://finance.yahoo.com/quote/%5EGSPC/news

3.7 Comparison

We can see the largest stock exchanges in the world according to market capitalizations in Figure 16. The market capitalization shows the total net worth of the companies whose shares are traded on the stock exchanges. The values are stated in billion USD dollars. We can see that the US American stock exchanges display the highest market capitalization followed by Japan, UK, China and Germany. The capitalization of NYSE is the highest and about 300 % higher than the NASDAQ on the second place.

Figure 16 : Market capitalization all stock exchanges



Source: Calculation based on www.statista.com data

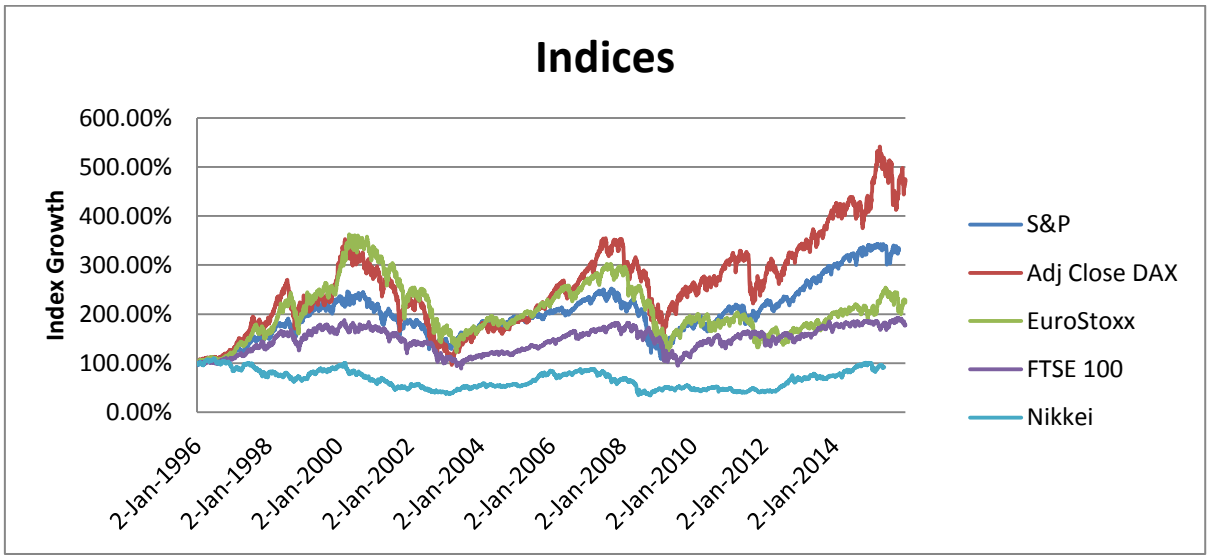
The stock exchanges display some similarities especially related to worldwide economy crisis. We can notice that the drops in the indexes associated with the crisis occur almost simultaneously. The major declines in the stock indexes occur in the year 2001 caused by the dot com crisis. Thereafter war in Iraq and rising oil prices in 2003 deepened the crisis even further. After a slight recovery, the prime-mortgage crisis led to plummeting share prices. The automotive crisis had a major impact on DAX and Eurostoxx. The FTSE, S&P and Nikkei were not affected as strongly as the other stock indexes.

The graph in Figure 17 shows the comparison of the indexes based on standardized values. The highest growth recorded the DAX after the recovery of the subprime-mortgage crisis. The index value increased almost four fold from 1996 to 2016. The second-best performer is the S&P index that was most largely affected by the prime-mortgage crisis. Thereafter the index shows a remarkable recovery. The indexes with lower performance never achieved the previous results after the prime-mortgage crisis.

The worst performance was recorded by Nikkei. First of all, the Japanese investors are known for being cautious. Second, they were discouraged to invest into shares after the past

economic crisis. The decline of the index was also affected by demographic problems that the Japanese economy needs to face. Last but not least, the Japanese people are famous for their high saving rate. All these factors contributed to disappointing results of the Japanese economy.

Figure 17 : Comparison indexes



Source: Calculations based on yahoo finance data from http://finance.yahoo.com/

4 Selection of indicators for the comparative analysis

4.1 Technical indicators

The technical analysis comprises the chart analysis also called the classical analysis. Investors try to identify and analyze recurring patterns in a price series. Another type of the technical analysis is based on statistical methods and the use of technical indicators. This method is more quantitative. We analyze the data based on four different indicators that showed most promising results in the literature and were a subject of a number of studies (Wong, Meher, & Boon-Kiat, 2003, p. 544; Chong & Ng, 2008, p. 1111; Ghobadi, 2014, pp. 337-338). Nevertheless, it is worth of mentioning some other important and interesting indicators (Lim, 2016, p. 11).

The technical indicators can be classified according to number of properties as we see in Figure 18. We can assign them to the basic categories according to price, volume, time or sentiment. Thereafter we can determine the sub-category. The sub-category tells us what properties an indicator is supposed to measure (Kahn, 2008, p. 219).

Figure 18 : Indicators overview

Classification of the Indicators		
Basic Category	**Measures**	**Indicators**
Price	Trend identification	Trend lines and channels Smoothing, Moving average
	Patterns	Triangles, Rectangles, Flags, Gaps Candlesticks
	Momentum	RSI, Departure, Stochastics, MACD Bollinger bands
	Relative levels	Benchmarking, relative strength to market Log scaling
Volume	Participation	Volume, cumulative volume
	Liquidity	Market capitalization, turnover
	Breadth	Up-Down volume Advance-decline Sector analysis
Time	Cycles	Form (translation) Seasonal Economic, political
	Time frame	Short, medium, long Cyclical vs secular
	Extent	Length of trend or base Relation of correlation to trend
Sentiment	Speculation (excesses)	Options activity, put-call ratio Junk bonds, initial public offerings Margin levels, mutual fund cash levels Commitment of traders report Effects of good and bad news
	Consensus	Percent of newsletters bullish or bearish Public opinion
	Anecdotal	Magazine covers Hemlines, Super bowl

Source: Our own illustration according to Kahn (2008), p. 219

The main categories are price, volume, time and sentiment. The majority of modern indicators usually concentrate only on these categories. In addition, the investors use a limited number of technical indicators to predict future prices. Even if it enables them to focus on

development in certain areas then a combination of technical indicators could achieve better results (Kahn, 2008, p. 219).

Price indicators are most important in comparison with indicators from the remaining categories. Professional investors usually put emphasis on the price indicators. This category involves analyzing price patterns as triangles and gaps. Furthermore, it includes the momentum indicators which measure the price momentum. The RSI indicator and rate of change belong to this category. The MACD indicator used in our study and exponential moving averages are also a part of the price indicators (Kahn, 2008, p. 220).

One of commonly used price indicators is also the stochastic oscillator. The stochastic oscillator shows the ratio of the present price as a percentage of the last close price over a specific time period. The interpretation of the buy- and sell- signals is similar to RSI. There are two bounds of 20 and 80 percent. When the stochastic oscillator goes above the 80 percent level the market is overbought and an investor should sell shares. Conversely, the market is oversold if the oscillator crosses the 20 percent line in the opposite direction (Lim, 2016, p. 259).

The Boillinger bands show the investor boundaries that indicate whether the trade is good or bad. It is the most commonly utilized price containment indicator that also belongs to the group of the momentum indicators. It consists of two moving averages with a difference of two standard deviations. If the price of a stock crosses the lower line it means that the prices will go up and a buy signal is issued. If the price index crosses or touched the upper bound then a sell signal is issued (Lim, 2016, p. 478).

Volume is an important measure that market analysts usually combine with other indicators to achieve good results in predicting future movements. The volume consists of three subcategories including participation, liquidity and breadth. The liquidity gives us information about the fact how easy or difficult it will be to sell or buy shares. In addition, it tells us what volume of shares needs to be traded in order to trigger a price change. The higher the liquidity the easier it will be for an investor to perform purchases or to dispose of large numbers of

shares (Kahn, 2008, p. 220). The breadth indicators show us what markets are involved in trading and provides detailed analysis of the money in- and out- flows (Kahn, 2008, p. 220).

The investors can determine the tendencies in a market according to the cumulative volume. If the share prices goes up then the volume is summed up. If the market goes down than the volume is deducted. It is based on the idea that bullish behavior prevails in the market if the volume is higher in the up-days. If the cumulative volume goes down then the volume is higher on the down-dates and it means that the bearish behavior starts controlling the market (Kahn, 2008, p. 112).

The next category involved indicators that analyze the time. There are different amounts of time required to finish certain stage in trading. It takes time to buy and sell shares, the bullish and bearish stages have different time duration. In addition, it can give us valuable information about the stages in the economic cycle. If an investor is able to determine what part of the economic cycle is she in and predict the future development in the market then she is also able to choose the best timing of her investment decisions (Kahn, 2008, p. 220).

The seasonal analysis was one of the first types of the technical analysis used to help the farmers to determine what the best time to plant crops is. As a consequence, it enabled them to maximize the harvest and cover the demand in the winter time (Kahn, 2008, p. 220). The Gebert indicator also tries to exploit seasonal patterns [7]. The share performance in the summer holidays is usually inferior to the rest of the year. It results in a slogan that some investors use: “Sell in May and Go Away” (Kahn, 2008, p. 119).

The newest area still under development is the sentiment analysis. This category is very subjective and the sentiment of people is hard to analyze. It is calculated based on activities as the bullish or bearish opinions of investors. It tries to analyze the bad and good news and monitor the public opinion. It scrutinizes the news in newspapers and on television and tries to put them into context in order to predict future price developments (Kahn, 2008, p. 221).

Actually, the sentiment indicators try to quantify expectations that drive markets. The sentiment is a term that includes all the expectation the investors possess about the future development of prices (Kahn, 2008, p. 123). The easiest forms are surveys. It means the

researchers ask the market participants and investors what they think about the factors that drive stock prices. The interpretation of these surveys is straightforward. When all the investors think in one direction then the market will move into the opposite direction really soon (Kahn, 2008, p. 127). We can imagine that all people think the price of share will rise. They buy shares. The price increases until the market is overbought. The momentum changes and a market moves into the opposite direction.

The put/call ratio as the name suggests tries to identify how many investors bet on rising and plummeting market. If the number of puts is high then the investors believe the market will decline. On the contrary, if a large number of investors buy calls then they suppose the share prices will increase. In both of these cases an analyst interpreting the put/call ratio should go against the opinion of the majority of investors (Kahn, 2008, p. 124).

An interesting indicator based on the feelings of the investors is the magazine cover indicator. It was designed by Paul M. Montgomery. The notion behind the indicator is the fact that the editors will publish such news that can be broadly accepted by the readers. It means that the readers must share the same opinion. They will not write a story about a growing internet market if the audience is not interested in it. When the stories gain broad acceptance then the investors turn to their bullish side. The market analysts can expect a change in the trend of the market in the coming 6 weeks (Kahn, 2008, p. 127).

In addition, there are some indicators that we could denominate as very rare as the Superbowl and hemlines indicators. Superbowl indicator predicts market growth based on the results of the Superbowl in January. If the winner is NFL then the share prices are likely to go up otherwise the stock market declines. However, it is important to mention the basic premise that correlation does not imply causation. It means this observation can be based on pure coincidence (Leinweber, 2007, p. 2). Leinweber (2007) points out that we could find similar relationships also when we look at the phases of moon (Leinweber, 2007, p. 2).

The hemline index is also an interesting indicator that describes the relationship between hemlines on women's dresses and the performance of an economy. It was firstly introduced by the economist George Taylor in 1926. It shows a correlation between a number of women

wearing hemlines and good economic prospects. It implies women start wearing miniskirts if there is a recession. The hemlines on the contrary are a sign of an upcoming economic boom (Baardwijk & Philip, 2010, p. 2).

4.1.1 Moving average

The moving average is a basic indicator. It shows the price of the index during a certain time frame. Usually the investor takes some of the values and divides it by the number of days considered. When we have a moving average of 50.6$ then that means that the average value of the shares was 50.6$ during this period. There are 20-, 30-, 50-, 100- and 200- days moving averages (Larson, 2007, p. 11). The calculation of the moving average is illustrated in the formula 1.

$$M_{t,n} = \frac{1}{n} \sum_{i=t-n+1}^{t} C_i = (C_t + C_{t-1} + \ldots + C_{t-n+2} + C_{t-n+1})/n \qquad (1)$$

$M_{t,n}$ = n-day moving average at t

n = the length of the moving average

C_i = closing price for period i

Figure 19 : Moving average graph

Source: Our own illustration, yahoo finance investment tool from http://finance.yahoo.com/

The difference in the periods considered indicates whether we want to examine long or short-term relationships. The moving average in Figure 19 considers 150 days period and it is used to scrutinize long-term effects and derive long-term relationships. In contrast, 30 days (12days) moving average (a part of the MACD) would be used to display short-term effects. The word "moving" comes from the fact that the value of the indicator for the next day is calculated by moving the calculation by one day into future and thus including one new day (Kahn, 2008, p. 31).

The moving averages can be simple. The simple moving average does not use any weighting technique and it takes the average over a certain period of time. It is a lagged indicator. It means that when an index starts rising and the new values are considerably higher than the historic values the MA indicator will adjust slowly its forecasts to the new observations. The adjustment speed depends then on the days taken into account (Kahn, 2008, p. 59).

The signals usually depend on some crossovers. The simplest signal is when the closing prices of the index chart cross the moving average line. When the index value increases then these crossovers are usually above the average. This means a buy and hold signal is generated. When the index values are above the average it means there is a positive momentum in the market it is a sign that the market gains strength and that the investors are likely to achieve positive returns (Larson, 2007, p. 15).

We can illustrate it on the example of the 30-days simple moving average. When the index values crosses the 30-days MA line downwards then it means that there is a high probability the price would drop even further. On the contrary, when the closing prices of an index rise above the 30-days MA it signals that the market has a high upside potential (Larson, 2007, p. 11).

This technical indicator emits a buy signal when the closing price is higher than the moving average and a sell signal when the closing price drops below the moving average. This method gives good results if the data series has a trend; however; its reliability decreases with rising volatility. There are two types of moving average indicators: the double and the triple moving average (Wong, Meher, & Boon-Kiat, 2003, p. 545).

In addition, investors can use two moving averages for creating buy and sell signals. One example would be to use the 20-day and 10-day averages. When the fast moving average crosses the slower moving average a signal is generated. When the 10-day averages moves across the 20-days MA descending it creates the sell signal. When the 10-days average passes over the 20-days moving average in the opposite direction then a buy signal is generated (Larson, 2007, p. 45).

Some investment experts recommend considering the length of the signals and not to act on signals that are shorter than 3 days. This means that an investor that observes a signal generated by the MA should wait for the confirmation signals in the coming 3 days in order to see whether these signals are reliable. On the other hand, if a signal proves to be long lived and is confirmed the investors may lose 3 days of stock returns and the final pay-off could be somehow lower (Larson, 2007, p. 16).

We could also apply the moving average to volume (Larson, 2007, p. 18). It would enable us to analyze changes in price and also the volume. The quality of a signal also depends on the number of investors that start trading. Usually it is a good signal if the market prices began to grow and there is an increasing number of investors participating on the trades with other words the trade volume growths. Thus the sustainability of the MA signals is based on the investors' future expectations. If they are convinced the future outlook is favorable in the market they are more likely to invest and the prices of shares are going to rise (Larson, 2007, pp. 19-20).

When the MA moves below the average line then it is a sign of the opposite market behavior. The prices are expected to go down. The strength of the signal and its quality also depends on the volume like in the case of a buy signal. When many investors believe there will be and adverse development in the market then the market will experience a deep dive (Larson, 2007, p. 20).

The weighted moving average tries to reduce fallacies of the simple moving averages by giving the analyst the opportunity to choose weights for different time periods. The analyst can for example choose to allocate more weight to the most current observations. Each of

these observations is weighted thereafter the weighted values are added up and the sum is divided by the total of its weights. The weighted average uses the arithmetic weights in contrast to the exponential moving average (Kahn, 2008, p. 59).

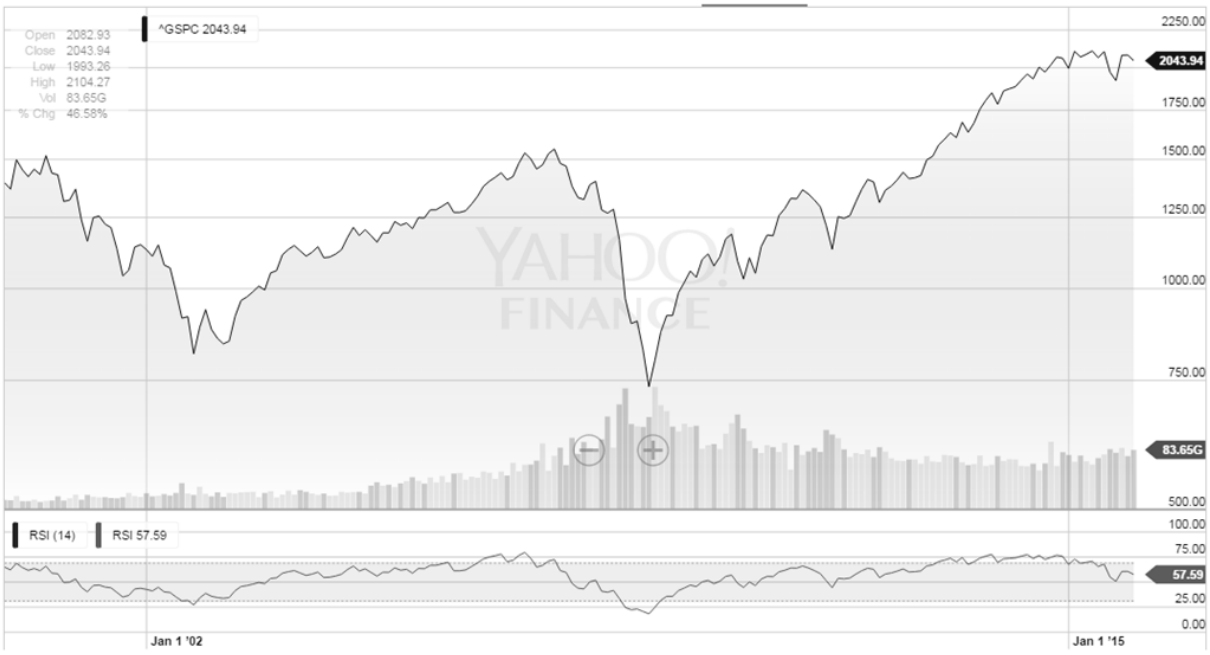
The exponential moving average also assigns weight to the date; however, it works on the basis of geometric weights. The exponential moving average is used as a part of the MACD indicator. Its advantage is that it reacts faster to changes in the value of indexes and it builds a link between the simple and weighted moving averages. However, the main disadvantage is that the signals are less effective. It is not necessary to show here the formula since we will learn about the exponential moving averages later on (Kahn, 2008, p. 60).

We will use a 4, 9 and 13 day triple moving average as used by (Wong, Meher, & Boon-Kiat, 2003, p. 546). The moving average generates a sell signal when the short-term moving average surpasses the long-term moving average. Accordingly, the buy signal is emitted when the short-term moving averages declines below the long-term moving average (Bessembinder & Chan, 1995, p. 261). The mid-term moving average has a purely informative purpose and signals a possible reversal [19].

4.1.2 RSI

The relative strength indicator (RSI) was developed by Welles Wilder, Jr. and it is based on the assumption that fast price changes lead to overbought or oversold markets and create investment opportunities (Kahn, 2008, p. 281). The indicator tells us about the speed of price changes. The relative strength indicator (RSI) is a momentum indicator and one of the most common indicators used in technical analysis (Kahn, 2008, p. 104). We can see the RSI with all the marks from 0 to 100 in Figure 20

Figure 20 : RSI rule graph



Source: Our own illustration, yahoo finance investment tool from http://finance.yahoo.com/

An interesting feature of this indicator is that it can go down (up) even if the price goes up (down). This characteristic distinguishes the RSI from other indicators as the MA. The reason is it can recognize the relative strength of the trends and issues signals just when the price change is strong enough. Nevertheless, it can slow down or drop slightly without generating any signal (Kahn, 2008, pp. 104-105).

There is a difference between RS and RSI. RS means relative strength and it is a relationship between the returns of two different instruments (Kahn, 2008, p. 143). The RSI is an indicator which is very useful for timing decisions. The RS is more suitable to decide which security to choose e.g. Intel or GM. It is also possible to display the RSI on a plot (Kahn, 2008, p. 105).

