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# Quantified Volatility Modelling and Diversification across Geographical Regions and Asset Classes

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June 1, 2014

## Abstract

Today's financial markets are currently experiencing stock index valuations close to all time high while low interest rates creates a negative outlook for fixed income-securities. Historically, stock markets will periodically experience downward corrections, and more and more market participants are starting to fear that the current five year bull-market is coming to an end soon. This thesis will therefore look into how an investor may position their portfolio to reduce the volatility without compromising the long-term return, both over a longer time-span and during times of increased uncertainty. An analysis is also done to try to predict which major, market-altering incidents that may occur over the coming years, while still recognizing that market-altering events are often characterized by being close to impossible to predict.

The historical cross-index relationship has been applied, and the index performance during times of market uncertainty was analyzed. This included an in-depth study of the financial crisis of 07-08 and the Eurozone crisis. The data was gathered using Reuters Datastream 5,1 with daily index observations from January 1<sup>st</sup> until the end of 2013. Combining this with a qualitative analysis of non-quantitative risk factors, as well as the likely future development, a new portfolio weighting was calculated, having the ability to achieve higher returns than the reference portfolio, while still experiencing lower historical volatility for the portfolio value. By using the GARCH(1, 1) equation, and calculating GARCH parameters for each relevant index, the forward development of volatility following a crisis could also be estimated.

The results indicated that institutional investors, such as Norway's Sovereign Wealth Fund, should increase their allocation to riskier asset classes such as high yield-bonds, gold and equities of emerging markets, and still be able to reduce their overall risk exposure by allocating more than half of the portfolio to fixed income-securities.

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*'Those who claim to foresee the future are lying,  
even if by chance they are later proved right.'*

*- Arabic Saying*

## Chapter 1: Introduction

This thesis will look into how volatility is used in today's financial markets, and why it is so important for an institutional investor. Volatility is a measurement of fluctuations in asset values and is a common source for a substantial part of an investor's risk exposure. By analyzing financial data across global markets and asset classes, this thesis aims at explaining how markets are intertwined, and how financial uncertainty spreads across markets. The goal is also to calculate how an institutional investor may position their portfolio to diversify away some of the market risk.

As explained in the *background* section, the financial markets of today are experiencing a low-return environment, with high multiples and unattractive valuations. The expectation of increasing interest rates makes the bond market unappealing for most investors, who consider the low yield as unattractive for the current interest rate risk.

Many of the historical assets bubbles underwent a belief that the market was experiencing a paradigm shift, a belief that eventually was proven wrong leading to a collapse in asset prices. Over the past six years, one can make the argument that markets have actually undergone a new kind of paradigm shift, where low-risk assets were ultimately proven to be the source of a substantial risk exposure. If investors start to consider low-risk assets as riskier, high-risk assets may see a sell-off, and the increased risk exposure may not be justified by the higher yield.

With the increased globalization of world trade, the interconnection of national economies, as well as the internet leading to a cross-border flow of capital and information, financial uncertainty will quickly spread across continents, and diversification strategies are becoming more complex than simply buying assets in various countries.

By comparing index data over several events that may lead to uncertainty, we will analyze how the markets are intertwined, and to which degree the uncertainty spreads. How does the market sentiment spread across asset classes, and is there any assets that investors automatically seek to, which may offset some of the portfolio volatility? A GARCH(1, 1) equation will also be established for the asset classes, which can be used to estimate future volatility based on historical data.

History has shown us that the incidents that disrupt financial markets are almost impossible to prepare for, and it is easier to prepare one's portfolio for a general uncertainty, than to position it for the specific events. By using quantitative methods, combined with qualitative analysis, the thesis will try to design a guideline for portfolio composition while still achieving satisfactory returns.



## 1.1 Background

This thesis started February 1<sup>st</sup>, 2014. After experiencing a 5 year bull-market, the S&P 500 closed yesterday(Jan 31<sup>st</sup>) at 1782.59 and ended up 29,6% for 2013. In two days, Janet Yellen, a “dovish” economist expected to continue Bernanke’s Quantitative Easing(QE), will be sworn in as the new Chair of the Federal Reserve Board of Governors. She must deal with an unemployment rate well above the historical average and a slow economic growth while balancing her relationship with the opposing wings of the U.S. congress. The quantitative easing, combined with increasing national debt and an inefficient political system, has even led to speculations regarding the status of the dollar as the global reserve currency(Rooney 2011).



From left to right: Mario Draghi, president of the ECB, Janet Yellen, Chair of the FED, and Shinzō Abe, Prime Minister of Japan.