If we want to see a real inversion of the trend then the strength of the price changes must be substantial in order to trigger reversal of the trend. The RSI indicator needs to be below 20, above 70 or cross the 50 mark. The investor also can choose the threshold according to what fits her data better. The condition for an oversold market is that RSI passes the 50-0 mark. On

the contrary, the market is overbought if the RSI indicator rises above the 50-100 mark (Kahn, 2008, p. 105).

The RSI formula is calculated on the basis of n last periods (Kahn, 2008, p. 282). First we need to calculate absolute gains and losses. Thereafter we calculate the average gain and loss from the past 14 observations. We determine the relative strength as the relation of an average gain and loss. Then we calculate the RSI according to the formula stated below. The value of RSI is then dependent on the power of price changes and also its duration (Lim, 2016, p. 262). We can use the formulas 2-4.

The formula 2 defines the up-closes (U_i) and down- closes (D_i) according to the current (C_i) and the past (C_{i-1}) closing prices. Consequently, if the new closing price is higher than the past closing price for the period i then we obtain an up-close. If the new closing price is lower than the past closing price we observe a down close. The index i is a part of the index set $I_{t,p}$ which can be defined as $I_{t,p} = \{i: t - p \leq i \leq t\}$ (Wong, Meher, & Boon-Kiat, 2003, p. 545).

$$U_i = \begin{cases} C_i - C_{i-1} & if \quad C_i > C_{i-1} \\ 0 \end{cases} \tag{2}$$

$$D_i = \begin{cases} C_{i-1} - C_i & if \quad C_{i-1} > C_i \\ 0 \end{cases}$$

$U_{t,p} = \text{Average of } U_i \text{ over } I_{t,p}$

$U_{t,p} = \text{Average of } U_i \text{ over } I_{t,p}$

We need to determine the relative strength (RS) as a basis of calculating the relative strength index. The RS is a ratio of the up- and down- closes and it is calculated as a moving average over the period of the last 14 days (Wong, Meher, & Boon-Kiat, 2003, p. 545).

$$RS_{t,p} = \frac{\bar{U}_{t,p}}{\bar{D}_{t,p}} \tag{3}$$

$$RSI_{t,p} = 100 - \frac{100}{1+RS_{t,p}} \quad (4)$$

$RSI_{t,p}$ = the relative strength indicator at time t for period p

$RS_{t,p}$ = the relative strength at time t for period p

U_i = up-closes in the period i

D_i = down-closes for the period i

C_i = the closing price for the period i

$I_{t,p}$ = an index set $\{ i: t - p \leq i \leq t \}$

When we analyze the RSI indicators we can also examine the divergences. Divergences are created when the prices go into the opposite direction than the value of the RSI. Divergences signal upcoming reversals and can be a good signal for the investors (Kahn, 2008, p. 32). There are two types of divergences the bullish and bearish divergence. The former one occurs when the RSI value goes up and the prices go down and indicates that the prices will rise soon. The bearish divergences present themselves when the price goes up but the RSI remains unchanged or sinks. It is usually a signal of an upcoming reversal and thus signals future decline in prices (Kahn, 2008, p. 305).

In the case of the calculation of averages a smoothing method is applied. The sum of the losses of the first period is divided by 14. We multiply the last value by 13, thereafter add the value of a new observation and divide the whole sum of values by 14. This creates a smoothing effect and it is one of the reasons why the RSI is sensitive to the length of the period (Lim, 2016, p. 262).

When comparing with stochastics the RSI still gives better results when we deal with trending markets. In the case the markets are flat then it is better to use stochastics. The reason is RSI was designed for a different objective. It tells the investor whether the prices moved too fast too far into a certain direction (Kahn, 2008, p. 283).

The RSI can be also effective with the combination of other indicators for example Time-Segmented Volume. TSV is a leading indicator which is under the copy right of the Worden Brothers (Larson, 2007, p. 61). Interestingly, the formula of TSV is kept in secret and the values are available just upon buying a tool from Worden Brothers. Larson (2007) claims that the RSI does not make reliable predictions if used alone. This finding was also reported in Wong et al. (2003).The combination of TSV and RSI allows him to make good predictions in 90 % of cases (Larson, 2007, p. 71).

There are several types of the RSI based on the touch, peak, retracement and 50 Crossover techniques (Wong, Meher, & Boon-Kiat, 2003, p. 545). The first three methods work with two bounds, the upper bound of 70 and the lower bound of 30. The upper bound indicates that the market is overbought thus the indicator generates a buy signal. The lower bound implies that the market is oversold and generates the buy signal (Wong, Meher, & Boon-Kiat, 2003, p. 545).

Anderson and Li examine whether the RSI is profitable. As many studies indicated the RSI displays disappointing results considering the 20 and 70 rule. Nevertheless, they can generate small profits by changing the threshold. Already the 20 and 80 rule makes a small profit of 0.02387 %. Surprisingly, it comes at a great cost. The biggest recorded loss is 0.02442 % and consequently even higher than the total profit. The investors need to be patient and put up with high losses for realizing small profits (Anderson & Li, 2015, p. 94). That is why we use the most broadly used form in the literature the 50 crossover method (Wong, Meher, & Boon-Kiat, 2003, p. 550).

4.1.3 MACD

The moving average convergence divergence MACD is a momentum indicator that shows the most convincing results according to recent studies. The research indicates that moving averages usually perform better than other indicators (Chong & Ng, 2008, p. 1112). It relies on the existence on a momentum. Kahn (2008) compares it to a momentum in physics likening it to the strength of a motion. The markets usually are stagnant or they move unless they act on the influence of an outside factor or force. The momentum indicators are based on

the speed and strength of the trends. Apart from MACD the RSI also belongs into the group of the momentum indicators (Kahn, 2008, p. 138).

Garald Appel used a simple departure oscillator in order to create the MACD. She added two moving averages and considered the distance among them. The indicator was called moving average convergence and divergence because the moving averages she used in his study either got closer (converge) or became more separated (diverge) (Kahn, 2008, p. 288). The indicator works with two exponential moving averages (EMA's), standardly the 12 days exponential moving average and the 26 days exponential moving average. MACD emits a buy signal when it cuts the zero axes from below. We can see an example of the triple moving average in Figure 21. In the case the MACD passes over the 0 line from above then a sell signal is generated (Chong & Ng, 2008, p. 1112).

$$MACD\ {}_t^{l,s} = EMA\ {}_t^{s} - EMA\ {}_t^{l} \quad (5)$$

$$EMA\ {}_t^{n} = \left[\frac{2}{n} * (P\ {}_t - EMA\ {}_{t-1})\right] + EMA\ {}_{t-1} \quad (6)$$

EMA_t = exponential moving average at time t

n = the number of periods for EMA

s, $l \in n$ = s describes the short EMA, l the long EMA, in our case $s = 12$ and $l = 26$

P_t = closing price on day t

Figure 21 : MACD rule graph

Source: Our own illustration, yahoo finance investment tool from http://finance.yahoo.com/

We can imagine the momentum indicator as a ball that we throw in the air. When the ball is ascending it loses its speed until its trajectory changes the direction and it starts falling down and the speed increases as the ball closes to the ground. It is the same like the share market, the trends start losing strength, the rate of return decreases until the trend is reversed and market begins to fall (Kahn, 2008, p. 138). There are two expressions that are usually brought into the context with the momentum: overbought and oversold (Kahn, 2008, p. 32). These terms mean that the market reached its boundaries and the market behavior is likely to change and the prices will go into the opposite direction (Kahn, 2008, p. 291).

The term overbought means that many investors have acquired the shares. However, such a behavior of the investors caused tremendous price increase that does not confirm to the fair asset prices. Consequently, the market behavior is likely to reverse and the prices will sink.

The term oversold means that the investors in their reaction to the falling share prices sold large quantities of shares. As a result, the share price plummeted and went below the fair price of shares (Kahn, 2008, p. 291).

We can make the best use of the MACD indicator in markets with an apparent trend or a volatile market. As we have mentioned previously MACD uses exponential moving averages that are very sensitive to price changes. Consequently, when we use this indicator in very volatile market we achieve better results than with simple or weighted moving averages. Nevertheless, the MACD performs rather poorly in stagnant markets with no up and down movements (Kahn, 2008, p. 289).

This characteristic can be put into the relation with the MACD signal line. When the investors see that a MACD and signal line passes the zero line it is a sign that the trend changes its direction. When we see divergence then crossover and then the MACD passes over the zero line then it constitutes strong evidence that there is a new trend in effect (Kahn, 2008, p. 292).. It is the biggest competitor of the Gebert indicator in our study.

4.2 The Gebert indicator

The Gebert indicator was invented and certified by Thomas Gebert in 2006. The indicator is based on four variables. These comprise the last inflation rate determined by Eurostat for the European Union (P1), the dollar value (P2), interest rate announced by the European Central Bank (P3) and the index gets one addition point (P4) when the date is between the first November and 30th of April. According to the statement of Thomas Gebert the investors could achieve superior returns of 2347 per cent on their portfolio by using the indicator in period from 1996 to 2015. In comparison to the indicator, the DAX had increased only by 344 per cent in the same time span [7].

The definition of the algorithm where TSP denominates the total sum of points and TF the total function:

$TF: \mathrm{TSP} = P1 + P2 + P3 + P4$

$if\ \mathrm{TSP}\ \{\ 0, 1\ \}\ then\ buy$

if TSP $\{ 2 \}$ $then\ hold$

if TSP $\{ 3, 4 \}$ $then\ sell$

Gebert and Calender effects

Research indicates that the calendar effects can have influence on the share prices. Some of the most discussed calendar effects are the pre-holiday effect, Monday effect and January effect. The pre-holiday effect implies that the share prices are higher before and after holidays and decline during the holiday time. The Monday effect suggests that the share prices are lower on Monday than during the week (Lean, Smyth, & Wong, 2007, p. 126). The January effect is an irregular behavior of a market indicating that common stock prices are higher in January than in other months (Lean, Smyth, & Wong, 2007, p. 127).

A significant pre-holiday effect was confirmed in the recent studies for the three major stock exchanges in Hong Kong, USA and GB. The results in Figure 22 show that the effect was strongest in Hong Kong, the effect was moderate in GB and weak in the United States. It can give a hint about possible reversal in some time periods. Nevertheless, the consideration of the whole time frame provides significant results (Chong, Hudson, Keasey, & Littler, 2005, p. 1231).

Figure 22 : Preholiday effect

Period 1973–2003	Hang Seng	S&P500	FT30
Panel A: means and standard deviations			
Non-pre-holiday days			
Mean	0.0358%	0.0297%	0.0198%
Standard deviation	1.9665%	1.0458%	1.2630%
Number of days	7242	7460	7544
Pre-holiday days			
Mean	0.4608%	0.1326%	0.1771%
Standard deviation	2.1244%	0.8628%	0.8909%
Number of days	300	250	178
t-Statistic for difference of the means[a]	$t = 3.405$***	$t = 1.840$*	$t = 2.302$**
Ratio of pre-holiday returns to non-pre-holidays	12.87	4.46	8.95
Panel B: frequency of advances			
Positive return days among total days	3859	3985	3925
Fraction positive return days among total days	0.5117	0.5169	0.5083
Positive return days among pre-holiday days	195	145	104
Fraction positive return days among pre-holiday days	0.6500	0.5800	0.5843
χ^2-Statistic[b]	22.439	3.856	4.044
t-Statistic[c]	$t = 4.737$***	$t = 1.964$**	$t = 2.011$**

*Significant at 10% level; **significant at 5% level; ***significant at 1% level.

Chang et al. (2005), Table 2, p. 1231

There is increasing evidence that the calendar effects are not sustainable and some of them are disappearing. Lean et. al (2007) investigates the calendar affects in the stock markets of seven Asian countries. He finds out that the January effect is largely disappearing. The Monday effect is as strong as in the past and did not undergo any major changes (Lean, Smyth, & Wong, 2007, p. 139). In addition, there is evidence that the pre-holiday effect became much weaker than in the late 1990s in the United States (Chong, Hudson, Keasey, & Littler, 2005, p. 1234).

Chon et al. examine whether the pre-holiday anomaly altered in the recent years. They divided the time frame into sub periods with the most recent period of 1997-2003. They find out that the strength of the phenomenon continuously declines. There is no evidence of the pre-holiday anomaly in the UK market. The study of the US market showed weak but insignificant relationship at the 10 % level from 1997-2003. However, it would not be the first reversal. Interestingly, the study shows significant negative relationship in the period from

1991-1997. That means the pre-holiday effect was negative in this time period (Chong, Hudson, Keasey, & Littler, 2005, p. 1235).

The pre-holiday effect is one of the anomalies that were extensively documented in the USA (Chong, Hudson, Keasey, & Littler, 2005, p. 1227). The explanations of the phenomenon are based on many different theories. The most viable ones state that some investors prefer buying before their holiday time. There might be also psychological effects of good mood before the holiday time. People are in a good mood in anticipation of their holidays. Nevertheless, Chong et al. examines the past literature on this anomaly and states that there is no unique and unambiguous cause (Chong, Hudson, Keasey, & Littler, 2005, p. 1228).

Gebert and inflation

The studied dedicated to the examination of the relationship between the inflation and stock prices provide the evidence that there is a negative relationship between the stock market and the inflation (Zhao, 1999, p. 509). Fama (1981) documents this negative correlation between the stock returns and inflation. According to the research, the inflation as the approximation of the economic activity and the output gives information about future stock prices. It is an indirect relationship since the investors are in fact interested in the output of companies (Fama, Stock returns, real activity, inflation, and money, 1981, p. 559).

The stock prices increase when the inflation declines since the stock returns are a reflection of the industrial activity (Fama, Stock returns, real activity, inflation, and money, 1981, p. 560). Fama (1981) uses the money demand model to determine the relationship between inflation, demand for money and interests. He argues that there is a negative relationship between demand for money, industrial activity and the inflation rates. This has as a consequence a positive relationship between changes in inflation and interest rates (Fama, Stock returns, real activity, inflation, and money, 1981, p. 560).

We need to imagine these changes as the incremental increase in the interest rate. The central bank will decrease interest rates when the inflation and the industrial activity are low to give the investors access to cheap money lending, boost the economy and increase the inflation. When the inflation is too high a central bank will increase interest rates (Fama, Stock returns,

real activity, inflation, and money, 1981, pp. 548-549). Zhao (1999) and Caporale & Jung (1997) confirm the findings of Fama (1981) and the relationship between the economic activity, inflation and share prices.

Some research puts emphasis on the differences between the long and short term effects (Anari & Kolari, 2001, p. 587). The investigation of the effects shows that there is a significant difference between the long term effect of inflation and short term effect changes in inflation. A short-term change of the inflation will have a negative repercussion on a stock market. However, growing commodity prices and constant inflation over long period of time has a positive effect on the stock prices (Anari & Kolari, 2001, p. 601). The study does not examine the effects of extremely high inflation or hyperinflation.

It is generally known that the interest rates have an inverse effect on the stock prices. If the interest rates rise then it becomes less attractive to buy securities and increasingly more attractive for the investors to keep the money in a bank. If the interest rates become lower than the central bank will give the investors an access to cheap lending. It decreases the cost of investments thus enticing the investors to purchase stocks and other securities (Blanchard, 1981, p. 141).

The studies show consensus that interest rates are negatively correlated with the returns on shares. Flannery and James (1984) go further and also examine the effects of the maturity of the company's net assets, the interest rates and share prices. They find a negative co-movement of the interest rates and the share prices and a positive relationship between the maturities of the net assets.

Gebert and the exchange rate

Already in 1981 Aggarwal found positive correlation between the exchange rate of the USD and the US stock markets. On the contrary, some recent studies discovered a negative relationship between the strength of the dollar and the exchange rates. The results of the recent studies are presented below showing the inconsistencies found in the research on exchange rate effects.

The study of Bernard and Galati (2000) shows that a strong dollar has a positive impact on all worldwide markets and that leads to higher share prices as the world stock markets are highly correlated. Nevertheless, the study does not reach an agreement on the strength of the effect and the price of the shares. They state that the correlation is not as strong as they expected. They also find positive correlation between daily and weekly increases of the exchange dates and American and Japanese markets with a correlation coefficient of 0.04 and 0.07 respectively. The monthly and weekly correlation coefficients are not significant (Bernard & Galati, 2000, p. 32).

In addition, they also found the evidence that an increase in the real USD exchange rate shows the opposite effect in particular significantly negative relationship between strong dollar and DAX value. That means that German market growth is linked with weak US dollar which is in contrast to the fundamentals of the Gebert indicator (Bernard & Galati, 2000, p. 32). Furthermore, Ajayi and Mougoue (1996) suggest that there is not effect of the exchange rates on stock prices. On the contrary, stock prices are the leading indicator for exchange rates. Consequently, an increase in the stock prices will lead to appreciation of the dollar but a dollar appreciation will not cause the stock prices to grow (Ajayi & Mougouė, 1996, p. 205).

Kim (2003) finds out that there is a negative effect of the dollar exchange rate on the S&P 500 performance. The study provided solid evidence that the dollar value, inflation and interest rates are negatively correlated with the share value. The industrial production index has a positive influence on the S&P value. The variance decomposition analysis in this study suggests that the stock prices are mostly influenced by the interest rate and that the exchange rate influences stock prices indirectly over the inflation (Kim, 2003, p. 312).

All in all, the results of the scientific research on the effects of the inflation prove to be inconclusive. On one hand, there is evidence that a strong local currency has negative medium and long time effects. There is a moderating short-terming effect but the currency depreciation leads to more expensive import and higher inflation which has a negative impact in stock markets (Granger, Huangb, & Yang, 2000, p. 346). On the other hand, some studies support the notion that weak currency can favor economies that are based on exporting goods like China or Germany (Granger, Huangb, & Yang, 2000, p. 347). In that case, the effect on

the stock market would be positive and in consistent with the fundamentals of the Gebert indicator.

The Gebert indicator and crisis

The prime mortgage crisis was one of the most serious crises in the world in the last 20 years. The major world economies needed at least 2 weeks so that the real GDP growth returned to its pre-crisis levels. Some countries experienced a decline of 2 % of the real GDP other countries even 5 % (Japan, Spain, Norway, Sweden) (Davis & Karim, 2008, p. 1).

In contrast to the Gebert indicator, the researchers usually use other variables to predict the prime-mortgage crisis. The studies use the housing prices, real equity prices, real GDP growth, current account balance and public debt to determine whether the crisis could be successfully predicted (Reinhart & Rogoff, 2008, pp. 340-342). The results suggest that a crisis could be successfully predicted by using at least a part of the financial variables (Reinhart & Rogoff, 2008, p. 343).

Nevertheless, some of the variables used by Gebert could be employed. The inflation was higher before the crisis than during the crisis. The interest rates also were higher and declined after the crisis first. Although the results had the expected sign and are in accordance with the Gebert indicator, the regression coefficients were not significant. The empirical observations show that only changes in the trade and GDP growth had negative and significant results on the predictions (Davis & Karim, 2008, p. 8).

5 Research and Hypothesis

5.1 Hypothesis and methodology

1) It is possible to achieve excess returns with technical indicators in international stock markets

We will use the daily closing prices from international stock exchange indexes that will take into consideration the last 20 years. These indexes will include S&P 500, DAX, FTSE 100,

NIKKEI 225, and Euro Stoxx 50. The sample will be divided into three sub periods reporting separately the subprime mortgage crisis. We will use the test statistic t to determine whether the investors are able to achieve significantly positive results.

The excess returns will be determined on the basis of statistically significant differences between the returns on the sell- and buy- days. In contrast to the performance of the Gebert indicator we will not assume that the portfolio will be reinvested at the prime lending rate. The reason is simple, we want to achieve a degree of comparability between the past studies on technical indicators and their methodology does not take into account any interest bearing reinvestments.

T-statistics for buy-signals:

$$x_{buy} = \frac{\mu_r - \mu}{\sqrt{\frac{\sigma^2}{N} + \frac{\sigma^2}{N_r}}} \quad (8)$$

It follows the research of Brock et al. (1992) where μ is the mean return of buying and hold strategy, N is the number of observations for buying and selling signals. The sub-index r denotes either the buy or the sell signal; s denominates the sell signal and b refers to the buy signal. The sigma squared (σ^2) is the variance of the whole sample (Chong & Ng, 2008, p. 1113).