### Industry Insight:

The Federal Reserve has to balance their policies, as actions to increase employment may affect the rate of inflation, and vice versa. The individual policy makers have different priority areas, and the financial community uses the terms “Doves” for those that focuses on employment, while “Hawks” worry mostly about inflation. Both Janet Yellen, and her predecessor, Ben Shalom Bernanke, are considered doves(Constable 2013).

Japan, on the other hand, has been struggling since the burst of the Japanese Asset Price Bubble, with the Nikkei 225 reaching its peak at December 29<sup>th</sup> 1989 at 38,957, Japan has experienced slow economic growth, an increase in unemployment and large budget deficits. With an inauspicious age demographic, where some estimates puts the share of the population aged 65 years or older at a staggering 40% by 2060(BBC 2012), it does not look very promising for future economic growth. In addition, the gross national debt of Japan now equals 214,3% of the GDP according to the IMF, by far the most in the world(Greece, number two on the list and presently in the middle of a debt crisis, still “only” has a debt-to-GDP level of 158,5% according to IMF data). To try to improve the Japanese economy and once again secure the place as the most powerful nation in south-east Asia, Prime Minister Shinzō Abe has implemented a variety of reforms and programs, popularly known as *Abenomics*. The well-renowned magazine *The Economist* best described *Abenomics* as “a mix of reflation, government spending and a growth strategy designed to jolt the economy out of suspended animation that has gripped it for more than two decades”(The

Economist 2013). By quantitative easing, specific inflation targeting, negative interest rates and an increase in fiscal spending, Shinzō Abe hopes to turn the tides of the Japanese economy.

Although significant variations between the individual states of Europe, the economy and wealth of European nations are still well above the global average, including several of the largest and most developed economies in the world. However, the Eurozone debt-crisis has hit the entire continent, causing debt-stricken nations to seek bailouts by IMF and ECB. The Eurozone economy is contracting, and austere fiscal policies combined with social inequalities have caused protests and uprisings in several European cities.

Nevertheless, despite the negative macroeconomic developments of some of their biggest trading partners, China is the locomotive pushing the world economy further, establishing themselves as the second biggest economy in the world. From producing \$330 worth of goods and services per person in 1991, that number had increased to \$5720 in 2012, adjusted for inflation. With domestic consumption starting to increase rapidly (fastest growing consumer market in the world, according to the IMF) (Nabar & Yan 2013) and the expected liberation and development of Chinese financial markets yet to come, the potential for satisfactory returns is still very much present. Financial markets are starting to worry that the future holds several aspects of uncertainty (see section 4.9) and that problems in the Chinese financial markets could easily propagate to the rest of the world.

As further elaborated in section 1.4, it is the opinion of the author that global financial markets will continue to face challenges and sudden shocks, which may have everything from long-term and market altering effects to no real macroeconomic effect at all. Financial markets have had to worry about different aspects and scenarios for decades, and it is not likely that the world will develop into a situation where the unforeseen and unanticipated can be ruled out. As the triggering events may stem from a wide variety of sources, both geographical and categorical, the question asked through this thesis is how an institutional investor may, at least to some degree, protect himself from the shock and increased volatility imposed by these events by portfolio diversification. With the insecurity following a triggering event, how will the uncertainty spread through asset classes and different financial markets?

Yngve Slyngstad, the CEO of Norway's Government Pension Fund Global, was quoted in August of 2013 telling Reuters that "It is less a reflection of our enthusiasm for equity markets and more a reflection of our lack of enthusiasm for bond markets" after increasing the fund's equity holdings to 63,4% (Waki 2013). This illustrates the market belief that stocks will have poor annual return over the next decade, but there really is no other option in today's investment climate if one seeks a satisfactory real rate of return. An investor cannot simply "abandon the market", but must try to

position themselves so that sufficient returns can be achieved while minimizing the risk exposure.

### **1.2 A selection of financial crises throughout history:**

- **1636: Tulip Mania**

Considered the first speculative bubble, as the price of a single tulip bulb reached 10 times the annual income of a craftsman. By setting up a market for tulip futures, speculators drove up the prices to unstable levels before it collapsed abruptly.

- **1792: Panic of 1792**

A financial credit crisis, following a substantial expansion of credit from the newly formed Bank of the United States. Credit was eventually tightened, at the same time as the value of U.S. debt securities and bank stocks started to fall. Panic grew among depositors, and a run on the banks occurred as people started to fear for their savings.

- **1907: Knickerbocker crisis**

The United States had already experienced a period of recession, with several banks experiencing a run from depositors. During all this, the billionaire Otto Heinze tried to corner the market for shares of the United Copper Company, as he believed that an increase in prices could initiate a short-squeeze for investors that had shorted the stock. When this scheme failed, depositors lost faith in banks controlled by Heinze, and the panic started to spread across the market. One week later, this led to the collapse of the Knickerbocker Trust Company, the third largest trust in New York City. This was known as a safe and vital financial institution, and the collapse led to a panic in New York's financial markets, which soon spread out across the nation. One can here draw parallels to the bankruptcy of Lehman Brothers in 2008, as the fall of an institution considered "too big to fail" caused market panic across the globe.