T-statistics for sell-signals:

$$x_{sell} = \frac{\mu_b - \mu_s}{\sqrt{\frac{\sigma^2}{N_b} + \frac{\sigma^2}{N_s}}} \quad (9)$$

The t-test requires independent, stationary and asymptotical normal distribution. These prerequisites usually cannot be fulfilled. However, we can use bootstrapping which was introduced to the financial analysis by Efron (1979). This method is widely used in the current literature to create simulated time series. In our case we use this method to produce simulated indexes (Vasiliou, Eriotis, & Papathanasiou, 2006, p. 86).

The bootstraps are determined by sampling with replacement. That means by randomly selecting data from the original series thus constructing a new pseudo series. We employ the technical indicators on the simulated indexes and calculate the returns for each indicator across all indexes. Thereafter we compare how many of these simulated series have larger or same excess return of the sell and buy signals compared to the original series (Marshall & Cahan, 2005, p. 389).

2) The indicators are able to predict price movements

The technical indicators are good predictors of future stock prices if the returns obtained from the buy signal do not defer significantly from the returns generated by the sell signal (Bessembinder & Chan, 1995, p. 263). We also use the t-test to determine whether there are significant differences between these returns (Vasiliou, Eriotis, & Papathanasiou, 2006, p. 97).

Furthermore, some studies showed that there can be differences in obtaining significant numbers considering different time periods (Wong, Meher, & Boon-Kiat, 2003, p. 546). As a result, we consider four different time periods namely five, ten, twenty and thirty days according to Wong et al. (2003). These intervals define the time duration of the signals.

3) Gerbert indicator can achieve superior returns in comparison to common technical indicators.

We compare each indicator with the returns of trading signals obtained by the Gebert indicator. The summary of the results will be displayed on the basis of multiple comparisons ANOVA. This statistical method is used if we compare the variances of more groups across the same measure (Ghobadi, 2014, p. 341). We can determine whether the Gebert indicator has superior returns in the Analysis of Variance table (Ghobadi, 2014, p. 345).

We slightly change our approach in the case of the Gebert indicator. We will adopt our methodology and assume that the portfolio will be reinvested at the prime lending rate published by the European Central Bank. The underlying reason is that the lending rate

should be comparable in all countries so that we do not discover significant differences owing to the differences in the lending rates in the countries but based on the performance of the Gebert indicator only.

5.2 Data and bootstrapping

We obtained the data on closing dates from the Federal Reserve portal. The Gebert indicator is not based on the index values. Its calculations requires large amount of input data. The exchange rates also come from the same data portal of the Federal Reserve. The inflation data were downloaded from the OECD database the interest rates were downloaded from the European Central Bank, FED reserve, Bank of England and Bank of Japan.

The London stock exchange had less closing days than other stock exchanges. Consequently, we have with 5203 most observations of all the indexes. The data include 5097 observations from Eurostoxx and 5078 observations for DAX. These are followed by S&P with 5035 observations. As we have mentioned previously, the Japanese stock exchange had most holidays and closing dates and thus our data set provides 4924 observations.

The price series downloaded from yahoo finance gives us historical data on daily closing prices, volume, high, low and adjusted close prices. We use the adjusted closing prices according to the standards of Center of Research in Security Prices (CRSP) because these prices are without any distortion and they are better suited for technical analysis [20].

We used the student premium edition of the IBM SPSS Statistics software for the ANOVA and t-statistics. This version enabled us to do all the ANOVA and t-tests necessary for determining the significance of the buy- and sell-signals. It includes some advanced features as bootstrapping techniques for testing the robustness of our models. In addition, it features some forecasting and advanced sampling models. The data can be directly exported to Excel [8].

Some studies assume normal distribution of the logarithmic returns and the series to be a lognormal random walk. The authors of these studies use the t-test without performing the bootstrapping. There are numerous studies using t-statistic without testing for normal distribution. These include the research of Anderson & Li (2015) on the RSI indicator, Chew

& Wong (2003) on technical analysis and Chong & Ng (2008) analysis of the RSI and MACD on the London stock exchange.

According to Ruppert (2011) the bell shaped curve is in many cases similar to the normal distribution and that the t-test can be used. Although the tails of the log returns tend to be heavier, usually the t-distribution with fewer degrees of freedoms follows the normal distribution. Nevertheless, the log-return distribution seems to be symmetrical (Ruppert, 2011, p. 9). This can be also confirmed with our research.

Figure 23 : Normality tests

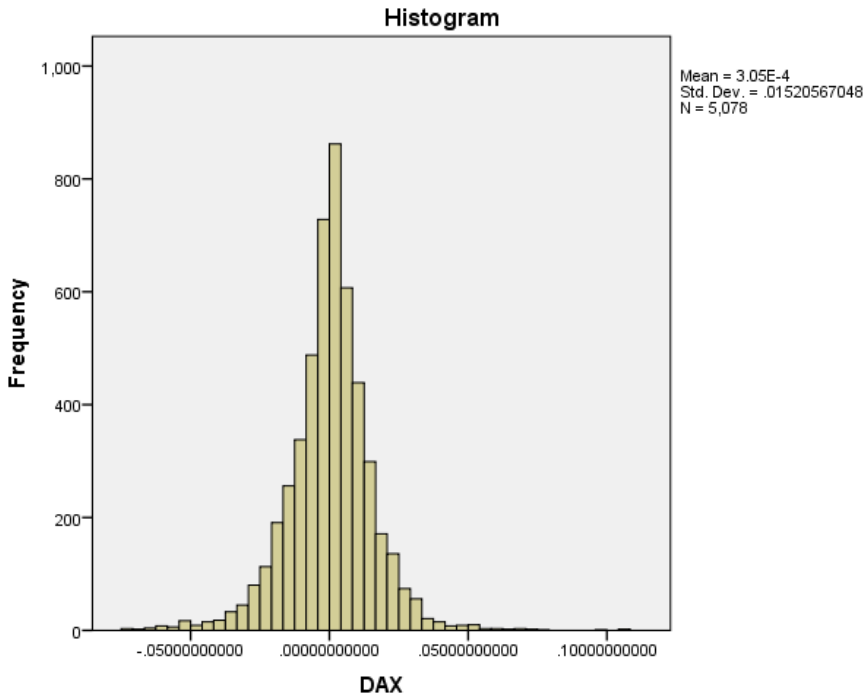
Tests of Normality			
	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
DAX	.076	5078	.000
S&P	.083	5035	.000
FTSE	.072	5203	.000
Eurostoxx	.071	5097	.000
Nikkey	.065	5203	.000

a. Lilliefors Significance Correction

Source: Our own illustration in SPSS

As an example we show the distribution of the DAX index in Figure 24. We can notice that it has the typically bell shaped curve that is similar to normal distribution. However, it is not identical to normal distribution which was confirmed by the Kolmogorov-Smirnov test of normality in Figure 23. According to this test we can see that neither of the stock indexes displays normal distribution. All the statistics are below the 0.05 significance level.

Figure 24 : Histogram DAX



Source: Our own illustration in SPSS

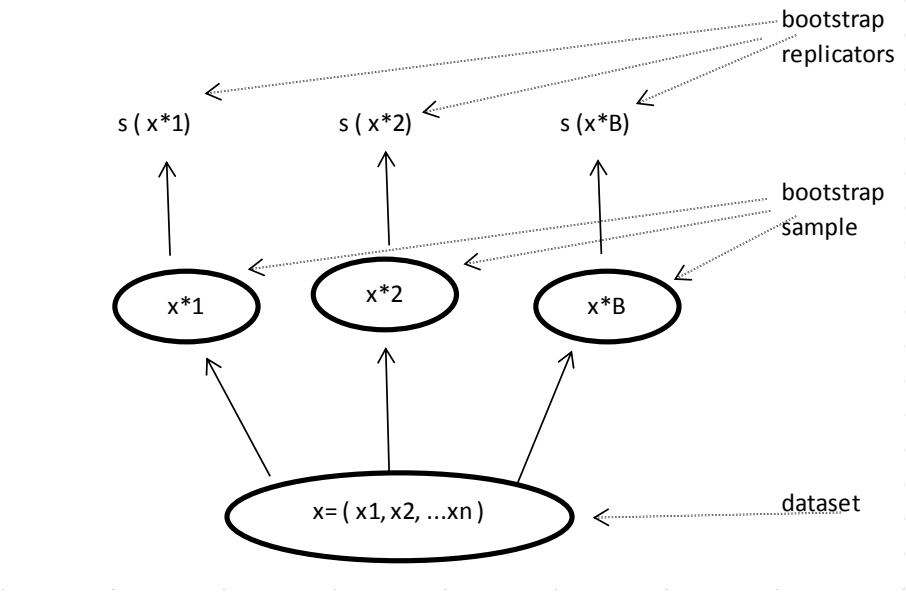
Therefore we also perform the bootstrapping test. The bootstrapping technique follows the research of Efron (1979), namely, the resampling method with replacement. That means we will build a new series from the original data by taking straps from the original series and repositioning them. Finally, we compare the data obtained by bootstrapping with the original series.

We can generate a bootstrap by taking a random sample from the original data series. If we want to create a sample of the length n=7 we could get $x^* = (x_5, x_7, x_5, x_3, x_4, x_2, x_7)$ from the original data series $x_1, x_2, \ldots, x_n$. We start with generating a random number with VBA; the random number determines the position of the value that will become a part of the new bootstrap sample. The first value will be identical to the value of the index 20 years ago so that all the samples have equal base (Efron & Tibshirani, 1994, p. 12).

Figure 25 describes the calculation of the standard error for different random samples. The bootstrap samples of the length 1 to B are created from the original data series. The bootstrap

replications s(x*1), s(x*2), s(x*B) are created by computing the standard deviation for each sample. These deviations can serve as an estimate of the standard error (Efron & Tibshirani, 1994, p. 13).

Figure 25 : Bootstrap Replications and standard error



Source: Our own illustration citing Efron & Tibshirani (1994),p.13, Figure 2.1

6 Empirical Results

6.1 Prediction of price movements

An indicator is able to forecast price movements if the differences between the buy- and sell-signals are statistically significant. The buy-signals must be positive and sell-signals negative. We use the t-test to determine the statistical significance of the results. The t-test was used in the majority of studies on technical analysis. This test is used to analyze the data and determine whether there is a statistically significant difference between the sell and buy signals. The p-value of the differences between the buy- and sell-signals is stated in tables and we highlight the 2 % and 5 % significance levels.

We can see the results of the data analysis for the DAX indicator in Figure 26. The data set was divided into two time periods. The first period includes all the observations or all data.

The second period describes the sub-prime mortgage crisis (SMC) and shows the performance of the technical indicators. It is realistic to assume that the indicators that performed best in the crisis are also the same indicators that performed best in the whole time period.

If we consider all the data for the whole time period we can see that most of the buy- and sell-signals are different and statistically significant at the 2 % level with exception of the whole time period of MA and the Gebert indicator. However, the buy- and sell-signals of the RSI and MA have the incorrect or opposite signs. That means that the RSI indicator could not be used to forecast price movements. An investor would make positive returns if she or he switched all the buy- and sell-signals.

The buy-signals of the moving average also have the incorrect sign. If we take a look at the whole time period then we can see that the difference between buy- and sell-signals is not statistically significant. Nevertheless, the buy- and sell- signals display statistically significant differences in the five, ten and thirty day periods. As a consequence, the moving average is a bad predictor of the future stock market behavior and an investor should avoid it.

The Gebert indicator is one of the exceptions that we might encounter. Although the buy- and sell-signals have the correct signs, the results with the p-value of 0.108 are not statistically significant. The investor cannot rely on the Gebert indicator in the German market as a good predictor of the future stock price development. It seems that the underlying fundamentals of the Gebert indicator are random and it is not possible to forecast the price movements using the Gebert indicator.

Figure 26 : Prediction of price movements in DAX

			All data				SMC			
Index	Indicator	Period	Mean-B	Mean-S	Mean-BS	p-Value	Mean-B	Mean-S	Mean-BS	p-Value
DAX	MA	Whole	0.000207	0.000090	0.00012	.584	-0.000616	-0.000619	0.00000	.998
		5	-0.000237	0.000447	-0.00068	.001**	-0.001370	-0.000211	-0.00116	.286
		10	-0.000520	0.000708	-0.00123	.000**	-0.001361	0.000252	-0.00161	.117
		20	-0.000314	0.000540	-0.00085	.000**	-0.000576	0.000254	-0.00083	.213
		30	-0.000083	0.000314	-0.00040	.000**	-0.000195	0.000000	-0.00019	.321
	RSI	Whole	-0.001304	0.001599	-0.00290	.000**	-0.002362	0.001127	-0.00349	.002**
		5	-0.001022	0.001272	-0.00229	.000**	-0.002357	0.000963	-0.00332	.003**
		10	-0.000960	0.001209	-0.00217	.000**	-0.002353	0.001005	-0.00336	.001**
		20	-0.000538	0.000875	-0.00141	.000**	-0.001304	0.000713	-0.00202	.010**
		30	-0.000268	0.000540	-0.00081	.000**	-0.000266	0.000589	-0.00086	.040*
	MACD	Whole	0.001103	-0.000810	0.00191	.000**	0.001050	-0.002285	0.00333	.003**
		5	0.001146	-0.000847	0.00199	.000**	0.001116	-0.002251	0.00337	.002**
		10	0.001091	-0.000896	0.00199	.000**	0.001033	-0.002243	0.00328	.002**
		20	0.000664	-0.000572	0.00124	.000**	0.000914	-0.001619	0.00253	.003**
		30	0.000269	-0.000164	0.00043	.000**	0.000948	-0.000318	0.00127	.016**
	Gebert	Whole	0.000324	-0.000019	0.00034	.108	-0.000092	-0.001143	0.00105	.351
		5	0.000324	-0.000019	0.00034	.108	-0.000092	-0.001143	0.00105	.351
		10	0.000324	-0.000019	0.00034	.108	-0.000092	-0.001143	0.00105	.351
		20	0.000324	-0.000019	0.00034	.108	-0.000092	-0.001143	0.00105	.351
		30	0.000324	-0.000019	0.00034	.108	0.000005	-0.001143	0.00115	.302
*with the 5 % significance level **with the 2 % significance level										

Source: Our own calculation

We can see that the MACD has the correct sign of the buy-signals in the time of the crisis. The differences between the buy and sell signals of the MACD indicator are significant at the 2 % level. Consequently, the MACD can be used to forecast price movements also in the time of the crisis. The RSI also shows significant differences between buy- and sell-signals. However, the buy-signals have the negative or incorrect sign. As a result, investors would make losses instead of profits.

The results considering the Eurostoxx index are similar to the German market and presented in Figure 27. We can see this phenomenon due to the fact that the markets are intercorrelated and many German companies are also the part of the Eurostoxx index. In addition, all the companies in the Eurostoxx form a part of the European monetary union which leads to the same prime lending interest rates.

We can observe that the MACD and the Gebert indicator have correct signs of the buy and sell signals in the case of the Eurostoxx index. The MA and RSI show incorrect or opposite signs. The buy-signals of the RSI and MA are negative with exception of the moving average for the whole data period. The sell-signals have a positive signs. It means an investor would make losses by following the signals of these two indicators.

Figure 27 : Prediction of price movements in Eurostoxx

			All data				SMC			
Index	Indicator	Period	Mean-B	Mean-S	Mean-BS	p-Value	Mean-B	Mean-S	Mean-BS	p-Value
EUROSTOXX	MA	Whole	0.000275	-0.000129	0.000404	.050	-0.001132	-0.000387	-0.000745	.521
		5	-0.000202	0.000272	-0.000473	.014**	-0.001673	-0.000186	-0.001488	.188
		10	-0.000458	0.000539	-0.000998	.000**	-0.001737	0.000165	-0.001902	.078
		20	-0.000320	0.000417	-0.000737	.000**	-0.001209	0.000162	-0.001371	.066
		30	-0.000068	0.000262	-0.000330	.000**	-0.000325	0.000000	-0.000325	.147
	RSI	Whole	-0.001326	0.001472	-0.002797	.000**	-0.002606	0.001088	-0.003694	.001**
		5	-0.001035	0.001097	-0.002131	.000**	-0.002468	0.000843	-0.003311	.002**
		10	-0.000967	0.001014	-0.001981	.000**	-0.002507	0.000848	-0.003355	.002**
		20	-0.000624	0.000708	-0.001333	.000**	-0.001455	0.000516	-0.001971	.012**
		30	-0.000275	0.000371	-0.000646	.000**	-0.000392	0.000516	-0.000908	.026**
	MACD	Whole	0.001006	-0.000864	0.001871	.000**	0.000838	-0.002356	0.003195	.006**
		5	0.001020	-0.000889	0.001909	.000**	0.000906	-0.002223	0.003129	.006**
		10	0.000973	-0.000869	0.001842	.000**	0.000912	-0.002240	0.003152	.006**
		20	0.000698	-0.000425	0.001123	.000**	0.001006	-0.001584	0.002590	.003**
		30	0.000320	-0.000040	0.000360	.000**	0.000790	-0.000418	0.001208	.004**
	Gebert	Whole	0.000227	-0.000074	0.000301	.145	-0.000191	-0.001327	0.001136	.328
		5	0.000227	-0.000074	0.000301	.145	-0.000191	-0.001327	0.001136	.328
		10	0.000227	-0.000074	0.000301	.145	-0.000191	-0.001327	0.001136	.328
		20	0.000227	-0.000074	0.000301	.145	-0.000191	-0.001327	0.001136	.328
		30	0.000227	-0.000074	0.000301	.145	-0.000191	-0.001327	0.001136	.328
*with the 5 % significance level **with the 2 % significance level										

Source: Our own calculation

The analysis of the data in the sub-prime mortgage crisis does not provide us with any major differences to the results in the German market. The moving average has the correct sign of the buy-signals for the whole and five day period. However, the differences between buy and sells are not statistically significant. The RSI shows statistically significant differences but the signals have the incorrect signs. Also in this market the differences between buy- and sell-signals are negative in the case of the RSI. It means these investment strategies are not profitable.

On the contrary, the MACD and the Gebert indicator produce best results. Nevertheless, the p-value of the differences between buy- and sell-signals indicates that the Gebert indicator is not able to predict price movements. Only the MACD can be used by investors to forecast price movements. Interestingly, the MACD shows even better predictive power if we consider all the data. The rule can be particularly effective to predict short-term movements because the mean daily returns decline with rising length of the signals. Accordingly, if we consider shorter (or all) signals we can perceive higher benefits than if we consider longer signals (30 days and more).

The S&P shows a similar pattern as the European and German stock exchange markets as we can see in Figure 28. The MA and RSI are inferior to the MACD and Gebert. They have incorrect signs of buy and sell signals with exception of the whole data set and the moving average. Nevertheless, an investor still could not achieve any positive returns on the signals generated by this indicator. The MACD and the Gebert indicator both have correct signs of the buy- and sell-signals. However, only the differences of the MACD indicator are statistically significant at the 2 % level.

Figure 28 : Prediction of price movements in S&P

			All data				SMC			
Index	Indicator	Period	Mean-B	Mean-S	Mean-BS	p-Value	Mean-B	Mean-S	Mean-BS	p-Value
S&P	MA	Whole	0.000265	-0.000024	0.000290	.096	-0.000767	-0.000435	-0.000332	.784
		5	-0.000057	0.000256	-0.000313	.059	-0.001204	-0.000008	-0.001196	.313
		10	-0.000322	0.000450	-0.000772	.000**	-0.001383	0.000269	-0.001652	.142
		20	-0.000240	0.000366	-0.000606	.000**	-0.000871	0.000299	-0.001170	.149
		30	-0.000176	0.000214	-0.000390	.000**	-0.000871	0.000000	-0.000871	.242
	RSI	Whole	-0.001064	0.001304	-0.002368	.000**	-0.002681	0.001480	-0.004161	.001**
		5	-0.000728	0.001007	-0.001735	.000**	-0.001859	0.000865	-0.002725	.015**
		10	-0.000684	0.000899	-0.001583	.000**	-0.001859	0.000682	-0.002541	.021**
		20	-0.000466	0.000633	-0.001099	.000**	-0.001355	0.000558	-0.001913	.027*
		30	-0.000246	0.000446	-0.000692	.000**	-0.001049	0.000413	-0.001462	.079
	MACD	Whole	0.000816	-0.000588	0.001404	.000**	0.000827	-0.002028	0.002855	.018**
		5	0.000834	-0.000624	0.001458	.000**	0.000854	-0.002153	0.003007	.012**
		10	0.000790	-0.000664	0.001454	.000**	0.000697	-0.002157	0.002854	.012**
		20	0.000557	-0.000339	0.000896	.000**	0.000560	-0.001421	0.001981	.029*
		30	0.000173	-0.000208	0.000381	.000**	0.000111	-0.001348	0.001460	.068
	Gebert	Whole	0.000167	0.000069	0.000098	.573	-0.000132	-0.001069	0.000938	.439
		5	0.000167	0.000069	0.000098	.573	-0.000132	-0.001069	0.000938	.439
		10	0.000167	0.000069	0.000098	.573	-0.000132	-0.001069	0.000938	.439
		20	0.000167	0.000065	0.000102	.573	-0.000132	-0.001069	0.000938	.439
		30	0.000167	0.000069	0.000098	.573	-0.000132	-0.001069	0.000938	.439
*with the 5 % significance level **with the 2 % significance level										

Source: Our own calculation

The SMC data show that MACD is the only indicator with the correct signs in the time of the crisis when applied to the S&P 500 index. Nevertheless, the longer the signal the lower is the predictive power. The signals with the length of thirty days lose its forecasting power in the sub-prime mortgage crisis. That means that the MACD is not a good predictor of long term market developments. All the remaining indicators have negative buy-signals. It means that an investor who buys the stocks replicating the S&P 500 would achieve negative returns.

The Nikkei 225 shows most interesting results in Figure 29. The MA and RSI have once again incorrect sign of the buy and sell signals considering the whole time period. The Gebert indicator and the MACD have positive and correct signs of the buy's and sell's. In addition, the Gebert indicator has predictive power in the Japanese market because the difference between buy and sell signals are statistically significant at the 5 % level. This is a very interesting finding since this indicator was designed for the German stock exchange market.

However, it does not have any predictive power in the German market in comparison with the Japanese market.

Figure 29 : Prediction of price movements in Nikkei

			All data				SMC			
Index	Indicator	Period	Mean-B	Mean-S	Mean-BS	p-Value	Mean-B	Mean-S	Mean-BS	p-Value
Nikkei	MA	Whole	-0.000037	0.000026	-0.000063	.774	-0.000384	-0.000798	0.000414	.758
		5	-0.000392	0.000368	-0.000760	.000**	-0.001044	-0.000074	-0.000970	.451
		10	-0.000601	0.000626	-0.001227	.000**	-0.001453	0.000426	-0.001879	.106
		20	-0.000464	0.000520	-0.000983	.000**	-0.001033	0.000508	-0.001542	.127
		30	-0.000240	0.000299	-0.000540	.000**	-0.000929	0.000000	-0.000929	.295
	RSI	Whole	-0.001443	0.001430	-0.002873	.000**	-0.002895	0.001713	-0.004608	.001**
		5	-0.001055	0.001112	-0.002167	.000**	-0.002207	0.001301	-0.003507	.004**
		10	-0.000992	0.001047	-0.002039	.000**	-0.002207	0.001155	-0.003362	.006**
		20	-0.000625	0.000764	-0.001389	.000**	-0.001538	0.001081	-0.002619	.012**
		30	-0.000411	0.000473	-0.000884	.000**	-0.000982	0.000544	-0.001526	.098
	MACD	Whole	0.001030	-0.001043	0.002073	.000**	0.001014	-0.002197	0.003211	.017**
		5	0.000989	-0.001006	0.001995	.000**	0.001003	-0.002168	0.003171	.017**
		10	0.000987	-0.001026	0.002013	.000**	0.000950	-0.002192	0.003142	.016**
		20	0.000652	-0.000711	0.001364	.000**	0.000888	-0.001175	0.002064	.072
		30	0.000262	-0.000206	0.000468	.000**	0.000425	0.000000	0.000425	.531
	Gebert	Whole	0.000207	-0.000223	0.000431	.048*	0.000389	-0.001571	0.001960	.144
		5	0.000206	-0.000223	0.000429	.049*	0.000389	-0.001571	0.001960	.144
		10	0.000206	-0.000231	0.000437	.045*	0.000389	-0.001571	0.001960	.144
		20	0.000206	-0.000218	0.000423	.052	0.000389	-0.001571	0.001960	.144
		30	0.000218	-0.000229	0.000447	.039*	0.000389	-0.001571	0.001960	.144
*with the 5 % significance level **with the 2 % significance level										

Source: Our own calculation

When we observe the data of the prime-mortgage crisis we can see that the MACD indicator has less predictive power than in other markets. Nevertheless, it is still significant for the whole time period and considering signals five days and longer. Although the Gebert indicator showed promising results in in the entire time period, the differences between buy- and sell- signals are not significant in the SMC period.

The FTSE 100 confirms the results found in all the other markets as we can see in Figure 30. The MACD indicator is the only indicator that has significant forecasting power. The difference between the buy- and sells are significant at the 2 % level. The Gebert indicator achieved positive returns on its buy-signals and also the sell signals are of a correct sign but the differences are not significant. Also the performance of the indicators in the time of the prime mortgage crisis shows a similar pattern like in the other markets. The MACD is the only indicator with the predictive power.

Figure 30 : Prediction of price movements in FTSE

			All data				SMC			
Index	Indicator	Period	Mean-B	Mean-S	Mean-BS	p-Value	Mean-B	Mean-S	Mean-BS	p-Value
FTSE	MA	Whole	0.000149	-0.000049	0.000198	.224	-0.001055	0.000049	-0.001103	.289
		5	-0.000167	0.000212	-0.000379	.015**	-0.001247	0.000110	-0.001357	.187
		10	-0.000378	0.000410	-0.000788	.000**	-0.001357	0.000425	-0.001782	.056
		20	-0.000271	0.000320	-0.000591	.000**	-0.000781	0.000556	-0.001337	.076
		30	-0.000115	0.000163	-0.000279	.000**	-0.000781	0.000556	-0.001337	.076
	RSI	Whole	-0.000989	0.001087	-0.002075	.000**	-0.002090	0.001083	-0.003173	.002**
		5	-0.000675	0.000783	-0.001457	.000**	-0.001715	0.000714	-0.002428	.015**
		10	-0.000653	0.000724	-0.001378	.000**	-0.001706	0.000693	-0.002400	.015**
		20	-0.000411	0.000471	-0.000882	.000**	-0.001345	0.000556	-0.001901	.017**
		30	-0.000173	0.000233	-0.000406	.000**	-0.000964	0.000220	-0.001184	.086
	MACD	Whole	0.000719	-0.000621	0.001340	.000**	0.000979	-0.001985	0.002964	.004**
		5	0.000722	-0.000650	0.001372	.000**	0.000900	-0.002055	0.002955	.003**
		10	0.000699	-0.000682	0.001381	.000**	0.000783	-0.002055	0.002838	.003**
		20	0.000411	-0.000371	0.000782	.000**	0.000625	-0.001325	0.001950	.011**
		30	0.000086	-0.000140	0.000226	.001**	0.000617	-0.001325	0.001943	.008**
	Gebert	Whole	0.000155	-0.000054	0.000209	.200	-0.000093	-0.000913	0.000820	.431
		5	0.000155	-0.000054	0.000209	.200	-0.000093	-0.000913	0.000820	.431
		10	0.000155	-0.000054	0.000209	.200	-0.000093	-0.000913	0.000820	.431
		20	0.000155	-0.000063	0.000218	.180	-0.000093	-0.000913	0.000820	.431
		30	0.000155	-0.000074	0.000229	.155	-0.000093	-0.000913	0.000820	.431
*with the 5 % significance level **with the 2 % significance level										

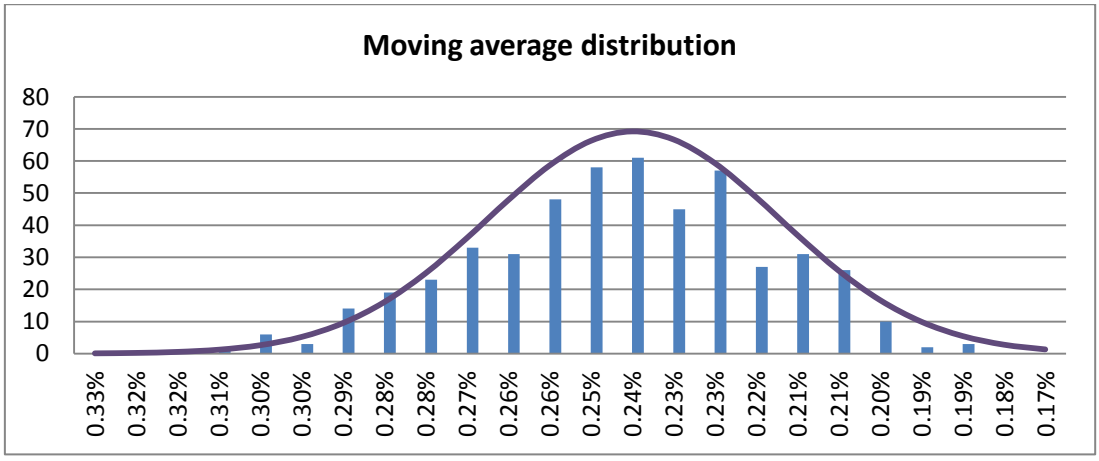
Source: Our own calculation

In order to determine the forecasting power independent from the time series and assuming the normal distribution we also use the bootstrap method. This method is necessary because the t-test assumes stationary, normal and time-independent distribution. The distribution of the MA rule can be seen in Figure 31. Our statistical tests show that our data have high skewedness and Kurtosis values (see Figure 23). We create 500 replications by using the bootstrapping method that was introduced to the financial analysis by Efron (1979). This method is very popular and was used in numerous studies (Vasiliou, Eriotis, & Papathanasiou, 2006, p. 86).

We adopt a similar approach as D. Vasiliou et al. (2006) for displaying the results of the bootstrapping. They show the mean returns on buy- and sell-signals in two separate columns for each rule. Furthermore, we will add the p-value and show the significance in Figure 32. We will display the returns on the sell signals with the correct sign and as a real number not a percentage.

We cannot confirm the notion found in some studies that the bootstrapping always shows same results as statistical analysis with the t-test of the original series. We find some differences in the case of the MA indicator assuming normal distribution. The buy- and sell-signals have always the correct signs and the p-value is lower than 0.00 suggesting that the results are highly significant and there is no doubt that the moving average has forecasting power in all the stock exchange markets.

Figure 31 : Distribution of the MA rule with bootstrapping



Source: Our own illustration

Figure 32 tells us that all the other indicators with exception of the MA show the same results like in the original time series. Nevertheless, they have higher significance levels. All the differences of the buy- and sell-signals are highly significant at the 2 % level. The RSI has the worst performance which is in accordance with our previous findings. It is important to point out that the bootstrapping cannot be applied to the Gebert indicator. That is why this indicator is not presented in the table. The Gebert indicator is independent of the share prices. Consequently, the creation of a pseudo series does not change its value and it is not viable.

The bootstrapping findings are consistent with all the past studies on technical analysis. They show that the technical indicators are able to forecast future price movements. We can interpret the values as the predicting power under normal distribution if the time series follows the random walk.

Figure 32 : Results bootstrapping

Results Bootstraps					
Index	Indicator	Buy	Sell	Buy-Sell	p-value
DAX	MA	.002412621638	-.002413544288	.004826165926	0.00**
	RSI	-.003997874985	.003997670609	-.007995545594	0.00**
	MACD	.001374160253	-.001373354340	.002747514593	0.00**
Eurostoxx	MA	.002353783238	-.002353668248	.004707451486	0.00**
	RSI	-.003856284775	.003855437346	-.007711722122	0.00**
	MACD	.001314318073	-.001314754396	.002629072469	0.00**
FTSE	MA	.001855749292	-.001856105573	.003711854865	0.00**
	RSI	-.003071606353	.003071731720	-.006143338073	0.00**
	MACD	.001022289665	-.001023027090	.002045316755	0.00**
Nikkei	MA	.002426950734	-.002427534087	.004854484821	0.00**
	RSI	-.004039686024	.004039018010	-.008078704034	0.00**
	MACD	.001478631020	-.001479153016	.002957784036	0.00**
S&P	MA	.001926195785	-.001926673056	.003852868841	0.00**
	RSI	-.003180418562	.003179852879	-.006360271440	0.00**
	MACD	.001039086260	-.001039211729	.002078297989	0.00**
*with 5% significance level **with 2% significance level					

Source: Our own calculation

In conclusion, the indicators have predictive power if there is a statistically significant difference among its buy- and sell-signals. We used the t-test in conformity with the past studies to determine whether these differences are significant at the 2 % and 5 % level. The MACD and Gebert indicator were the only indicators with correct signs of the buy- and sell-signals. The MACD indicator was the only indicator able to predict future price movements in all markets and which also showed reliable results in the time of the crisis.

There were few exceptions considering the Japanese stock exchange market. In this market the Gebert indicator was capable of forecasting the price movements considering the whole time period of twenty years. This is an interesting finding because the Gebert indicator was never applied to Nikkei 225 stock index. Nevertheless, it is necessary that future studies confirm if the Gebert indicator is a good predictor for stock price movements in the Japanese market.

Although the Gebert indicator showed positive returns of the buy-signals in other stock exchange markets, the differences between buy- and sell-signals were not significant. Consequently, investors who follow the signals of the Gebert indicator would be able to achieve positive returns; however, it remains unclear whether these results were not achieved by the design of the indicator. That means looking for and choosing such variables so that the Gebert indicators shows high returns in the past but actually not being able to predict future price movements.

The bootstrapping results clearly show that the technical indicators are able to forecast price movements. The RSI results are negative and confirm our previous findings. The best performing indicators are the MA and MACD. The Gebert, indicator was not included in the bootstrapping test because its value is independent of the price series.

6.2 Returns on Gebert Indicator

The value of the Gebert indicator is calculated on the basis of the information provided on the official website by Thomas Gebert. We use the monthly inflation data from the OECD portal. In the case of the Eurostoxx, we use the average inflation rate of the West European OECD countries. The exchange rates come from the portal of the Federal Reserve and interest rates from national banks. The Eurostoxx and DAX indexes share the same data on exchange rates and interest rates because the companies quoted in these indexes are a part of the Euro zone from 1999 until 2016.

The data come from diverse sources and comprise different time periods. Consequently, we designed a date matching algorithm that is published in the appendix. Generally, it compares the time periods among the different data sets as the inflation, exchange rate and interest rate and assigns them to correct trading dates. When the data on a particular trading data is not available the algorithm assigns it the last known value. It is based on the VBA code.

The final value denominated as GebertP is then copied in the results' table and uploaded to SPSS for the analysis. As a validation, we compare the score of the indicator with values that are published on the official web site of the Gebert indicator. It is important to point out that the Gebert indicator has been calculated for the German stock index DAX only. All the results

match accordingly. This shows that the value of the Gebert indicator was calculated correctly in the case of DAX not for other indexes. The similar solution obtained across the stock exchange markets imply that the Gebert indicator was calculated in these markets correctly as well.

We report the results of our analysis in the tables 30, 31 and 32. We use the t-test to compare whether Gebert indicator achieves superior returns in comparison with the other technical indicators. This comparison is based on all buy-signals generated by these indicators over the period of 20 years. If an investor could achieve superior returns using the Gebert indicator in comparison with other indicators then the results would show significantly positive differences in favor of the Gebert indicator.

According to the descriptive statistics we can see that MACD and Gebert indicator offer superior performance and are the two fiercest competitors. The data shows the average daily returns in the five major world stock exchange markets. In this case the sell rules were excluded from the comparison because they do not generate profits and if an investor does not include the share in her portfolio she does not participate in trading.

The Gebert indicator shows the best results in the German market with average daily return of 0.03237 %. The returns generated by following the buy and hold signals in the Eurostoxx are 0.02752 % followed by the Japanese market 0.0207 %, US stock exchange market 0.01674 % and the British market 0.01551 %.

There are differences in the trading dates and effective dates as we can see in Figure 33. We can see that we have different number of observations for each stock index. The FTSE 100 has the most observations. These differences can be put down to different trading dates and holidays in each country. It does not play an important role in our calculation and as a validation we can easily notice that the indicators display similar results, similar means and standard deviations in all the stock exchange markets.

Figure 33 : Mean Returns on buy-signals

Descriptive Statistics Mean Returns on Buy Signals				
Index	Indicator	Mean	Std. Deviation	Observations
Eurostoxx	MA	0.0002752465	0.0114558330	5078
	RSI	-0.0013257833	0.0113859036	5078
	MACD	0.0010064887	0.0090708976	5078
	Gebert	0.0002268181	0.0124853370	5078
FTSE	MA	0.0001491898	0.0092543908	5203
	RSI	-0.0009887225	0.0093334153	5203
	MACD	0.0007193032	0.0072206009	5203
	Gebert	0.0001550714	0.0089857044	5203
NIKKEI	MA	-0.0000367432	0.0117266212	4924
	RSI	-0.0014431028	0.0118077287	4924
	MACD	0.0010296843	0.0094820507	4924
	Gebert	0.0002071417	0.0105558589	4924
S&P	MA	0.0002651505	0.0094135826	5035
	RSI	-0.0010641865	0.0096808486	5035
	MACD	0.0008155328	0.0073950900	5035
	Gebert	0.0001674073	0.0089394673	5035
DAX	MA	0.0002067018	0.0116593319	5078
	RSI	-0.0013035713	0.0114324998	5078
	MACD	0.0011030911	0.0096794229	5078
	Gebert	0.0003236524	0.0129351574	5078

Source: Our own calculation

If we compare the means we can observe that only two indicators have always the correct signs in all stock exchange markets, the Gebert indicator and the MACD. It is apparent that the moving average offers us relatively stable returns in all the markets with exception of the Japanese market. This could be for the reason that the Japanese market had the weakest trend. Nevertheless, the moving average shows also positive mean daily returns in the case of Eurostoxx.

The RSI indicator's performance is rather disappointing and the data shows that it was not possible for investors to generate positive returns. The returns always have incorrect signs are negative and inferior to the Gebert indicator. Nevertheless, maybe its performance in the prime mortgage crisis could be better since the momentum indicators show better results in volatile markets. By following the trading rules generated by RSI for the whole time period from 1996 to 2006. The investors could realize an average loss of 0.1 % daily.

The Gebert indicator shows the best performance in the German and European markets. This means in the market it was designed for. However, it is interesting that almost in all markets the MACD generates superior returns. What is more, the MACD indicator outperforms the Gebert indicator in its home market. When we apply the Gebert indicator to DAX we earn average daily returns of 0.03 % and the MACD offers the investors 0.1 % that is three times more than the Gebert indicator.

The following Figures 34, 35 and 36 show the ANOVA multiple comparison of the performance of technical indicators in five major stock exchange markets. The coefficients are the mean daily differences of the trading rules including MA, RSI, MACD and the Gebert indicator. The p-value is stated in the parenthesis. The star implies that the results are significant at the 5 % level. Nevertheless, it is easy to determine the significance at any other level deriving it from the p-value. The first table shows the mean difference without transaction cost. The next two tables describe the differences with 1 % and 2 % transaction cost respectively.