- **1929: The great depression**

Started with a substantial fall in the stock market on September 4<sup>th</sup>, 1929, and led to a widespread depression across the global economy. International trade dropped by more than 50% while the unemployment rate in the United States exceeded 25%. As banks had invested much of depositor's money in the stock market, several banks had to declare bankruptcy, pulling the economy into a negative spiral. Severe drought and dust storms resulted in poor crops, resulting in farmers often not being able to feed themselves, and foreclosing on their farms. For some countries, the recession lasted until after World War

II, and historians generally contribute it to being one of the causes to why the Nazi regime of Adolf Hitler could gain power in Germany.

- **1987: Black Monday**

*Black Monday* of 1987 refers to October 19<sup>th</sup> of 1987, as the stock market crash spread from Hong Kong throughout the world, causing the DJIA to drop almost 22% in one day. The fall was additionally amplified by trading algorithms and portfolio insurance-arrangements.

- **1997: Asian Crisis**

Starting with the government of Thailand deciding not to peg their currency to the US dollar anymore, currency devaluations spread across East-Asia. This led to declining stock markets and reduced import revenues starting in the summer of 1997.

- **The Internet Bubble**

Also called the dot-com bubble, a speculative driven bubble around the year 2000, where investors valued telecom and internet firms at extreme multiples. Investors talked about a paradigm shift as the internet would change how businesses operate, but it eventually led to the collapse in the market capitalization of several companies.

- **The financial crisis of 2008**

Further elaborated in section 4.8.1, the crash of the American housing market led to panic in global financial markets, resulting in the worst economic downturn since the great depression.

### **1.3 Authors opinion: a paradigm shift for investor sentiment**

Over the last 25 years, financial markets all over the world have gone through drastic changes, renewing themselves with respect to increasing globalization of trade and information. Especially emerging markets have a need to develop a modern financial system to fund their domestic businesses and industry, to avoid stagnating as merely the factories for the developed economies. As the markets are getting closely intertwined, the individual markets will become more and more affected by the performance of non-domestic economies, and the overall market performance will move closer with macroeconomic tendencies.

At the same time, access to the internet has given the public an opportunity to check the performance of their investments within seconds on their cell phones, instead of checking the stock sections of tomorrow's newspapers or having to wait for their mutual funds to release their quarterly reports. This makes it much more evident if their investments are underperforming compared to the overall market, and will strengthen the psychological barriers against exiting a Bull market when stock indices keeps on growing. No fund manager wants to miss out on a period of growing stock prices, which may cause investors to withdraw their funds due to

underperformance. As the market moving incidents are likely to be unforeseen, the market participants will be influenced by both the market performance and the media saying that the stock market will keep growing, and investor capital will stay in the stock market until an unexpected incident causes a large downwards correction.

Historically, the length of bull-markets is much longer than that of bear-markets, with an average duration of 108,5 months against 16,25 months. This is illustrated in chart 1.1, published by Morningstar’s Jerry Kerns. It is the opinion of the author that future market development is likely to be characterized by even longer upward trends and sudden downward corrections, instead of smooth periods of falling markets. This will reinforce the historical trend, with bear-markets experiencing fluctuations of an even greater magnitude over a short period of time.