Figure 34 : ANOVA no transaction fees

ANOVA MULTIPLE COMPARISON WITH THE WHOLE DATA SET

		Eurstoxx				FTSE				NIKKEY				S&P 500				DAX			
		MA	RSI	MACD	GEBERT	MA	RSI	MACD	GEBERT	MA	RSI	MACD	GEBERT	MA	RSI	MACD	GEBERT	MA	RSI	MACD	GEBERT
Eurstoxx	MA	x	.002*(0.00)	-.001*(0.00)	0.00(0,74)	0.00(0,55)	.001*(0.00)	.000*(0,01)	0.00(0,56)	0.00(0,18)	.002*(0.00)	-.001*(0.00)	0.00(0,73)	0.00(0,95)	.001*(0.00)	-.001*(0,01)	0.00(0,6)	0.00(0,76)	.002*(0.00)	-.001*(0.00)	0.00(0,85)
	RSI	-.002*(0.00)	x	-.002*(0.00)	-.002*(0.00)	-.001*(0.00)	0.00(0,12)	-.002*(0.00)	-.001*(0.00)	-.001*(0.00)	0.00(0,77)	-.002*(0.00)	-.001*(0.00)	-.002*(0.00)	0.00(0,19)	-.002*(0.00)	-.001*(0.00)	-.002*(0.00)	0.00(0,91)	-.002*(0.00)	-.002*(0.00)
	MACD	.001*(0.00)	.002*(0.00)	x	.001*(0.00)	.001*(0.00)	.002*(0.00)	0.00(0,09)	.001*(0.00)	.001*(0.00)	.002*(0.00)	0.00(0,95)	.001*(0.00)	.001*(0.00)	.002*(0.00)	0.00(0,23)	.001*(0.00)	.001*(0.00)	.002*(0.00)	0.00(0,62)	.001*(0.00)
	GEBERT	0.00(0,74)	.002*(0.00)	-.001*(0.00)	x	0.00(0,73)	.001*(0.00)	.000*(0,01)	0.00(0,75)	0.00(0,28)	.002*(0.00)	-.001*(0.00)	0.00(0,91)	0.00(0,87)	.001*(0.00)	-.001*(0.00)	0.00(0,78)	0.00(0,93)	.001*(0.00)	-.001*(0.00)	0.00(0,7)
FTSE	MA	0.00(0,55)	.001*(0.00)	-.001*(0.00)	0.00(0,73)	x	.001*(0.00)	-.001*(0.00)	0.00(0,96)	0.00(0,37)	.002*(0.00)	-.001*(0.00)	0.00(0,81)	0.00(0,56)	.001*(0.00)	-.001*(0.00)	0.00(0,94)	0.00(0,8)	.001*(0.00)	-.001*(0.00)	0.00(0,45)
	RSI	-.001*(0.00)	0.00(0,12)	-.002*(0.00)	-.001*(0.00)	-.001*(0.00)	x	-.002*(0.00)	-.001*(0.00)	-.001*(0.00)	0.00(0,07)	-.002*(0.00)	-.001*(0.00)	-.001*(0.00)	0.00(0,83)	-.002*(0.00)	-.001*(0.00)	-.001*(0.00)	0.00(0,17)	-.002*(0.00)	-.001*(0.00)
	MACD	.000*(0,01)	.002*(0.00)	0.00(0,09)	.000*(0,01)	.001*(0.00)	.002*(0.00)	x	.001*(0.00)	.001*(0.00)	.002*(0.00)	0.00(0,12)	.001*(0.00)	.000*(0,01)	.002*(0.00)	0.00(0,63)	.001*(0.00)	.001*(0,01)	.002*(0.00)	.000*(0,03)	.000*(0,05)
	GEBERT	0.00(0,56)	.001*(0.00)	-.001*(0.00)	0.00(0,75)	0.00(0,96)	.001*(0.00)	-.001*(0.00)	x	0.00(0,35)	.002*(0.00)	-.001*(0.00)	0.00(0,83)	0.00(0,57)	.001*(0.00)	-.001*(0.00)	0.00(0,97)	0.00(0,82)	.001*(0.00)	-.001*(0.00)	0.00(0,46)
NIKKEY	MA	0.00(0,18)	.001*(0.00)	-.001*(0.00)	0.00(0,28)	0.00(0,37)	.001*(0.00)	-.001*(0.00)	0.00(0,35)	x	.001*(0.00)	-.001*(0.00)	0.00(0,14)	0.00(0,17)	.001*(0.00)	-.001*(0.00)	0.00(0,33)	0.00(0,3)	.001*(0.00)	-.001*(0.00)	0.00(0,15)
	RSI	-.002*(0.00)	0.00(0,77)	-.002*(0.00)	-.002*(0.00)	-.002*(0.00)	0.00(0,07)	-.002*(0.00)	-.002*(0.00)	-.001*(0.00)	x	-.002*(0.00)	-.002*(0.00)	-.002*(0.00)	0.00(0,11)	-.002*(0.00)	-.002*(0.00)	-.002*(0.00)	0.00(0,68)	-.002*(0.00)	-.002*(0.00)
	MACD	.001*(0.00)	.002*(0,77)	0.00(0,00)	.001*(0.00)	.001*(0.00)	.002*(0,07)	0.00(0,00)	.001*(0.00)	.001*(0.00)	.002*(0.00)	x	.001*(0.00)	.001*(0.00)	.002*(0.00)	0.00(0,26)	.001*(0.00)	.001*(0.00)	.002*(0.00)	0.00(0,59)	.001*(0.00)
	GEBERT	0.00(0,73)	.001*(0.00)	-.001*(0.00)	0.00(0,91)	0.00(0,81)	.001*(0.00)	-.001*(0.00)	0.00(0,83)	0.00(0,14)	.002*(0.00)	-.001*(0.00)	x	0.00(0,76)	.001*(0.00)	-.001*(0.00)	0.00(0,86)	0.00(0,98)	.001*(0.00)	-.001*(0.00)	0.00(0,61)
S&P 500	MA	0.00(0,95)	.002*(0.00)	-.001*(0.00)	0.00(0,87)	0.00(0,56)	.001*(0.00)	.000*(0,01)	0.00(0,57)	0.00(0,17)	.002*(0.00)	-.001*(0.00)	0.00(0,76)	x	.001*(0.00)	-.001*(0.00)	0.00(0,45)	0.00(0,79)	.002*(0.00)	-.001*(0.00)	0.00(0,78)
	RSI	-.001*(0.00)	0.00(0,19)	-.002*(0.00)	-.001*(0.00)	-.001*(0.00)	0.00(0,83)	-.002*(0.00)	-.001*(0.00)	-.001*(0.00)	0.00(0,11)	-.002*(0.00)	-.001*(0.00)	-.001*(0.00)	x	-.002*(0.00)	-.001*(0.00)	-.001*(0.00)	0.00(0,23)	-.002*(0.00)	-.001*(0.00)
	MACD	.001*(0,01)	.002*(0.00)	0.00(0,23)	.001*(0.00)	.001*(0.00)	.002*(0.00)	0.00(0,63)	.001*(0.00)	.001*(0.00)	.002*(0.00)	0.00(0,26)	.001*(0.00)	.001*(0.00)	.002*(0.00)	x	.001*(0.00)	.001*(0.00)	.002*(0.00)	0.00(0,09)	.000*(0,02)
	GEBERT	0.00(0,6)	.001*(0.00)	-.001*(0.00)	0.00(0,78)	0.00(0,94)	.001*(0.00)	-.001*(0.00)	0.00(0,97)	0.00(0,33)	.002*(0.00)	-.001*(0.00)	0.00(0,86)	0.00(0,45)	.001*(0.00)	-.001*(0.00)	x	0.00(0,84)	.001*(0.00)	-.001*(0.00)	0.00(0,47)
DAX	MA	0.00(0,76)	.002*(0.00)	-.001*(0.00)	0.00(0,93)	0.00(0,8)	.001*(0.00)	-.001*(0,01)	0.00(0,82)	0.00(0,3)	.002*(0.00)	-.001*(0.00)	0.00(0,98)	0.00(0,79)	.001*(0.00)	-.001*(0.00)	0.00(0,84)	x	.001*(0.00)	-.001*(0.00)	0.00(0,43)
	RSI	-.002*(0.00)	0.00(0,91)	-.002*(0.00)	-.001*(0.00)	-.001*(0.00)	0.00(0,17)	-.002*(0.00)	-.001*(0.00)	-.001*(0.00)	0.00(0,68)	-.002*(0.00)	-.001*(0.00)	-.002*(0.00)	0.00(0,23)	-.002*(0.00)	-.001*(0.00)	-.001*(0.00)	x	-.002*(0.00)	-.002*(0.00)
	MACD	.001*(0.00)	.002*(0.00)	0.00(0,62)	.001*(0.00)	.001*(0.00)	.002*(0.00)	.000*(0,03)	.001*(0.00)	.001*(0.00)	.002*(0.00)	0.00(0,59)	.001*(0.00)	.001*(0.00)	.002*(0.00)	0.00(0,09)	.001*(0.00)	.001*(0.00)	.002*(0.00)	x	.001*(0.00)
	GEBERT	0.00(0,85)	.002*(0.00)	-.001*(0.00)	0.00(0,7)	0.00(0,45)	.001*(0.00)	.000*(0,05)	0.00(0,46)	0.00(0,15)	.002*(0.00)	-.001*(0.00)	0.00(0,61)	0.00(0,78)	.001*(0.00)	.000*(0,02)	0.00(0,47)	0.00(0,43)	.002*(0.00)	-.001*(0.00)	x

Figure 35 : ANOVA transaction fees of 1 %

ANOVA MULTIPLE COMPARISON WITH TRANSACTION FEES OF 1%

		Eurstoxx				FTSE				NIKKEY				S&P 500				DAX			
		MA	RSI	MACD	GEBERT	MA	RSI	MACD	GEBERT	MA	RSI	MACD	GEBERT	MA	RSI	MACD	GEBERT	MA	RSI	MACD	GEBERT
Eurstoxx	MA	x	.002*(0.00)	-.001*(0.00)	.000(0.11)	.001*(0.00)	.002*(0.00)	.000(0.76)	.000(0.2)	.000(0.59)	.002*(0.00)	.000*(0.03)	.000(0.15)	.000*(0.04)	.001*(0.00)	-.001*(0.00)	.000(0.11)	.000(0.05)	.002*(0.00)	.000*(0.03)	.000(0.06)
	RSI	-.002*(0.00)	x	-.003*(0.00)	-.002*(0.00)	-.001*(0.00)	.000(0.18)	-.002*(0.00)	-.002*(0.00)	-.002*(0.00)	.001*(0.02)	-.002*(0.00)	-.002*(0.00)	-.002*(0.00)	-.001*(0.00)	-.003*(0.00)	-.002*(0.00)	-.001*(0.00)	.000(0.07)	-.002*(0.00)	-.002*(0.00)
	MACD	.001*(0.00)	.003*(0.00)	x	.001*(0.00)	.002*(0.00)	.003*(0.00)	.001*(0.00)	.001*(0.00)	.001*(0.00)	.003*(0.00)	.001*(0.00)	.001*(0.00)	.001*(0.00)	.002*(0.00)	.000(0.22)	.001*(0.00)	.002*(0.00)	.003*(0.00)	.001*(0.00)	.001*(0.00)
	GEBERT	.000(0.11)	.002*(0.00)	-.001*(0.00)	x	.001*(0.00)	.002*(0.00)	.000(0.11)	.000(0.6)	.000(0.3)	.003*(0.00)	.000(0.74)	.000(0.81)	.000(0.83)	.001*(0.00)	-.001*(0.00)	.000(0.83)	.001*(0.00)	.002*(0.00)	.000(0.73)	.000(0.75)
FTSE	MA	-.001*(0.00)	.001*(0.00)	-.002*(0.00)	-.001*(0.00)	x	.001*(0.00)	-.001*(0.00)	-.001*(0.00)	-.001*(0.00)	.002*(0.00)	-.001*(0.00)	-.001*(0.00)	-.001*(0.00)	.000(0.13)	-.002*(0.00)	-.001*(0.00)	.000(0.51)	.001*(0.00)	-.001*(0.00)	-.001*(0.00)
	RSI	-.002*(0.00)	.000(0.18)	-.003*(0.00)	-.002*(0.00)	-.001*(0.00)	x	-.002*(0.00)	-.002*(0.00)	-.002*(0.00)	.000(0.26)	-.002*(0.00)	-.002*(0.00)	-.002*(0.00)	-.001*(0.00)	-.003*(0.00)	-.002*(0.00)	-.001*(0.00)	.000(0.57)	-.002*(0.00)	-.002*(0.00)
	MACD	.000(0.76)	.002*(0.00)	-.001*(0.00)	.000(0.11)	.001*(0.00)	.002*(0.00)	x	.000(0.08)	.000(0.73)	.002*(0.00)	.000*(0.02)	.000(0.14)	.000*(0.03)	.001*(0.00)	-.001*(0.00)	.000(0.09)	.001*(0.01)	.002*(0.00)	.000*(0.02)	.000(0.06)
	GEBERT	.000(0.2)	.002*(0.00)	-.001*(0.00)	.000(0.6)	.001*(0.00)	.002*(0.00)	.000(0.08)	x	.000(0.51)	.002*(0.00)	.000(0.31)	.000(0.76)	.000(0.37)	.001*(0.00)	-.001*(0.00)	.000(0.7)	.001*(0.00)	.002*(0.00)	.000(0.3)	.000(0.37)
NIKKEY	MA	.000(0.59)	.002*(0.00)	-.001*(0.00)	.000(0.3)	.001*(0.00)	.002*(0.00)	.000(0.73)	.000(0.51)	x	.002*(0.00)	.000(0.08)	.000(0.22)	.000(0.15)	.001*(0.00)	-.001*(0.00)	.000(0.32)	.001*(0.02)	.002*(0.00)	.000(0.12)	.000(0.18)
	RSI	-.002*(0.00)	-.001*(0.00)	-.003*(0.00)	-.003*(0.00)	-.002*(0.00)	.000(0.00)	-.002*(0.00)	-.002*(0.00)	-.002*(0.00)	x	-.003*(0.00)	-.003*(0.00)	-.003*(0.00)	-.001*(0.00)	-.003*(0.00)	-.003*(0.00)	-.002*(0.00)	.000(0.59)	-.003*(0.00)	-.003*(0.00)
	MACD	.000*(0.00)	.002*(0.02)	-.001*(0.00)	.000(0.00)	.001*(0.00)	.002*(0.26)	.000*(0.00)	.000(0.00)	.000(0.00)	.003*(0.00)	x	.000(0.34)	.000(0.9)	.001*(0.00)	-.001*(0.00)	.000(0.52)	.001*(0.00)	.003*(0.00)	.000(0.97)	.000(0.96)
	GEBERT	.000(0.15)	.002*(0.00)	-.001*(0.00)	.000(0.81)	.001*(0.00)	.002*(0.00)	.000(0.14)	.000(0.76)	.000(0.22)	.003*(0.00)	.000(0.34)	x	.000(0.6)	.001*(0.00)	-.001*(0.00)	.000(0.96)	.001*(0.00)	.002*(0.00)	.000(0.51)	.000(0.56)
S&P 500	MA	.000*(0.04)	.002*(0.00)	-.001*(0.00)	.000(0.83)	.001*(0.00)	.002*(0.00)	.000*(0.03)	.000(0.37)	.000(0.15)	.003*(0.00)	.000(0.9)	.000(0.6)	x	.001*(0.00)	-.001*(0.00)	.000(0.47)	.001*(0.00)	.002*(0.00)	.000(0.87)	.000(0.88)
	RSI	-.001*(0.00)	.001*(0.00)	-.002*(0.00)	-.001*(0.00)	.000(0.13)	.001*(0.00)	-.001*(0.00)	-.001*(0.00)	-.001*(0.00)	.001*(0.00)	-.001*(0.00)	-.001*(0.00)	-.001*(0.00)	x	-.002*(0.00)	-.001*(0.00)	.000*(0.05)	.001*(0.00)	-.001*(0.00)	-.001*(0.00)
	MACD	.001*(0.00)	.003*(0.00)	.000(0.22)	.001*(0.00)	.002*(0.00)	.003*(0.00)	.001*(0.00)	.001*(0.00)	.001*(0.00)	.003*(0.00)	.001*(0.00)	.001*(0.00)	.001*(0.00)	.002*(0.00)	x	.001*(0.00)	.001*(0.00)	.003*(0.00)	.001*(0.00)	.000*(0.02)
	GEBERT	.000(0.11)	.002*(0.00)	-.001*(0.00)	.000(0.83)	.001*(0.00)	.002*(0.00)	.000(0.09)	.000(0.7)	.000(0.32)	.003*(0.00)	.000(0.52)	.000(0.96)	.000(0.47)	.001*(0.00)	-.001*(0.00)	x	.001*(0.00)	.002*(0.00)	.000(0.51)	.000(0.56)
DAX	MA	.000(0.05)	.001*(0.00)	-.002*(0.00)	-.001*(0.00)	.000(0.51)	.001*(0.00)	-.001*(0.01)	-.001*(0.00)	-.001*(0.02)	.002*(0.00)	-.001*(0.00)	-.001*(0.00)	-.001*(0.00)	.000*(0.05)	-.001*(0.00)	-.001*(0.00)	x	.002*(0.00)	-.001*(0.00)	-.001*(0.00)
	RSI	-.002*(0.00)	.000(0.07)	-.003*(0.00)	-.002*(0.00)	-.001*(0.00)	.000(0.57)	-.002*(0.00)	-.002*(0.00)	-.002*(0.00)	.000(0.59)	-.003*(0.00)	-.002*(0.00)	-.002*(0.00)	-.001*(0.00)	-.003*(0.00)	-.002*(0.00)	-.002*(0.00)	x	-.003*(0.00)	-.003*(0.00)
	MACD	.000*(0.03)	.002*(0.00)	-.001*(0.00)	.000(0.73)	.001*(0.00)	.002*(0.00)	.000*(0.02)	.000(0.3)	.000(0.12)	.003*(0.00)	.000(0.97)	.000(0.51)	.000(0.87)	.001*(0.00)	-.001*(0.00)	.000(0.51)	.001*(0.00)	.003*(0.00)	x	.000(0.98)
	GEBERT	.000(0.06)	.002*(0.00)	-.001*(0.00)	.000(0.75)	.001*(0.00)	.002*(0.00)	.000(0.06)	.000(0.37)	.000(0.18)	.003*(0.00)	.000(0.96)	.000(0.56)	.000(0.88)	.001*(0.00)	.000*(0.02)	.000(0.56)	.001*(0.00)	.003*(0.00)	.000(0.98)	x