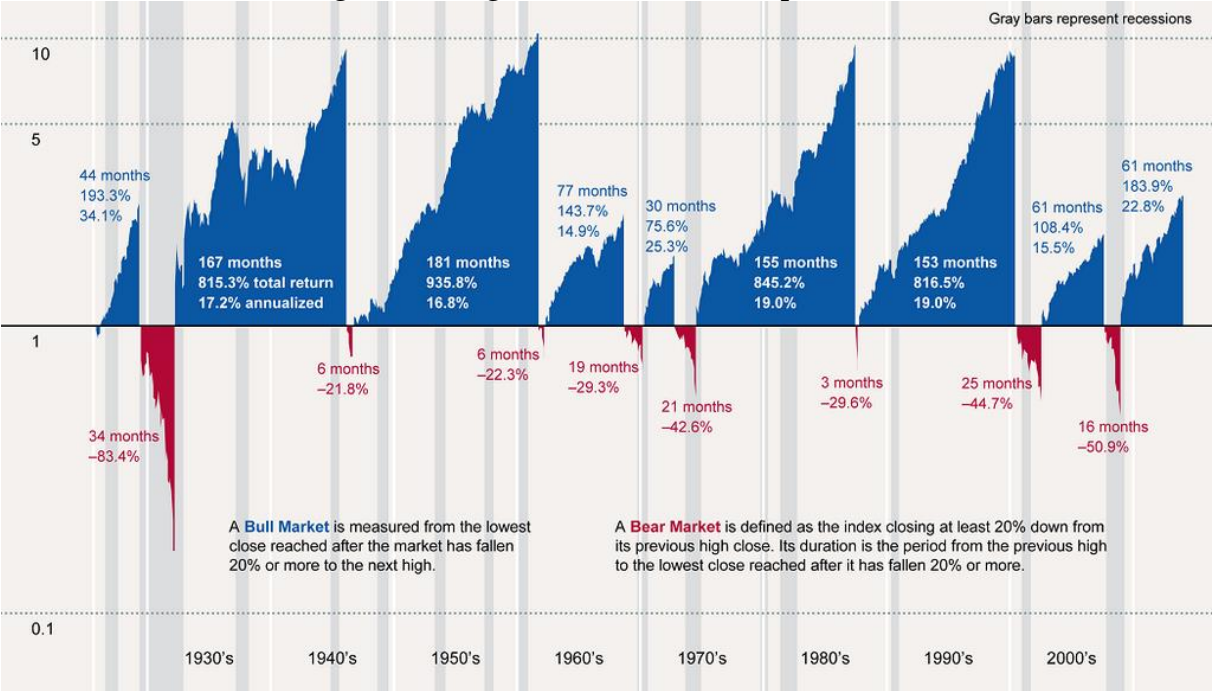


Chart 1.1, duration and performance of bull- and bear-markets.  
 Source: Morningstar, Jerry Kerns

**1.4 Important Institutional Investors:**

**Berkshire Hathaway(NYSE: BRKA and BRKB)**



Berkshire Hathaway Inc. is an American holding company, headquartered in Omaha, Nebraska, controlling assets totaling \$484,9 billion(BRK 2013).

The company is most known for its chairman and CEO, Warren Buffet(pictured on the left), considered by many to be the world’s greatest investor. By focusing on long-term investing, with a low debt ratio and large capital reserves, he has managed to achieve an annual return in book value of 19,7% to

underperformance. As the market moving incidents are likely to be unforeseen, the market participants will be influenced by both the market performance and the media saying that the stock market will keep growing, and investor capital will stay in the stock market until an unexpected incident causes a large downwards correction.

Berkshire Hathaway's shareholders. Berkshire Hathaway invests in public and privately owned companies, as well as bonds and derivatives.

### **Norway's Government Pension Fund Global**

The world's largest sovereign wealth fund, established in 1990 to manage the surplus income resulting from the Norwegian petroleum sector. The fund is currently estimated to be the largest stock owner in Europe, with a total market value of more than \$837 billion(NBIM 2014a). The fund consists of 60% stocks, 35-40% bonds and up to 5 % real estate investments(NBIM 2014b). Using dollar-cost averaging and a long-term time horizon, the fund aims at minimizing their losses during market corrections and bear markets. The fund is an active investor, with their main geographical exposure towards European and North-American markets, but also geographic diversification through investments in developed nations in Oceania and Asia, as well as emerging markets on all continents.

### **Yale Endowment Fund**

The Yale Endowment Fund consists of thousands of sub-funds, with different purposes and mandates, totaling \$20,8 billion( as of June, 2013). Led by Chief Investment Officer David Swensen, the Endowment fund has achieved a staggering annual return of 13,5% over the least twenty years(Yale 2013). David Swensen wrote the book *Pioneering Portfolio Management*, the "bible" of the Yale Model, which argues for a broadly diversified and equity oriented investment strategy, avoiding low-return asset classes such as fixed income and bank deposits. Swensen argues that due to the eternal time horizon, a University will achieve greater returns by taking high risks and take advantage of market imperfections.

## **1.5 Diversification**

Although financial markets are heavily intertwined, there are opportunities to lower portfolio volatility by diversification. By having the positive performance of some assets neutralize the negative performance of others, the overall performance of the portfolio can be smoothed out to avoid some of the fluctuations.

A fall in Asian financial markets may not affect European or American markets, and geographical rebalancing may lead to greater long-term return. Even within equity markets, there are great differences in the market risk and the corresponding risk premium. Emerging markets are considered far riskier than already developed economies, but has returned a significant amount to investors over the last decade.

During an economic downturn, the expectation of a decrease in corporate earnings will usually lower the stock market. At the same time, central banks will try to increase consumption and investments in the economy by lowering the interest rates, which again will raise the value of bonds. If one were periodically to rebalance the portfolio throughout a bear market, selling bonds and buying stocks, one would lower the average dollar-cost of your positions, preparing the portfolio for a market recovery.