Figure 36 : ANOVA transaction fees of 2 %

ANOVA MULTIPLE COMPARISON WITH TRANSACTION COST OF 2%																					
		Eurstoxx				FTSE				NIKKEY				S&P 500				DAX			
		MA	RSI	MACD	GEBERT	MA	RSI	MACD	GEBERT	MA	RSI	MACD	GEBERT	MA	RSI	MACD	GEBERT	MA	RSI	MACD	GEBERT
Eurstoxx	MA	x	.002*(0.00)	-.002*(0.00)	-.001*(0.00)	.001*(0.00)	.002*(0.00)	0.00(0.23)	-.001*(0.00)	.001*(0.00)	.003*(0.00)	0.00(0.42)	-.001*(0.00)	-.001*(0.00)	.000*(0.04)	-.001*(0.00)	-.001*(0.00)	0.00(0.95)	.002*(0.00)	-.001*(0.00)	-.001*(0.00)
	RSI	-.002*(0.00)	x	-.003*(0.00)	-.003*(0.00)	-.001*(0.00)	.001*(0.00)	-.001*(0.00)	-.002*(0.00)	-.001*(0.00)	.001*(0.00)	-.002*(0.00)	-.002*(0.00)	-.003*(0.00)	-.001*(0.00)	-.003*(0.00)	-.002*(0.00)	-.002*(0.00)	0.00(0.72)	-.003*(0.00)	-.003*(0.00)
	MACD	.002*(0.00)	.003*(0.00)	x	.001*(0.00)	.003*(0.00)	.004*(0.00)	.002*(0.00)	.001*(0.00)	.003*(0.00)	.004*(0.00)	.001*(0.00)	.001*(0.00)	.001*(0.00)	.002*(0.00)	0.00(0.22)	.001*(0.00)	.002*(0.00)	.003*(0.00)	.001*(0.00)	.001*(0.00)
	GEBERT	.001*(0.00)	.003*(0.00)	-.001*(0.00)	x	.002*(0.00)	.003*(0.00)	.001*(0.00)	0.00(0.46)	.002*(0.00)	.004*(0.00)	.001*(0.01)	0.00(0.71)	0.00(0.79)	.001*(0.00)	-.001*(0.00)	0.00(0.87)	.001*(0.00)	.002*(0.00)	0.00(0.69)	0.00(0.71)
FTSE	MA	-.001*(0.00)	.001*(0.00)	-.003*(0.00)	-.002*(0.00)	x	.002*(0.00)	-.001*(0.00)	-.002*(0.00)	0.00(0.94)	.002*(0.00)	-.001*(0.00)	-.002*(0.00)	-.002*(0.00)	.000*(0.01)	-.002*(0.00)	-.002*(0.00)	-.001*(0.00)	.001*(0.00)	-.002*(0.00)	-.002*(0.00)
	RSI	-.002*(0.00)	-.001*(0.00)	-.004*(0.00)	-.003*(0.00)	-.002*(0.00)	x	-.002*(0.00)	-.003*(0.00)	-.002*(0.00)	0.00(0.28)	-.003*(0.00)	-.003*(0.00)	-.003*(0.00)	-.002*(0.00)	-.004*(0.00)	-.003*(0.00)	-.002*(0.00)	-.001*(0.00)	-.003*(0.00)	-.003*(0.00)
	MACD	0.00(0.23)	.001*(0.00)	-.002*(0.00)	-.001*(0.00)	.001*(0.00)	.002*(0.00)	x	-.001*(0.00)	.001*(0.00)	.003*(0.00)	.000*(0.02)	-.001*(0.00)	-.001*(0.00)	0.00(0.25)	-.002*(0.00)	-.001*(0.00)	0.00(0.27)	.001*(0.00)	-.001*(0.00)	-.001*(0.00)
	GEBERT	.001*(0.00)	.002*(0.00)	-.001*(0.00)	0.00(0.46)	.002*(0.00)	.003*(0.00)	.001*(0.00)	x	.002*(0.00)	.003*(0.00)	.000*(0.02)	0.00(0.69)	0.00(0.23)	.001*(0.00)	-.001*(0.00)	0.00(0.47)	.001*(0.00)	.002*(0.00)	0.00(0.18)	0.00(0.25)
NIKKEY	MA	-.001*(0.00)	.001*(0.00)	-.003*(0.00)	-.002*(0.00)	0.00(0.94)	.002*(0.00)	-.001*(0.00)	-.002*(0.00)	x	.002*(0.00)	-.001*(0.00)	-.002*(0.00)	-.002*(0.00)	-.001*(0.02)	-.002*(0.00)	-.002*(0.00)	-.001*(0.00)	.001*(0.01)	-.002*(0.00)	-.002*(0.00)
	RSI	-.003*(0.00)	-.001*(0.00)	-.004*(0.00)	-.004*(0.00)	-.002*(0.00)	0.00(0.00)	-.003*(0.00)	-.003*(0.00)	-.002*(0.00)	x	-.003*(0.00)	-.003*(0.00)	-.004*(0.00)	-.002*(0.00)	-.004*(0.00)	-.004*(0.00)	-.003*(0.00)	-.001*(0.00)	-.004*(0.00)	-.004*(0.00)
	MACD	0.00(0.00)	.002*(0.00)	-.001*(0.00)	-.001*(0.00)	.001*(0.00)	.003*(0.28)	.000*(0.00)	.000*(0.00)	.001*(0.00)	.003*(0.00)	x	-.001*(0.00)	-.001*(0.00)	.001*(0.00)	-.001*(0.00)	-.001*(0.00)	0.00(0.38)	.002*(0.00)	-.001*(0.00)	-.001*(0.00)
	GEBERT	.001*(0.00)	.002*(0.00)	-.001*(0.00)	0.00(0.71)	.002*(0.00)	.003*(0.00)	.001*(0.00)	0.00(0.69)	.002*(0.00)	.003*(0.00)	.001*(0.00)	x	0.00(0.46)	.001*(0.00)	-.001*(0.00)	0.00(0.79)	.001*(0.00)	.002*(0.00)	0.00(0.39)	0.00(0.45)
S&P 500	MA	.001*(0.00)	.003*(0.00)	-.001*(0.00)	0.00(0.79)	.002*(0.00)	.003*(0.00)	.001*(0.00)	0.00(0.23)	.002*(0.00)	.004*(0.00)	.001*(0.00)	0.00(0.46)	x	.001*(0.00)	-.001*(0.00)	0.00(0.47)	.001*(0.00)	.002*(0.00)	0.00(0.87)	0.00(0.88)
	RSI	.000*(0.04)	.001*(0.00)	-.002*(0.00)	-.001*(0.00)	.000*(0.01)	.002*(0.00)	0.00(0.25)	-.001*(0.00)	.001*(0.02)	.002*(0.00)	-.001*(0.00)	-.001*(0.00)	-.001*(0.00)	x	-.002*(0.00)	-.001*(0.00)	.000*(0.05)	.001*(0.00)	-.001*(0.00)	-.001*(0.00)
	MACD	.001*(0.00)	.003*(0.00)	0.00(0.22)	.001*(0.00)	.002*(0.00)	.004*(0.00)	.002*(0.00)	.001*(0.00)	.002*(0.00)	.004*(0.00)	.001*(0.00)	.001*(0.00)	.001*(0.00)	.002*(0.00)	x	.001*(0.00)	.001*(0.00)	.003*(0.00)	.001*(0.00)	.000*(0.02)
	GEBERT	.001*(0.00)	.002*(0.00)	-.001*(0.00)	0.00(0.87)	.002*(0.00)	.003*(0.00)	.001*(0.00)	0.00(0.47)	.002*(0.00)	.004*(0.00)	.001*(0.00)	0.00(0.79)	0.00(0.47)	.001*(0.00)	-.001*(0.00)	x	.001*(0.00)	.002*(0.00)	0.00(0.51)	0.00(0.56)
DAX	MA	0.00(0.95)	.002*(0.00)	-.002*(0.00)	-.001*(0.00)	.001*(0.00)	.002*(0.00)	0.00(0.27)	-.001*(0.00)	.001*(0.00)	.003*(0.00)	0.00(0.38)	-.001*(0.00)	-.001*(0.00)	.000*(0.05)	-.001*(0.00)	-.001*(0.00)	x	.002*(0.00)	-.001*(0.00)	-.001*(0.00)
	RSI	-.002*(0.00)	0.00(0.72)	-.003*(0.00)	-.002*(0.00)	-.001*(0.00)	.001*(0.00)	-.001*(0.00)	-.002*(0.00)	-.001*(0.01)	.001*(0.00)	-.002*(0.00)	-.002*(0.00)	-.002*(0.00)	-.001*(0.00)	-.003*(0.00)	-.002*(0.00)	-.002*(0.00)	x	-.003*(0.00)	-.003*(0.00)
	MACD	.001*(0.00)	.003*(0.00)	-.001*(0.00)	0.00(0.69)	.002*(0.00)	.003*(0.00)	.001*(0.00)	0.00(0.18)	.002*(0.00)	.004*(0.00)	.001*(0.00)	0.00(0.39)	0.00(0.87)	.001*(0.00)	-.001*(0.00)	0.00(0.51)	.001*(0.00)	.003*(0.00)	x	0.00(0.98)
	GEBERT	.001*(0.00)	.003*(0.00)	-.001*(0.00)	0.00(0.71)	.002*(0.00)	.003*(0.00)	.001*(0.00)	0.00(0.25)	.002*(0.00)	.004*(0.00)	.001*(0.00)	0.00(0.45)	0.00(0.88)	.001*(0.00)	.000*(0.02)	0.00(0.56)	.001*(0.00)	.003*(0.00)	0.00(0.98)	x

When we look at the first ANOVA multiple comparisons table without the transaction cost then we can see that an investor could achieve superior returns with the Gebert and MACD indicators in most markets. The RSI indicator usually displays negative returns and the Gebert indicator is significantly better than the RSI in all the markets.

Interestingly, we cannot say that Gebert indicator is significantly better than the triple moving average in the German market. Although the indicator enables an investor to generate higher returns, we can notice that the differences between the mean daily returns of the MA and the Gebert indicator are not statistically significant.

In the absence of the transaction fees the MACD is the superior indicator and beats the Gebert indicator in the Japanese, US, the European and UK markets. All the differences in means are positive and statistically significant. The mean daily difference of the MACD compared to the Gebert indicator is positive and statistically significant at the 5 % level even in the German Market. With other words, investors can achieve superior returns with the MACD compared to the Gebert indicator. Nevertheless, it is important to point out that this applies only in the absence of transaction fees.

The amount of the transaction fees varies according to the firm size, stock exchange and the amount of shares purchased. We consider two levels of transaction fees of 1 % and 2 %. The studies show that the transaction fees for the large stock exchanges and large companies are negligible and reach maximally 1 % for the institutional investors. The small private investors need to use the services of a broker and most banks offer brokerage services which costs do not exceed 2 % (Jones, 2002, p. 43).

When we look at the following table with the transaction fees of 1 % we can see that the MACD does not generate superior returns to the Gebert and MACD indicators in the German, Japanese and UK markets. It means that the returns on the trading rules of MA, RSI and MACD decline at a greater pace than the returns on the Gebert indicator. The MA and RSI show significantly worse results in comparison with the MACD and the Gebert indicator.

The next table shows the effect of raising the transaction fees by 1 % further. We can notice that the comparative performance of the Gebert indicator rises. Nevertheless, the MACD is still superior to the Gebert indicator in the case of Eurostoxx and S&P. The DAX shows

inconclusive results and neither of the both indicators is significantly better. The remaining indexes FTSE and NIKKEI display significantly better results in favor of the Gebert indicator.

The ANOVA multiple comparisons do not show any significant differences in the profitability of the Gebert indicator among the different exchange markets. Even though the Gebert indicator in the German market has the highest coefficient the differences to other markets are very low and close to zero. Consequently, the Gebert indicator does not make significantly higher returns in the German market in comparison with other markets.

We can notice that the introduction of transaction fees gives the Gebert indicator an advantage in comparison with RSI, MACD and MA. The length of the signals is negatively correlated with the amount of the transactions fees the investors need to pay. The transaction fees are paid in both cases when the investors buy and sell shares.

The following table shows the signal length of the buy-signals. The mean signal length is the average of the observations across all the stock exchange markets. The maximum denominates the duration of the longest buy-signal. Conversely, the minimum is the shortest signal. The number of observations gives information about the number of signals with different length; e.g. five ten and thirty days are three different signal lengths.

When we look at Figure 37 we can clearly see that the average signal length from the Gebert indicator is in the range between 90-97 days across all the markets. The longest signal is the buy signal of 1059 days in the German market. The Gebert indicator always generates the longest buy- and sell- signals in all the markets. The signal length is at least 5 times higher than of the MACD indicator. In addition, the minimal signal length is substantially higher. The Gebert indicator has the minimal signal length of 43 days; in contrast, the MACD, MA and RSI have signals that last for one day only.

The remaining indicators generate substantially shorter signals. The moving average generates mean signals in the range of 17-23 across the markets with the highest average length in the US stock exchange market. The RSI signal length ranges between 19-26 days. Interestingly, the MACD issues relatively short signals in the range between 16-18 days.

Figure 37 : Signal length

Descriptive Statistics Signal Length					
Index	Indicator	Mean	Maximum	Minimum	Observations
Eurostoxx	MA	17,8113	65,00	1,00	41
	RSI	22,2264	65,00	1,00	45
	MACD	15,8868	53,00	1,00	40
	Gebert	96,1887	1047,00	43,00	13
FTSE	MA	21,6226	64,00	1,00	53
	RSI	18,7547	75,00	1,00	48
	MACD	16,7925	46,00	1,00	46
	Gebert	95,7358	570,00	12,00	30
NIKKEI	MA	17,7925	54,00	1,00	42
	RSI	24,8113	99,00	1,00	48
	MACD	17,3774	46,00	1,00	42
	Gebert	92,9245	887,00	5,00	21
S&P	MA	23,1509	119,00	1,00	45
	RSI	26,2830	80,00	1,00	51
	MACD	14,8868	42,00	1,00	39
	Gebert	90,2642	633,00	107,00	15
DAX	MA	20,5094	80,00	1,00	44
	RSI	25,5094	77,00	1,00	49
	MACD	17,5472	48,00	1,00	42
	Gebert	95,8302	1059,00	43,00	13

Source: Our own calculation

To sum up, the Gebert indicator can generate positive returns. When we compare its performance with other indicators then the MACD emerges again as the most serious competitor. The MACD offers superior returns to the Gebert indicator if we do not consider the transaction fees. However, the transaction fees result in diminishing returns of all the indicators. For the reason that the Gebert indicator has the highest signal length the investors do not need to sell and buy share as often as in the case of the others indicators. That clearly speaks in favor of the Gebert indicator.

We need to point out that the indicator never has been applied to different stock indexes. It has been only calculated for the DAX. That is why we need to keep in mind that if the author wanted the Gebert indicator to be used for other stock indexes she would make some changes to its fundaments. Some of these changed could include changing the prime lending rates for the interest rates on the government bonds or bills. Nevertheless, the data analysis provides the evidence that there are no differences among the stock exchange markets. The Gebert indicator achieves similar results. It casts doubt whether some changes to the fundamentals could lead to an improvement.

6.3 Returns on buys and sells

The following tables show the performance of the technical indicators in comparison to the buy and hold strategy. The first two columns define the index it was applied to and the indicator. The period tells us about the length of the buy-signals in days. The whole data set is then divided into two major sections that display the sub-prime mortgage crisis or all the observations.

The column Mean-B shows the mean return of the buy-signals in the periods under consideration. The Mean BH is the mean return of the buy- and hold-strategy. This strategy assumes that the investors buy all the shares of an index at the beginning of the period and do not sell them also when the market situation changes. The Mean-BBH column shows the mean differences between the buy-and hold- strategy and the buy-signals emitted by the indicators.

Figure 38 displays the results obtained by applying the technical indicators to DAX. When we analyze the mean daily returns of the buy-signals we can observe interesting patterns. The daily mean returns of the MA and RSI indicator improve when we consider larger periods of the buy and sell signals. This finding is in accordance with some recommendation of experienced investors who advise to wait for confirmation signals for few days.

However, the MACD shows an opposite pattern to the MA and RSI. It means that the MACD is especially efficient by forecasting short term movements of the DAX. The performance of the Gebert indicator does not change when we consider the five, ten, twenty and thirty day periods. The reason is that the Gebert indicator issues buy and sell signals that are longer than thirty days.

The results show that in the case of the MA and RSI indicators the performance is worse than of the standard buy and hold strategy. The five-, ten- and twenty- day periods show significantly worse performance in comparison to the buy and hold strategy. Although the MACD and Gebert display on average better returns than buy- and hold- strategy then the results are significant just in the case of the MACD taking into account all signals and signals larger or equal five days.

Figure 38 : Returns DAX

			All data				SMC			
Index	Indicator	Period	Mean-B	Mean-BH	Mean-BBH	p-Value	Mean-B	Mean-BH	Mean-BBH	p-Value
DAX	MA	Whole	0.000207	0.000305	-0.000098	.466	-0.000616	-0.001235	0.000619	.336
		5	-0.000237	0.000305	-0.000541	.000**	-0.001370	-0.001235	-0.000135	.845
		10	-0.000520	0.000305	-0.000825	.000**	-0.001361	-0.001235	-0.000126	.856
		20	-0.000314	0.000305	-0.000619	.001**	-0.000576	-0.001235	0.000659	.485
		30	-0.000083	0.000305	-0.000388	.060	-0.000195	-0.001235	0.001040	.348
	RSI	Whole	-0.001304	0.000305	-0.001608	.000**	-0.002362	-0.001235	-0.001127	.064
		5	-0.001022	0.000305	-0.001326	.000**	-0.002357	-0.001235	-0.001122	.070
		10	-0.000960	0.000305	-0.001265	.000**	-0.002353	-0.001235	-0.001118	.075
		20	-0.000538	0.000305	-0.000843	.000**	-0.001304	-0.001235	-0.000069	.938
		30	-0.000268	0.000305	-0.000573	.000**	-0.000266	-0.001235	0.000969	.382
	MACD	Whole	0.001103	0.000305	0.000798	.000**	0.001050	-0.001235	0.002285	.008**
		5	0.001146	0.000305	0.000841	.000**	0.001116	-0.001235	0.002350	.008**
		10	0.001091	0.000305	0.000786	.000**	0.001033	-0.001235	0.002268	.011**
		20	0.000664	0.000305	0.000360	.059	0.000914	-0.001235	0.002149	.029*
		30	0.000269	0.000305	-0.000035	.861	0.000948	-0.001235	0.002183	.031*
	Gebert	Whole	0.000324	0.000305	0.000019	.862	-0.000092	-0.001235	0.001143	.155
		5	0.000324	0.000305	0.000019	.862	-0.000092	-0.001235	0.001143	.155
		10	0.000324	0.000305	0.000019	.862	-0.000092	-0.001235	0.001143	.155
		20	0.000324	0.000305	0.000019	.862	-0.000092	-0.001235	0.001143	.155
		30	0.000324	0.000305	0.000019	.862	-0.000092	-0.001235	0.001143	.155
*with 5 % significance level **with 2 % significance level										

Source: Our own calculation

The performance of the indicators in the time of the prime mortgage crisis shows that the MACD stands out in comparison with other indicators. The mean differences between the returns of MACD and buy- and hold- strategy are twice as large as in the case of the Gebert indicator. In addition, the differences are significant at the 2% significant level. The Gebert indicator also displays positive difference; nevertheless, the differences are very subtle.

The Eurostoxx has similar patterns as the DAX as we can see in Figure 39. This can be put down to the dependence of the index on the performance of the German companies. We can see that the MA has a negative significant performance in comparison with the buy- and hold-strategy. These results are significant for five, ten and twenty day signals. The MACD shows again the best performance. In contrast to DAX the results are not significantly larger for twenty and thirty day signals.

Figure 39 : Returns Eurostoxx

			All data				SMC			
Index	Indicator	Period	Mean-B	Mean-BH	Mean-BBH	p-Value	Mean-B	Mean-BH	Mean-BBH	p-Value
Eurostoxx	MA	Whole	0.000275	0.000153	0.000122	.050	-0.001132	-0.001518	0.000387	.543
		5	-0.000202	0.000153	-0.000355	.015	-0.001673	-0.001518	-0.000155	.817
		10	-0.000458	0.000153	-0.000611	.000**	-0.001737	-0.001518	-0.000219	.751
		20	-0.000320	0.000153	-0.000473	.000**	-0.001209	-0.001518	0.000309	.736
		30	-0.000068	0.000153	-0.000220	.000	-0.000325	-0.001518	0.001193	.295
	RSI	Whole	-0.001326	0.000153	-0.001479	.000**	-0.002606	-0.001518	-0.001088	.075
		5	-0.001035	0.000153	-0.001187	.000**	-0.002468	-0.001518	-0.000950	.141
		10	-0.000967	0.000153	-0.001120	.000**	-0.002507	-0.001518	-0.000989	.127
		20	-0.000624	0.000153	-0.000777	.000**	-0.001455	-0.001518	0.000063	.945
		30	-0.000275	0.000153	-0.000428	.004**	-0.000392	-0.001518	0.001126	.323
	MACD	Whole	0.001006	0.000153	0.000854	.000**	0.000838	-0.001518	0.002356	.012**
		5	0.001020	0.000153	0.000867	.000**	0.000906	-0.001518	0.002424	.010**
		10	0.000973	0.000153	0.000820	.000**	0.000912	-0.001518	0.002430	.011**
		20	0.000698	0.000153	0.000545	.059	0.001006	-0.001518	0.002524	.014**
		30	0.000320	0.000153	0.000167	.861	0.000790	-0.001518	0.002308	.035*
	Gebert	Whole	0.000227	0.000153	0.000074	.145	-0.000191	-0.001518	0.001327	.119
		5	0.000227	0.000153	0.000074	.145	-0.000191	-0.001518	0.001327	.119
		10	0.000227	0.000153	0.000074	.145	-0.000191	-0.001518	0.001327	.119
		20	0.000227	0.000153	0.000074	.145	-0.000191	-0.001518	0.001327	.119
		30	0.000227	0.000153	0.000074	.145	-0.000090	-0.001518	0.001429	.099
*with 5 % significance level **with 2 % significance level										

Source: Our own calculation

Although MA, RSI and Gebert show positive performance in the time of the crisis, the results are statistically not significant. That means their positive performance can be attributed to mere coincidence. Consequently, the investors cannot rely on these indicators in the time of a crisis. However, the MACD shows once again the best forecasting power. It is on average 0, 24 % better than the buy and hold strategy. The positive differences of the MACD are significant in the five, ten and twenty day periods at 2 % and in the 30 day period at the 5 % level.

We can see in Figure 40 that the American market displays some differences to Eurostoxx and DAX. Although the MA and RSI show similar results to the European and German markets, the Gebert indicator generates inferior returns to the buy- and hold- strategy. The mean buy-signals generate positive returns of about 0.0167 % daily. The buy- and hold strategy achieves 0.0237 % mean daily return. However, the difference is too small to be significant.