This leads to the research question of this thesis;

### 1.6 Research Question:

Volatility is an important factor within financial risk management, and a vital variable in portfolio management. The objective of this thesis is to look into volatility theory, and the relationship between historical and implied volatility, as well as comparing how the volatility of different types of investments moves according to one another. How may an institutional investor reduce its volatility through diversification, both regionally and through various asset classes? Could a portfolio be structured so that the volatility could be minimized, without compromising returns?

### 1.7 Outline of the Thesis

**Chapter 1** gives an introduction to the rest of the thesis and illustrates the motivation for the thesis, as well as the present situation in modern financial markets.

**Chapter 2** presents the background theories that most of the modelling and calculations of this thesis are founded on. It also defines some key aspects of the most important financial assets, and defines the scope of the assets included in the thesis. A closer definition of the concept of volatility, as well as the mathematic foundation it is built on, is done in this chapter.

**Chapter 3** applies financial ratios and economic indicators, and looks into historical relationships between the variables and both historical and implied volatility. The goal is to study if a change in volatility can be predicted so that an investor may position itself to minimize the negative consequences of the increased uncertainty.

**Chapter 4** is the chapter where most of the calculations and optimization is done. Here, the difference between asset classes is studied, and the relationship between indices during times of distress. Market performance during both the Financial Crisis and the Eurozone crisis, as well as several other incidents over the past decade, is analyzed. In addition, some incidents have been listed that may occur in the future, that has the potential to alter global financial markets. Estimations regarding market performance in the event of such crisis were done, and a recommended portfolio composition was calculated.

**Chapter 5** discussed the results found in chapter 4, and potential sources of errors were brought up. This led to **Chapter 6**, where the conclusion was written, based on the previous 5 chapters, and answering the research question.

To round it all off, an **Afterword** is included in the back, describing the performance of financial markets during the work period of this thesis.

## Chapter 2: Theory

### Part I, Volatility

When one works with the volatility( $\sigma$ ) of a security, one refers to the fluctuations in the value of the security, e.g. up-and-down movements in price levels. It is represented as the standard deviation of price movements, assuming normally distributed daily return.

#### 2.1.1 Defining volatility:

Volatility isn't just one single number; it is based on X days of data to predict the volatility over the next Y days, where X and Y is chosen based on the usage of the result. There are two important types of volatility, implied and historical:

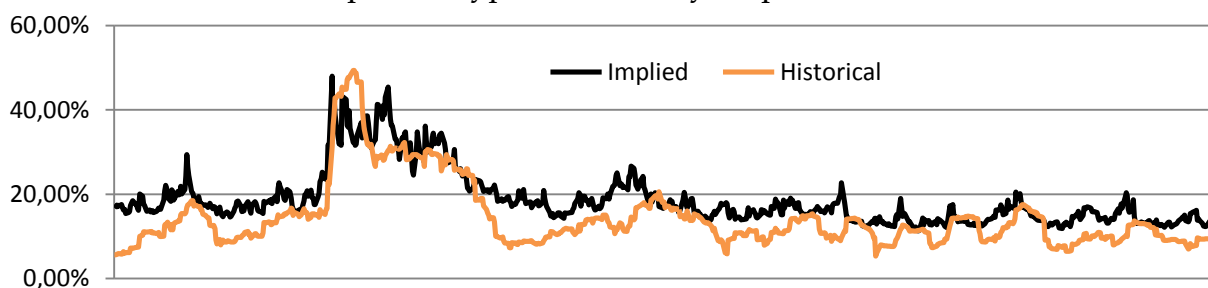


Chart 2.1.1, Implied and historical 30-day volatility for the S&P 500, expressed as volatility pr. annum.  
Source: Reuters Datastream 5,1 and The Federal Reserve Bank of St. Louis

- Historical volatility: uses historical prices, observed over a fixed interval of time, to calculate the expected annual volatility of a financial instrument. One usually utilizes data from the last 30 days, to calculate  $u_i$  and  $\bar{u}$ :

$$u_i = \ln\left(\frac{S_i}{S_{i-1}}\right) \quad \text{for } i=1,2,\dots,n.$$

$$\text{Historical volatility, } \sigma = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (u_i - \bar{u})^2}$$

The fixed interval of time is given in calendar days instead of trading days, but 21 trading days is commonly used to replace 30 calendar days. The number of trading days in a year is then used as a basis for calculating the annual volatility, and a year is assumed to have 252 trading days in it.

$$\text{Volatility pr annum} = \text{Volatility pr trading day} \times \sqrt{252}$$

One assumes a normal distribution for the price of the underlying(see section 2.3.12), so the volatility represents one standard deviation of expected change, meaning that in the next 30 days, we can be 68,27% certain that the magnitude of change will be equal to, or less than  $1 \sigma$ .



- Implied volatility: the volatility implied by the option prices observed in the market, when using the Black-Scholes-Merton pricing formula, and solving for  $\sigma$ . The volatility is the only value in the option pricing formula that is not directly observable in the market. As the implied volatility tends to vary for different strike prices and expiration dates, one uses the average of the implied volatilities for the different options representing the underlying.

The Black-Scholes-Merton differential equation has multiple solutions, each corresponding to the different derivatives that can be defined with  $S$  as the underlying variable. The differential equation is written:

$$\frac{\partial f}{\partial t} + rS \frac{\partial f}{\partial S} + \frac{1}{2} \sigma^2 S^2 \frac{\partial^2 f}{\partial S^2} = rf$$

By this, solutions may be derived for different derivatives, when given the *boundary conditions*. The most common solution is that of European options, with the boundary conditions:

$$\begin{aligned} \text{Call: } f &= \max(S - K, 0) && \text{when } t=T \\ \text{Put: } f &= \max(K - S, 0) && \text{when } t=T \end{aligned}$$

The Black-Scholes-Merton pricing formulas for the prices of European call and put options are:

$$\text{Price, Call option: } c = S_0 N(d_1) - Ke^{-rT} N(d_2)$$

$$\text{Price, Put option: } p = Ke^{-rT} N(-d_2) - S_0 N(-d_1)$$

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

$$\text{And } d_2 = \frac{\ln(S_0/K) + \left(r - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$$

*The function  $N(x)$  is the cumulative probability distribution function for a standardized normal distribution,  $S_0$  is the stock price,  $K$  is the option strike price,  $r$  is the risk-free interest rate when continuously compounded,  $T$  is the options time to maturity, and  $\sigma$  is the stock price volatility.*

Implied volatility is an indicator of the markets opinion of the underlying security, and quantifies the expected volatility for that security over the next 30 days. As it is not necessarily based on fundamental economic data, but simply the expectations and the opinion of the market participants, significant movements can be founded on everything from rumors to technical analysis.

Due to how changes in the historical volatility is diluted across 1 month of data, the implied volatility tend to adjust faster to increased uncertainty, as the prices of the underlying options changes almost instantly.

### 2.1.2 The VIX index:

VIX is a volatility index computed and published by CBOE, where the value of the VIX reflects the market's expectation of future volatility on the S&P 500, based on the implied volatility of option prices.

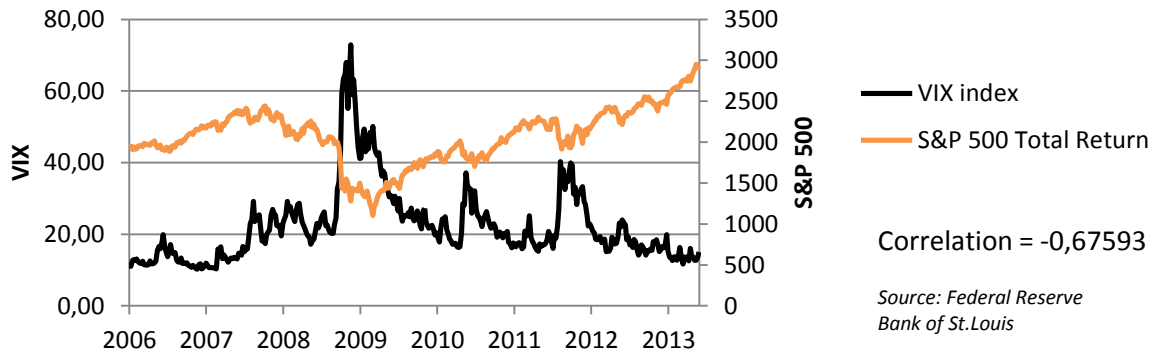


Chart 2.1.2, VIX and the S&P 500

The value of the VIX is quoted in percentage points, and can *roughly* be translated to the expected annualized movement in the S&P 500 over the next 30-day period. To illustrate this with an example, if the current value of the VIX is 20, the market expects an annualized change of 20% over the next 30 days (calendar days). There are twelve months in a year, so we find the expected magnitude of change over the next month to be

$$\frac{20\%}{\sqrt{12}} = \pm 5,77\%.$$

### 2.1.3 Is volatility mean reverting?

As one may interpret from a graphical presentation of the volatility, and confirmed by previous studies (Bali & Demirtas 2006), the volatility always returns to a mean level after spiking during negative events or a crisis. If the volatility would not return to the long term mean after a spike, it would most likely cause an increase in risk premium demanded by investors, and the investor sentiment would likely be heavily altered, due to a higher market risk being placed on the investors of the asset. The GARCH(1, 1) equation used in this thesis assumes mean reversion for volatility (Hull 2012a), as one can see in later chapters.