Figure 40 : Returns S&P

			All data				SMC			
Index	Indicator	Period	Mean-B	Mean-BH	Mean-BBH	p-Value	Mean-B	Mean-BH	Mean-BBH	p-Value
S&P	MA	Whole	0.000265	0.000237	0.000028	.795	-0.000767	-0.001201	0.000435	.516
		5	-0.000057	0.000237	-0.000293	.011**	-0.001204	-0.001201	-0.000003	.997
		10	-0.000322	0.000237	-0.000558	.000**	-0.001383	-0.001201	-0.000182	.799
		20	-0.000240	0.000237	-0.000476	.002**	-0.000871	-0.001201	0.000331	.730
		30	-0.000176	0.000237	-0.000413	.008**	-0.000871	-0.001201	0.000331	.730
	RSI	Whole	-0.001064	0.000237	-0.001301	.000**	-0.002681	-0.001201	-0.001480	.015**
		5	-0.000728	0.000237	-0.000965	.000**	-0.001859	-0.001201	-0.000658	.339
		10	-0.000684	0.000237	-0.000921	.000**	-0.001859	-0.001201	-0.000658	.339
		20	-0.000466	0.000237	-0.000702	.000**	-0.001355	-0.001201	-0.000153	.870
		30	-0.000246	0.000237	-0.000482	.002**	-0.001049	-0.001201	0.000152	.874
	MACD	Whole	0.000816	0.000237	0.000579	.000**	0.000827	-0.001201	0.002028	.029**
		5	0.000834	0.000237	0.000597	.000**	0.000854	-0.001201	0.002055	.028**
		10	0.000790	0.000237	0.000553	.000**	0.000697	-0.001201	0.001898	.048*
		20	0.000557	0.000237	0.000320	.040*	0.000560	-0.001201	0.001761	.100
		30	0.000173	0.000237	-0.000064	.703	0.000111	-0.001201	0.001313	.252
	Gebert	Whole	0.000167	0.000237	-0.000069	.556	-0.000132	-0.001201	0.001069	.210
		5	0.000167	0.000237	-0.000069	.556	-0.000132	-0.001201	0.001069	.210
		10	0.000167	0.000237	-0.000069	.556	-0.000132	-0.001201	0.001069	.210
		20	0.000167	0.000237	-0.000069	.556	-0.000132	-0.001201	0.001069	.210
		30	0.000167	0.000237	-0.000069	.556	-0.000132	-0.001201	0.001069	.210
*with 5 % significance level **with 2 % significance level										

Source: Our own calculation

The results in the time of the sub-prime mortgage crisis favor the MACD indicator again. Investors who used the MACD indicator in the whole time period would generate higher returns by 0.2 % the buy and hold. The mean difference is significant at the 2 % level in the case of the 5 day period and at the 5 % level in the cause of the 10 day period. The longer signals produce positive but non-significant results.

When we observe the results of the FTSE 100 in Figure 41, we can notice that the MA and RSI generate in most cases negatively significant results. The investors would be well-advised not to use these indicators and rather buy and hold the shares for the whole time period. In the case of RSI the buy- and hold- strategy outperforms the RSI signals by 0.11 % daily. The MA indicator shows inconclusive results for the whole time period. The five, ten and twenty day signals have significant negative performance in comparison with the buy- and hold- strategy.

The best results are achieved by using the MACD. That applies to the whole time period and also the time of the crisis. We can see that the results are better and the significance higher in the case of shorter signals. That means MACD can predict short-term price movements in the

British stock market with reliably high confidence. According to that the MACD outperforms other indicators especially with its sensitivity to the development of the stock market.

Figure 41 : Returns FTSE

			All data				SMC			
Index	Indicator	Period	Mean-B	Mean-BH	Mean-BBH	p-Value	Mean-B	Mean-BH	Mean-BBH	p-Value
FTSE	MA	Whole	0.000149	0.000101	0.000048	.633	-0.001055	-0.001006	-0.000049	.932
		5	-0.000167	0.000101	-0.000268	.012**	-0.001247	-0.001006	-0.000241	.681
		10	-0.000378	0.000101	-0.000479	.000**	-0.001357	-0.001006	-0.000350	.593
		20	-0.000271	0.000101	-0.000372	.008**	-0.000781	-0.001006	0.000225	.776
		30	-0.000115	0.000101	-0.000216	.149	-0.000781	-0.001006	0.000225	.776
	RSI	Whole	-0.000989	0.000101	-0.001090	.000**	-0.002090	-0.001006	-0.001083	.043*
		5	-0.000675	0.000101	-0.000776	.000**	-0.001715	-0.001006	-0.000708	.211
		10	-0.000653	0.000101	-0.000754	.000**	-0.001706	-0.001006	-0.000700	.217
		20	-0.000411	0.000101	-0.000512	.000**	-0.001345	-0.001006	-0.000339	.648
		30	-0.000173	0.000101	-0.000274	.064	-0.000964	-0.001006	0.000043	.957
	MACD	Whole	0.000719	0.000101	0.000618	.000**	0.000979	-0.001006	0.001985	.020**
		5	0.000722	0.000101	0.000621	.000**	0.000900	-0.001006	0.001906	.026**
		10	0.000699	0.000101	0.000598	.000**	0.000783	-0.001006	0.001790	.041*
		20	0.000411	0.000101	0.000310	.035*	0.000625	-0.001006	0.001632	.091
		30	0.000086	0.000101	-0.000015	.924	0.000617	-0.001006	0.001624	.102
	Gebert	Whole	0.000155	0.000101	0.000054	.608	-0.000093	-0.001006	0.000913	.195
		5	0.000155	0.000101	0.000054	.608	-0.000093	-0.001006	0.000913	.195
		10	0.000155	0.000101	0.000054	.608	-0.000093	-0.001006	0.000913	.195
		20	0.000155	0.000101	0.000054	.608	-0.000093	-0.001006	0.000913	.195
		30	0.000155	0.000101	0.000054	.608	-0.000093	-0.001006	0.000913	.195
*with 5 % significance level **with 2 % significance level										

Source: Our own calculation

The RSI indicator has an equally bad performance in the crisis. Nevertheless, the performance of the RSI indicator does not display major differences to the whole time period. The MACD has significantly better performance in the sub-prime mortgage crisis and the results of the Gebert indicator are positive but inconclusive again.

The Japanese stock market is very interesting by the fact that the mean buy and hold strategy would result in negative earnings. Investors who bought and hold the shares of the Japanese companies in the Nikkei 225 index would lose their money. In contrast to other markets the numerous crisis caused a loss of confidence of the Japanese investors in profiting by buying shares.

That is why it is marked by sluggish performance without any apparent trend. Consequently, the investors should avoid trend indicators. One could assume that the Gebert indicator should make significantly better predictions than other indicators because it is based on macroeconomic variables. As a result, it should better assess the development on the market.

Although the Gebert indicators shows positive returns then the results are not statistically significant. We cannot say that investors could achieve superior returns to buy- and hold-strategy.

The MA and RSI once again have worse performance than the rest of the indicators as we can observe in Figure 42. The investors should rather avoid them. The MACD displays the best performance which is consistent with its performance in all the other markets. The investors would be better off by 0.1 % daily. All the buy- signals are positive and have the correct sign.

The results in the time of the subprime-mortgage crisis correspond with the results in the other markets. The investors would be able to produce best results with the MACD indicator. The coefficients are significant at the 5 % level. On the contrary, the RSI shows the worst performance which is also confirmed statistically on the 2 % significance level.

Figure 42 : Returns Nikkei

			All data				SMC			
Index	Indicator	Period	Mean-B	Mean-BH	Mean-BBH	p-Value	Mean-B	Mean-BH	Mean-BBH	p-Value
Nikkei	MA	Whole	-0.000037	-0.000016	-0.000021	.878	-0.000384	-0.001182	0.000798	.275
		5	-0.000392	-0.000016	-0.000376	.008**	-0.001044	-0.001182	0.000138	.858
		10	-0.000601	-0.000016	-0.000585	.000**	-0.001453	-0.001182	-0.000271	.751
		20	-0.000464	-0.000016	-0.000447	.012**	-0.001033	-0.001182	0.000149	.877
		30	-0.000240	-0.000016	-0.000224	.253	-0.000929	-0.001182	0.000254	.802
	RSI	Whole	-0.001443	-0.000016	-0.001427	.000**	-0.002895	-0.001182	-0.001713	.012**
		5	-0.001055	-0.000016	-0.001038	.000**	-0.002207	-0.001182	-0.001024	.193
		10	-0.000992	-0.000016	-0.000976	.000**	-0.002207	-0.001182	-0.001024	.193
		20	-0.000625	-0.000016	-0.000609	.001**	-0.001538	-0.001182	-0.000356	.713
		30	-0.000411	-0.000016	-0.000395	.040*	-0.000982	-0.001182	0.000200	.846
	MACD	Whole	0.001030	-0.000016	0.001046	.000**	0.001014	-0.001182	0.002197	.032*
		5	0.000989	-0.000016	0.001005	.000**	0.001003	-0.001182	0.002185	.035*
		10	0.000987	-0.000016	0.001004	.000**	0.000950	-0.001182	0.002132	.042*
		20	0.000652	-0.000016	0.000669	.001**	0.000888	-0.001182	0.002071	.054
		30	0.000262	-0.000016	0.000278	.174	0.000425	-0.001182	0.001608	.166
	Gebert	Whole	0.000207	-0.000016	0.000223	.145	0.000389	-0.001182	0.001571	.141
		5	0.000206	-0.000016	0.000222	.148	0.000389	-0.001182	0.001571	.141
		10	0.000206	-0.000016	0.000222	.148	0.000389	-0.001182	0.001571	.141
		20	0.000206	-0.000016	0.000222	.148	0.000389	-0.001182	0.001571	.141
		30	0.000218	-0.000016	0.000234	.129	0.000389	-0.001182	0.001571	.141
*with 5 % significance level **with 2 % significance level										

Source: Our own calculation

To sum up, there were some differences among the markets in terms of the performance of the buy- and hold strategy. This strategy shows negative returns in the Japanese market in contrast to the German, European and British markets. Nevertheless, the performance of all indicators resembles in all the markets.

Furthermore we can convince ourselves that the MACD shows reliable performance in both the time of the crisis and the whole time period. Investors who used this indicator for the past 20 years were able to achieve significantly higher results than investors who bought the shares and kept them in its portfolio. The moving average and RSI show worst results compared to the buy and hold strategy and they fare badly especially in the time of the crisis.

This applies in the absence of the transaction costs. The effects of the transaction costs on the performance of the MACD indicator will be scrutinized later. Nevertheless, we can reveal that the MACD still achieves better results than other indicators with transaction cost of 1 %. When we raise the transaction costs then the Gebert indicator is getting ahead of all the other indicators due to its longer buy- and sell- signals.

6.4 Transaction cost and trading

The transactions fees play an important role for investors and they need to incorporate them into their investment plans. The transaction fees are incurred when an investor carries out a transaction, which means, she buys or sells shares. They are calculated on the basis of the value of shares that are involved in a trade. The average transaction fees range from 1 % for institutional investors to about 1.5 % for the private investors. The transaction fees offered by the major banks never exceed 2 % in the markets considered (Barclay, Kandel, & Marx, 1998, p. 141).

The commissions for the institutional investors went down significantly because of the use of modern technologies and automation on the stock exchanges. The data shows that the average commission for trading 100 shares was at 0.975 % in 1962 and it had become almost insignificant in the current years. The commissions on NYSE were just 0.12 % and transactions fees less than 0.3 % for the institutional investors in 1997 (Jones, 2002, p. 43).

Although the transaction fees affect the final returns for the investors, higher transaction fees may signal that the shares are of more reliable companies traded on one of the major stock exchanges. Some studies show evidence that even though transaction cost at major stock exchanges (e.g. NYSE) are higher the stocks traded on NYSE are more likely to show abnormal returns. This finding is also consistent with current literature that the investors must be compensated for cost of higher transaction fees (Barclay, Kandel, & Marx, 1998, p. 131).

This could be the case because investors who pay larger transactions fees are willing to hold the shares for longer period of times since the trading is more expensive. The investors are

able to redeem the cost over a longer time horizon. It results in growing share prices. (Barclay, Kandel, & Marx, 1998, p. 131). Nevertheless, the transaction fees do not have any direct effect on the share prices. According to Barclay et al. (1997) the transaction fees only have an impact on the trading volume and final investment returns but they do not affect the share prices (Barclay, Kandel, & Marx, 1998, pp. 130-131).

There is a considerable spread between the transaction fees on major stock exchanges (NYSE, Frankfurt, and London) and smaller stock exchanges. In addition, there are differences among the transaction cost expressed as a percentage for shares with lower prices (less and equal to 5 dollars) because some charges are fixed. Lesmond et al. (1999) try to deal with this problem and design a new model for determining the transaction fees independent of firm, period and exchange (Lesmond, Ogden, & Trzcinka, 1999, p. 1113).

The authors use the Cap-Based Portfolio Index of the Center for Research in Security Prices as the determinant of the firms' size. According to the assessment the majority of companies in our indexes belong to the large company size. They use a model that examines the relationship of zero returns and daily gains on the transaction cost. The assumption is that the zero returns are realized if the investors do not expect any gain from the trade as they expect that the transaction cost would exceed the expected gain. The fact that the investors decide not to trade leads to no price changes on from the previous to the current day (Lesmond, Ogden, & Trzcinka, 1999, p. 1114).

The statistical regression tests show that there is a significant relationship between the number of zero returns and the transaction cost. They find that the transaction cost range from 10.3 % for small companies to 1.2 % for large enterprises. Among others they support the idea that the incidence of zero returns is negatively correlated to the firm size and positively correlated to bid-ask spreads (Lesmond, Ogden, & Trzcinka, 1999, p. 1117).

The study supports the evidence that the common models overestimated the transaction cost by 15 % for small companies and 50 % for large companies. The value of 1.2 % is similar to previously mentioned 0.9 %. Consequently, we will consider two different transaction cost one of 1 % which will represent the transaction fee for insider companies and 2 % considered to be the maximum transaction fee for large companies (Lesmond, Ogden, & Trzcinka, 1999, p. 1137).

The table 42 shows the effect of the transaction cost on the returns made by individual trading rules. The first two columns describe the index and the indicator under consideration. Thereafter the third column gives us information about the mean returns of the buy-signals. The mean TC1 % column contains the returns of the indicators with 1 % transaction fees. The mean difference column always comprises the difference between the mean return of buy-signals without any transaction fees and the mean return on buy- signals with transaction fees. The p-value tells us about the significance of the differences.

The mean difference with the transaction cost of 2 % is also the difference between the mean buy-signals without the transaction cost and the mean returns on buy-signals with transaction cost of 2 %. It indicates whether the introduction of transaction fees led to a significant decrease of income of the investors. It is calculated with reference to the same base like the mean difference for the transaction fees of 1 %.

We can observe that the buy-signals for the whole time period have incorrect signs in the case of RSI which is in accordance with the results presented in previous tables. The rest of the buy- signals have correct (positive) sign with only the exception of the moving average in Nikkei. It means that the investors would make positive returns if they timed their investments following the signals generated by these indicators.

The analysis of the mean returns provides the evidence that some indicators are more likely to be affected by the transaction fees than others. The MACD and the Gebert indicator seem to be affected by the transaction fees significantly less than other indicator. We can notice that the mean daily return is reduced by about the half in the case of the MACD in comparison with other indicators. The Gebert indicator is less affected by the transaction fees due to its considerable signal length and its profitability is reduced about 50 times less than in the cause of other indicators.

The differences are rather specific to the markets than to the particular indicators. We can observe that the introduction of transaction fees results in lower returns in all of the markets (see Figure 43). The differences are significant in the American, Japanese and German market. The transaction fees also lead to somewhat lower return for RSI and MACD indicators in the case of Eurostoxx. The differences become more visible when the transaction fees rise from 1 % to 2 %.

The Gebert indicator is not affected by the transaction fees when applied to Eurostoxx. The returns of buy-signals before and after transactions fees differ slightly. if we applie the transaction fees of 1 % then the return will decline from 0.0222 % to 0.0211 %. If we increase the transaction fees to 2 % then the returns go down to 0.0199 %. The change of the returns in the European stock market is so small that both the institutional and private investors do not need to take the transaction fees into account if they decide to invest into Eurostoxx shares.

Figure 43 : Transaction cost

Transaction Cost All Periods								
Index	Indicator	Mean-B	Mean-TC1%	Mean Diff TC1%	p-Value	Mean-TC2%	Mean Diff TC2%	p-Value
Eurostoxx	MA	0.000207	-0.000159	-0.000365631	.000**	-0.000587	-0.000794148	.000**
	RSI	-0.001304	-0.001804	-0.000500333	0.030*	-0.002309	-0.001005713	.000**
	MACD	0.001103	0.000592	-0.000511177	0.028*	0.000198	-0.000905159	.000**
	Gebert	0.000324	0.000211	-0.000113028	.963	0.000199	-0.000124557	.925
FTSE	MA	0.000149	-0.000744	-0.000893539	.000**	-0.001523	-0.001671787	.000**
	RSI	-0.000989	-0.002099	-0.001110692	.000**	-0.003068	-0.002079170	.000**
	MACD	0.000719	-0.000103	-0.000822446	.000**	-0.000826	-0.001544967	.000**
	Gebert	0.000155	0.000097	-0.000057648	.000**	0.000040	-0.000115296	.000**
Nikkei	MA	-0.000037	-0.000037	0.000000055	.317	-0.001541	-0.001504556	.000**
	RSI	-0.001443	-0.002353	-0.000910062	.000**	-0.003341	-0.001897758	.000**
	MACD	0.001030	0.000281	-0.000749099	.000**	-0.000413	-0.001442796	.000**
	Gebert	0.000207	0.000156	-0.000051499	.000**	0.000115	-0.000091852	.000**
S&P	MA	0.000265	-0.000560	-0.000825302	.000**	-0.001377	-0.001641982	.000**
	RSI	-0.001064	-0.002023	-0.000958940	.000**	-0.003017	-0.001952407	.000**
	MACD	0.000816	-0.000001	-0.000816286	.000**	-0.000791	-0.001606063	.000**
	Gebert	0.000167	0.000129	-0.000038104	.000**	0.000097	-0.000070771	.000**
DAX	MA	0.000207	-0.000603	-0.000810115	.000**	-0.001409	-0.001615265	.000**
	RSI	-0.001304	-0.002223	-0.000919880	.000**	-0.003175	-0.001871071	.000**
	MACD	0.001103	0.000287	-0.000816273	.000**	-0.000503	-0.001606050	.000**
	Gebert	0.000324	0.000291	-0.000032755	.000**	0.000266	-0.000057736	.000**
*with the 5 % significance level **with the 2 % significance level								

Source: Our own calculation

In conclusion, the Gebert indicator and MACD fare much better than the other indicators when compared across markets because their mean return decreases at a lower rate. Consequently, if the transaction costs are high an investor should favor these two indicators. However, the Gebert indicator is the only indicator that shows positive returns when the transaction costs are 2 %.

Although the returns on the Gebert indicators are reduced far less than the returns of other indicators the differences before and after transactions fees are still significant with exception

of the Eurostoxx. That implies the importance of the transaction cost for investors. The investors should look for opportunities to reduce the transaction cost.

6.5 The comparison with other studies

Our analysis showed similar results to other studies considering the returns of the indicators. We would also like to use the comparison with past studies for a validation of our results. However, we need to point out that there are differences in the design of the indicators and periods considered. Consequently, we present the description of the differences. The Gebert indicator has not been examined in past scientific writing that is why it cannot be compared to the past research and the indicator was left out in this chapter.

We start with the MACD that has achieved the best results in our study. The MACD is a momentum and price indicator consisting of two moving averages and a signal line. Chong & Ng (2008) conducted a research on the performance of the RSI rule and the MACD rule in the Asian stock exchange market. They used the same methodology including the t-statistics to determine the significance of their results (Chong & Ng, 2008, p. 1113).

The Japanese market shows lower returns this can be attributed to the different period under consideration. Chong and NG (2008) took into account a twenty year period between 1974 and 1994 (Chong & Ng, 2008, p. 1112). In addition, we use the Japanese market as an approximation for the average of the Asian markets. All in all, we achieve comparable results as we can see in Figure 44.

Figure 44 : MACD comparison with current studies

MACD							
Chong & Ng (2008)				Our own research			
Period	Place	Buy	Sell	Period	Place	Buy	Sell
Whole (1974-1994)	Asia	0.01375**	-0.00679**	Whole (1996-2016)	Japan	0.001030**	-0.001043**

Source: Our own illustration of the MACD comparison and Chong & Ng (2008), p.1113 (Wong, Manzur, & Chew, 2003)

Their findings are congruent with our own research. The MACD performs better than the RSI rule and the buy-signals generate approximately three times higher returns. The buy- and sell-signals have the correct signs and the differences are statistically significant. We can observe that the MACD rule generates higher returns in the Chong & Ng (2008) study. It is mainly for the reason as the period does not include the prime-mortgage crisis.

Moving average

Our research suggests that the moving average rule is less profitable than the MACD. The buy-signals have the correct signs in most cases but the sell-signals have incorrect signs and are usually positive. That means that the triple moving average with 4, 9, and 13 day averages is not effective in forecasting the future prices. However, there are many different types of moving averages and certainly, some combination of the period lengths could achieve higher returns.

We compare our analysis with Metghalchi et al. (2012) who performed the most recent study on the profitability of moving average trading rules. They consider the time period from 1990 to 2006. In addition, they use a double moving average as part of their research. A signal is issued when the short-term moving average crosses the long-term moving average. They took into account three different moving average rules: the SMA, IMA and ARMA rules (Metghalchi, Marcucci, & Chang, 2012, p. 1542).