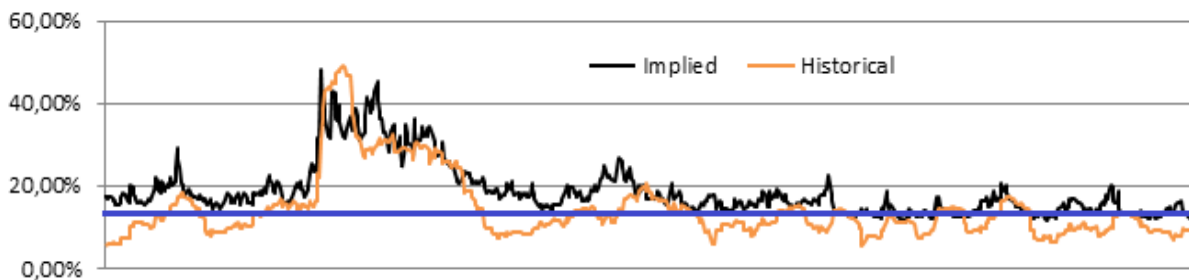


Chart 2.1.3, Mean reversion of volatility

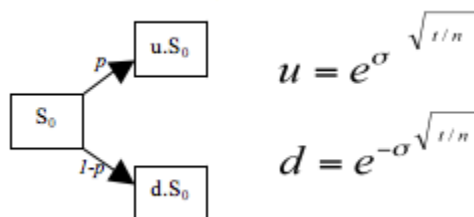
### 2.1.4 What causes volatility?

Previously, economists agreed that volatility stems from new information reaching market participants, causing investors to change their opinion of the market. In 1984, Richard Roll compared the variance for closing prices of OJ futures (futures contracts for frozen orange juice) for consecutive trading days (e.g. Thursday to Friday) and for the closing price between Friday and Monday. The decisive value movers for OJ contracts are news about the weather, which is released at any time of the week/day. Due to oranges concentrated region of origin, the weather in a relatively small geographical area can have a major impact on the global supply of oranges. Comparing the data observations, one would expect the variance between close on Friday and Monday to be three times the variance of any two days without intervening nontrading days. However, Roll found the variance to be only 1,54 times greater, leaving him with the conclusion that volatility is largely caused by trading itself (Roll 1984).

### 2.1.5 Practical use for volatility

- Pricing: a high volatility is undesirable for an asset, as it leads to uncertainty regarding the market value of the asset. As stated in section 2.1.1, volatility is also an important variable in the formulas used to price options, and an increase in volatility will cause an increase in the option prices.

The Cox-Ross-Rubenstein Binomial Option Pricing Model also utilizes the historical volatility, predicting price movements of an asset over discrete time periods from the current date to the date of expiration. It looks at potential up- and downwards price movements for the underlying security in given time-intervals, making it a popular measurement for American option (can be exercised at any time).



- Measuring exposure: When interested in measuring the exposure to market risk, Value at Risk (VaR) is currently the most popular measure used to summarize portfolio risk as a single and quantifiable value. Utilized by both fund managers and regulators to answer the question “what can we expect to lose, due to market fluctuations, over a given time period, with X percent certainty”. The Basel Committee on Bank Supervision added an amendment to the Basel I directive in 1996, demanding that banks apply VaR to determine the amount of capital the bank is required to hold, to protect against market risk. Each bank was awarded a multiplier  $k$  of 3.0 or more, depending on the bank, and the bank was required to hold a minimum amount of capital equal to  $k \times 10 \text{ day } 99\% \text{ VaR}$ . This VaR-value means that the loss over a 10-day

period is only expected to exceed the VaR-value 1% of the time. As volatile securities will cause the VaR of the portfolio to increase, requiring the bank to hold more capital, an increase in volatility may hurt a bank's return on equity. Also for leveraged investment portfolios, a broker's maintenance margin is widely dependent on the volatility of the underlying securities, and increased volatility could lead to an investor being forced to close out a portion of their position, forcing them to take a loss (Hull 2012b).

*A known shortfall for this risk-measurement is the tail-risk ignored by the VaR. It says nothing about the magnitude of the losses that will occur the (1-X)% of the time, in this case 1%, which may have catastrophic consequences.*

- **Measuring performance:** Volatility is a common measurement of market risk, and with greater risks comes expectations of higher returns. This is further explained on in section 2.2.