The standard moving average rule (SMA) issues a buy-signal if the closing price is above the long moving average. The investor will buy the shares at the close price the next day after seeing the signal. The increasing moving average (IMA) follows the same rules like the standard moving average. In addition, the long moving average must have positive slope. The results of our study are quite similar to the results of the Autoregressive Moving Average (ARMA). The ARMA trading rules relate the price to the short and long moving averages. If the price is higher than the moving averages then the indicator issues a buy-signal. Conversely, a sell signal is emitted (Metghalchi, Marcucci, & Chang, 2012, p. 1542).

Figure 45 : Moving average comparison with current studies

MA ARMA							
Metghalchi et al. (2012)				Our own research			
Period	Place	Buy	Sell	Period	Place	Buy	Sell
Whole (1990-2006)	Germany	0.00066	0.00002	Whole (1996-2016)	Germany	0.000207	0.000090

Source: Our own illustration of the MA comparison and Metghalchi et al. (2012), p.1549

We can see that the moving average in our study shows somehow lower returns in Figure 45. The reason is that Metghalchi et al. (2012) did not consider the prime-mortgage crisis that started in the year 2006. As we have shown in our study, the subprime mortgage crisis had

negative repercussions on the profitability of most of the technical indicators. The only indicator that fared well was the MACD.

If we contemplate the effects of the subprime mortgage crisis and the European automotive crisis then we can see that our results are highly comparable with the ARMA model. The difference is 0.04 %. The buy- and sell-signals are not significant and the sell-signals have the incorrect signs in both of the studies. These findings apply to both the London stock exchange and the Frankfurter stock exchange (Metghalchi, Marcucci, & Chang, 2012, p. 1549).

RSI

The RSI shows worse results in our analysis. The buy- and sell-signals have the opposite signs in all the markets. The signs do not change in the time of crisis which means that the RSI rule cannot be inverted and has generally bad performance. In comparison with other indicators the RSI rule achieves worse results.

Wong et al. (2003) examines the performance of different RSI trading rules and they find out that only the 50 crossover method displays some useful results. According to their study the results were inconclusive for other RSI trading rules. The RSI showed lower returns than other indicators. In contrast to our findings, the signals of their research displayed correct signs (Wong, Manzur, & Chew, 2003, p. 547).

Figure 46 : RSI comparison with current studies

RSI							
Wong et al. (2003)				Our own research			
Period	Place	Buy	Sell	Period	Place	Buy	Sell
Whole (1935-1994)	UK	0.00779**	-0.00127*	Whole (1996-2016)	UK	-0.000988**	0.00109**

Source: Our own illustration of the RSI performance and Wong et al. (2003), p. 550

They attribute the worse performance of the RSI to the fact that it should be accompanied by another indicator called the Average Directional Moving Index (Wong, Manzur, & Chew, 2003, p. 547). The ADX then shows whether the market has a trend or is non-trending. The RSI can cause some problems in markets where the prices display a notable trend. However, we find that the RSI rules is not profitable also in the Japanese market that has no notable trend.

We can see the comparison of our research on RSI in Figure 46. The differences can be ascribed again to the different periods under consideration. In addition, there is a high number of RSI rule combinations. Actually, the boundaries can be set arbitrary between 1-99 for the up and down bound respectively. Each rule will generate different profits. We decided to consider the 50 crossover rule according to Wong et al. (2003).

The choice of the boundaries for the RSI indicator plays an important role. Anderson & Li (2015) concentrate their study only on different versions of the RSI indicator. They find considerable differences among the RSI rules. On one hand, The RSI at 30 and 70 records a loss of -3009 pips. On the other hand there are rules that still generate some profits. The RSI rule at 10 and 90 makes a small profit of 1094 pips. In all the research the RSI rule had worse performance than other indicators which conforms to our results (Anderson & Li, 2015, p. 95).

The reason that we did not find any profitability of the RSI rule can be attributed to the fact that RSI belongs to the most used indicators by the analysts. When already many people try to exploit some RSI rules like the 50 crossover rule then these rules disappear or their returns decrease. The solution would be to find such rules that still work. However, designing new rules that worked in the past does not necessarily mean that these rules will be also able to forecast future price (Anderson & Li, 2015, p. 95).

6.6 The results of hypothesis testing

The aim of my master thesis was to analyze the performance and predictive power of four different technical indicators. These indicators included the moving average, the MACD, the Gebert indicator and the RSI. In addition, we put the Gebert indicator under scrutiny and analyzed its performance under various conditions. Consequently, we took into account different time periods, different transaction costs and different signal lengths.

We used the t-test to test both the predictive power and the returns. In addition, we used the bootstrapping technique to create simulated series and analyze whether the results can confirm or reject the findings of the past studies. We used the SPSS software for the calculation of the coefficients and the p-values.

The returns

We tested the performance by analyzing the significance of the differences between the returns on the signals of the indicators and the simple buy- and hold-strategy. We considered

signals with the five, ten, twenty and thirty signal length. The data was also divided into two major periods. First period comprises all the data and the second period shows the results from the subprime-mortgage crisis. We can see the summary of results in Figure 47.

Figure 47 : Hypothesis on returns

Hypotheses Description	*Empirical results for the whole time period*			
	Index	Indicator	H0	Description
H1: It is possible to achieve excess returns. We need to find significant differences amongthe buy- and hold- strategy and the returns on trading rules.	Eurostoxx	MA	cannot be rejected	no significant results
		RSI	cannot be rejected	incorrect signs
		MACD	rejected	excess returns can be achieved
		Gebert	cannot be rejected	no significant results
	FTSE	MA	cannot be rejected	no significant results
		RSI	cannot be rejected	incorrect signs
		MACD	rejected	excess returns can be achieved
		Gebert	cannot be rejected	no significant results
	NIKKEI	MA	cannot be rejected	no significant results
		RSI	cannot be rejected	incorrect signs
		MACD	rejected	excess returns can be achieved
		Gebert	cannot be rejected	no significant results
	S&P	MA	cannot be rejected	no significant results
		RSI	cannot be rejected	incorrect signs
		MACD	rejected	excess returns can be achieved
		Gebert	cannot be rejected	no significant results
	DAX	MA	cannot be rejected	no significant results
		RSI	cannot be rejected	incorrect signs
		MACD	rejected	excess returns can be achieved
		Gebert	cannot be rejected	no significant results

Source: Our own research

The data show that there are some minor differences in the markets. The buy- and hold-strategy would lead to losses in the Japanese market because the Nikkei index has never reached its previous values. Nevertheless, the indicators show similar results in the case of DAX, FTSE 100, Nikkei 225 and S&P 500.

Our study provides evidence that the investors using the MACD achieve better results considering both periods of time: the sub-prime mortgage crisis and all data. The MACD demonstrated its reliability in the past 20 years and technical analysts following the buy- and sell-signals of this indicator could achieve superior returns compared to the buy- and hold-strategy.

On the contrary, the moving average rules and RSI display worst results and their use by technical analysts is not recommended. Usually, the RSI and MA already emit signals with incorrect signs. That means the buy-signals have the negative signs thus investor would make losses when she buys and holds the shares in her portfolio.

It cannot be confirmed that the Gebert indicator achieves better results than the buy- and hold-strategy in any market. The MACD is always superior to the Gebert indicator considering the

returns. It is important to point out that this applies in the absence of the transaction costs. When we introduce the transaction costs of 2 % then the Gebert indicator demonstrate encouraging results in some markets.

The Gebert indicator

There were high expectations of the Gebert indicator considering its performance. This indicator was devised by Thomas Gebert who also holds the certification for the same-named indicator. The indicator is comprised by four parameters: the interest rates, the exchange rates, the inflation rate and seasonal variable. According to the author of this indicator, an investor would generate returns of 2347 per cent in the period from 1996 to 2015. The results of all the hypothesis are summarized in Figure 48.

Figure 48 : Hypothesis on the Gebert indicator

Hypotheses Description	***Empirical results for the whole time period***			
	Index	Scenario	H0	Description
H1:Gerbert indicator can achieve superior returns in comparison to common technical indicators. We need to find significant differences amongthe buy- and hold- strategy and the returns on trading rules.	Eurostoxx	No TC	cannot be rejected	no excess returns to MACD
		TC 1%	cannot be rejected	no excess returns to MACD
		TC 2%	cannot be rejected	no excess returns to MACD
	FTSE	No TC	cannot be rejected	no excess returns to MACD
		TC 1%	cannot be rejected	no excess returns to MACD
		TC 2%	rejected	excess returns to all indicators
	NIKKEI	No TC	cannot be rejected	no excess returns to MACD
		TC 1%	cannot be rejected	no excess returns to MACD
		TC 2%	rejected	excess returns to all indicators
	S&P	No TC	cannot be rejected	no excess returns to MACD
		TC 1%	cannot be rejected	no excess returns to MACD
		TC 2%	cannot be rejected	no excess returns to MACD
	DAX	No TC	cannot be rejected	no excess returns to MACD
		TC 1%	cannot be rejected	no excess returns to MACD
		TC 2%	cannot be rejected	no significant results

Source: Our own research

The results show that the Gebert indicator achieves positive returns in all the markets. The returns are significantly higher than those of the MA and RSI indicators. However, the MACD indicator has superior returns to the Gebert indicator in all the markets with the absence of the transaction fees. When we raise the transaction fees then the relative performance of the Gebert indicator improves due to the fact that it emits longer buy- and sell-signals.

The considerable signal length of the Gebert indicator does not require an investor to constantly sell- and buy- shares. On the contrary, it enables the investors to save money on transaction fees. When we introduce transaction fees of 2 % then we can notice that the Gebert indicator achieves superior returns to the MACD in the UK and Japanese stock

exchange markets. The DAX shows results that are not statistically significant. The performance in the case of Eurostoxx and S&P remains unchanged. Even with the transaction fees of 2 % the MACD still shows better results when applied to these indexes.

The predictive power

According to the current literature on technical analysis, we can determine whether a technical indicator is able to forecast future past movements by analyzing the trading signals. If an indicator displays statistically significant differences between the buy- and sell–signals then it will be able to predict future price movements. Consequently, we use the t-test to determine the statistical significance. The results are shown in Figure 49.

Figure 49 : Hypothesis on price movements' prediction

Hypotheses Description	***Empirical results for the whole time period***			
	Index	Indicator	H0	Description
H1:The indicators are able to predict price movements We need to find significant differences amongthe buy- and hold- strategy and the returns on trading rules.	Eurostoxx	MA	cannot be rejected	no significant results
		RSI	cannot be rejected	incorrect signs
		MACD	rejected	excess returns can be achieved
		Gebert	cannot be rejected	no significant results
	FTSE	MA	cannot be rejected	no significant results
		RSI	cannot be rejected	incorrect signs
		MACD	rejected	excess returns can be achieved
		Gebert	cannot be rejected	no significant results
	NIKKEI	MA	cannot be rejected	no significant results
		RSI	cannot be rejected	incorrect signs
		MACD	rejected	excess returns can be achieved
		Gebert	rejected	weak but significant relationship
	S&P	MA	cannot be rejected	no significant results
		RSI	cannot be rejected	incorrect signs
		MACD	rejected	excess returns can be achieved
		Gebert	cannot be rejected	no significant results
	DAX	MA	cannot be rejected	no significant results
		RSI	cannot be rejected	incorrect signs
		MACD	rejected	excess returns can be achieved
		Gebert	cannot be rejected	no significant results

Source: Our own research

The results clearly indicate that there are just two indicators that possess the ability to forecast future price movements but only the MACD can be used to forecast them in all the markets. Although the Gebert indicator has the correct sign of the buy– and sell-signals which is an important prerequisite for making profits on technical trading rules then the differences between its buy- and sell-signals are not significant in most markets with exception of the Japanese market (Nikkei 225).

The MACD always displays the correct signs of the buy- and sell-signals. Nevertheless, it is able to forecast price movements of all the indexes. In addition, it has a very good forecasting power in the time of the crisis. It especially excels at identifying short-term price movements.

It issues more signals than the Gebert indicator. That means an investor needs to buy and sell shares regularly what in contrast, results in higher transaction cost.

The Bootstrapping confirms that some indicators have predictive power. However, only two indicators have the correct signs of the buy- and sell-signals, namely the moving average and the MACD. The differences between their buy- and sell-signals are highly significant. It means that shares prices that follow the random walk hypothesis and their returns are normally distributed can be forecasted based on these two indicators.

The transaction fees

There are several factors having the influence on the transaction fees. The firm size, type of the stock exchange, number of shares purchased are some of them. We consider transaction fees of two different sizes. First, we use 1 % transaction fees. This amount was used in some studies as an approximation of the transaction cost for institutional investors. Thereafter we increase the transaction fees to 2 %. Most of the investors pay transaction fees between one and two per cent. The transaction fees of 2 % can be viewed as the upper boundary or the cost for private investors.

The data analysis shows that the transaction fees reduce the income significantly. The significance of the profit reduction depends more on the type of the index and the market. The indicators in markets that are volatile or stagnant show a number of false signals. These reduce the profitability of the trading rules.

In the presence of transaction fees, the Gebert indicator and the MACD are the superior indicators because their returns decrease at a lower rate with rising transaction fees. An investor who wants to make profit also with transaction fees should give preference to these two indicators. It is also important to point out that the Gebert indicator is the only indicator that shows positive returns with transaction fees of 2 %.

In conclusion, we could confirm the empirical evidence presented by the past studies. The RSI indicator has no forecasting power and low profitability. The performance of the moving average is better. However, the indicator has mostly no forecasting power in the period considered. The MACD and the Gebert indicator show positive returns on the trading rules as the only indicators in our analysis. The MACD is the only indicator able to predict price movements in all the markets and it has superior returns to the buy- and hold- strategy.

Although the Gebert indicator has higher returns in some markets when we introduce the transaction fees, the results of our study provide the evidence that the Gebert indicator is not able to forecast the price movements. It means that all the predictions are attributed to chance or to the deliberate design of the indicator. It can be likened to choosing such variables that achieved good results in the past but are not able to predict future price movements.

7 Conclusion

The thesis sought to analyze the profitability of the Gebert indicator and compare its performance with the MA, RSI and MACD. For this reason we used the daily closing prices of the indices DAX, Eurostoxx, FTSE, NIKKEI and S&P 500 for the last 20 years. The data sample was split into three sub periods documenting separately the subprime mortgage crisis. Furthermore we examined the predictive power of these indicators and determined whether the positive returns are statistically significant.

We took into consideration different scenarios. First we studied how the indicators perform in the markets without transaction fees. Thereafter we introduced two different levels of transaction fees of one and two percentage points. These transaction fees should reflect both, the costs of the private and institutional investors respectively.

The data was processed in Excel using VBA programming. Thereon we imported the data into SPSS and used the t-statistics to determine whether there are significant differences between the buy- and sell- signals. We also performed bootstrapping tests and the test of normal distributions that demonstrated that the distribution of our data matched the bell shaped curve. Consequently, we could proceed with our analysis.

The results clearly indicated that an investor would achieve higher returns using the MACD indicator or moving average rules than the Gebert indicator in a market with no transaction fees. However, the performance of the Gebert indicator improved significantly after introducing the transaction fees. What is more, the Gebert indicator is the only indicator that displayed positive returns when we considered the transaction fees of 2 %. All the indicators showed consistent results across the markets. In addition, the bootstrapping method confirmed our previous findings.

Future research should focus on contribution of the fundamentals of the Gebert indicator to its performance. These fundamentals include the inflation rate, exchange rate, interest rate and the calendar effects. Each of these variables has different predictive strength. In addition, the researches should scrutinize whether one of these variables could be replaced or altered in order to increase the indicator's predictive power.

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Appendix 1: Abstract

Abstract English

The thesis seeks to provide an in-debt analysis of four major technical indicators. These indicators are applied to DAX, S&P 500, FTSE 100 and NIKKEI 225. We assess the performance and the forecasting ability of the MACD, MA and RSI rules. In addition, we scrutinize the fundamentals of the Gebert indicator and look under what conditions it could be profitable for the investors. The theoretical part provides introduction to the stock exchange markets and describes technical indicators. The empirical part presents results of the statistical analysis. We obtain some interesting insides on the technical analysis. We found out that the markets are intercorrelated and indicators display similarities regarding their profitability and forecasting ability. The MACD indicator stands out in comparison with other indicators in absence of transaction fees. The Gebert indicator shows better performance with high transaction fees due to the higher length of the buy- and sell-signals.

Abstract German

Ziel der vorliegenden Arbeit ist eine Tiefanalyse der vier wichtigsten technischen Indikatoren. Diese Indikatoren werden auf den DAX, S/P 500, FTSE 100 und NIKKEI 225 angewandt. Wir untersuchen die Performance und die Vorhersagegenauigkeit von MACD, MA und RSI. Zusätzlich überprüfen wir die Grundlagen des Gebert-Börsenindikators und zeigen unter welchen Bedingungen er profitable für die Investoren sein kann. Der Theorieteil beginnt mit einer Einführung über Aktienbörsen und beschreibt in weiterer Folge die oben gennannten technische Indikatoren. Im empirischen Teil werden die Ergebnisse der statistischen Analysen präsentiert. Hierdurch bekommen wir einige interessante Einblicke in die technische Analyse. Im Zuge dieser Arbeit haben wir herausgefunden, dass die untersuchten Märkte sehr eng miteinander verflochten sind und dass die Indikatoren Ähnlichkeiten aufweisen, was die Profitabilität und die Vorhersagegenauigkeit betrifft. Werden die Transaktionsgebühren nicht berücksichtigt weist der MACD Indikator eine bessere Performance auf. Allerdings der Gebert-Indikator weist eine bessere Performance bedingt durch längere Kauf- und Verkaufssignale unter der Berücksichtigung der höheren Transaktionsgebühren auf.

Appendix 2: Bootstrapp

```
Sub BootstrapRandom()
Dim UpperBound, DownBound, randomValue, x, y, z, k, u, indexA As Integer
Dim LogReturn As Double
DownBound = 1
UpperBound = Sheets("Simulation25").Range("K2").Value
'Sheets("Bootstrap").Range("H5") = Rep
For z = 1 To Rep
   x = 2
   indexA = 0
      Do Until Sheets("Simulation25").Cells(x, 1) = ""
         ArrRandVal(indexA) = CInti(Int((UpperBound * Rnd()) + DownBound))
         y = ArrRiandVal(indexA) + 1
         ArrLogRet(indexA) = Sheets("Simulation25").Cells(y, 4)
         ArrSeries(indexA) = 6900 * (1 + ArrLogRet(indexA)
         x = x + 1
         indexA = indexA +
      Loop
k = z + 2
u = z - 1
Next z

End Sub
```

Appendix 3: Data Matching

```
Sub Gerbert_BUY_SELL()
Dim read, LastValue As String
Dim x, y, z, LastCell As Integer
Dim ArrResults(6000) As Variant
x = 3
z = 3
LastCell = 0
Do Until Cells(z, 1) = "" 'Define the number of dates
   LastCell = LastCell + 1
   z = z + 1
Loop
LastCell = LastCell + 3
y = 0
Do While x < LastCell
read = Cells(x, 46).Value
   Do While read <> "HOLD" And x < LastCell 'Copy SELL and BUY signals until reaching
HOLD
   read = Cells(x, 46).Value
   ArrResults(y) = Cells(x, 46).Value
      If read <> "HOLD" Then
         LastValue = Cells(x, 46).Value
         x = x + 1
         y = y + 1
      End If
   Loop
   Do While read = "HOLD" And x < LastCell 'Define if HOLD is BUY or SELL
   read = Cells(x, 46).Value
      If read = "HOLD" Then
         ArrResults(y) = LastValue
         x = x + 1
         y = y + 1
      End If
   Loop
 Loop
Range("AU3:AU6000").Value = WorksheetFunction.Transpose(ArrResults)
End Sub
```

```
Sub Infl()
Dim Quotation As Double
Dim read As Double
Dim x, y, g, z As Integer
Dim ArrResults(9000) As Variant
y = 3
x = 3
z = 3
read = Cells(x, 10).Value
Do Until Cells(x, 6).Value = ""
read = Cells(x, 10).Value
y = z              'starts writing at the last position with a value
   Do Until Cells(y, 25).Value = "" 'Copy points for Inflation into results table for each month
and yr
       If Cells(x, 7).Value = Cells(y, 26).Value Then 'compare yrs
          If Cells(x, 8).Value = Cells(y, 27).Value Then 'compare months
           g = y - 3
           ArrResults(g) = read
           z = z + 1
          End If
       End If
   y = y + 1
   Loop
x = x + 1
Loop
Range("AC3:AC9003").Value = WorksheetFunction.Transpose(ArrResults)
End Sub
```