### **2.1.6 Faults and Limitations:**

As a measure of fluctuations, volatility is an excellent measurement of the past. A direct and quantitative measurement, giving a numerical result which is easily interpretable. However, for risk management, historical volatility has several shortcomings, and gives a severely insufficient measurement of risk exposure. These shortcomings become even more severe, as volatility is gaining popularity among risk managers, mostly due to its logical and interpretable nature. If one were to regard the risk exposure for price movements both up- and downwards, the traditional volatility measurement still holds its ground. This could apply for market makers among others, who are obliged to offer price quotes for both buying and selling, and may want to widen their bid-ask spread when anticipating an increased volatility.

The overall mentality of predicting the future by using data from the past gives an incomplete picture and fails to see the scope of the future risk exposure. There have been several examples (see Section 1.2) of how the "unthinkable" actually occurs, causing market turmoil and panic. These periods of market turmoil are often preceded by times of low historical volatility.

Volatility holds an important position in the modern day financial markets, and is, despite its limitations, the main measurement of how much risk is associated with a financial asset. As an increased volatility can lead to pressure and criticism from both investors and regulators, and the cost of both the assets and related securities may see large fluctuations, institutional investors will do well by keeping tight control over the volatility of all its assets. So even if it is easy to conclude that today's volatility measurement is insufficient and almost unusable to some of its applications, it would be unwise to not represent all results with respect to the traditional volatility model.

## Part II Portfolio Performance

Much of the foundation of modern portfolio theory is based on the assumption that investors are risk averse, and will choose the portfolio with the least amount of risk, if not compensated by higher returns in the form of a risk premium. The Capital Asset Pricing Model (CAPM) is a great example of this, explaining how an investor's return on a risk-less investment should equal the time value of money, and the only way to achieve higher returns is by taking on a higher exposure to risk. The expected return of a stock can be written as  $R_S = R_F + \beta \times (R_M - R_F)$ , where

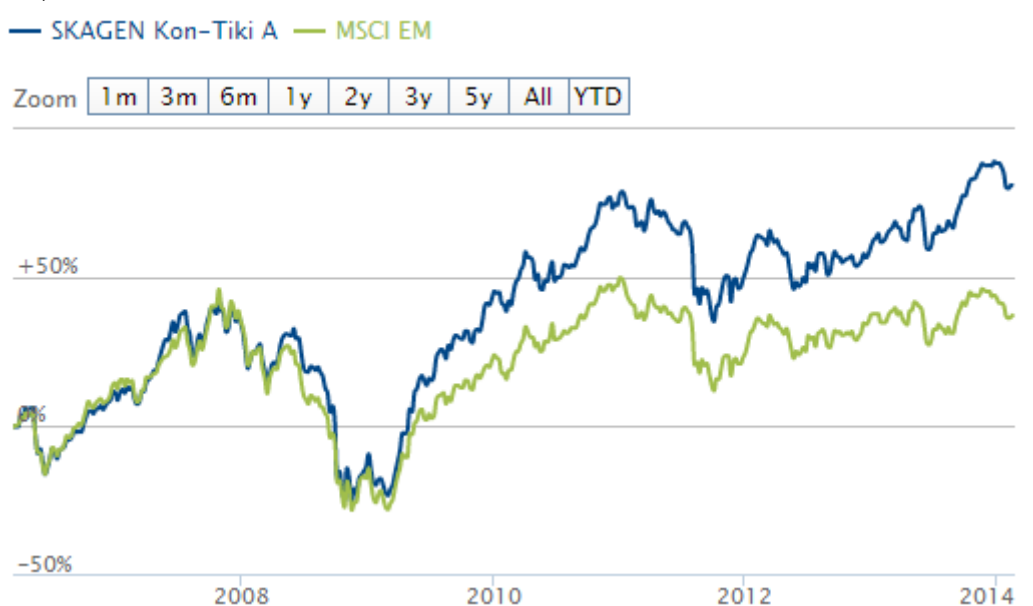
- Beta( $\beta$ ): a coefficient measuring the fluctuations, compared to the market. Beta of security  $i = \frac{Cov(R_i, R_M)}{Var(R_M)} = \frac{\sigma_{i,M}}{\sigma_M^2}$ , and the beta of a portfolio =  $\sum_{i=1}^n W_i \beta_i$ , for securities  $i$  to  $n$ .
- $R_F$ : The risk-free rate of return.
- $R_M$ : The return of the market portfolio. This gives the market risk premium  $R_M - R_F$ .

The return of an investment must be compared to the risk exposure of the portfolio, and investors should be rewarded for taking on higher volatility and uncertainty. Because of this, portfolio performance isn't just a question of return, and there are several different approaches used for measurement.

### 2.2.1 Different Approaches used to measure portfolio performance:

#### Traditional Approach

Most portfolios use a benchmark for comparison, for example a stock index. The industry standard among mutual funds is to simply compare their own annual performance with one or more indices (e.g. the S&P 500, or a weighting of stocks and bonds) to prove that they can beat the market. However, this is an overly simplified measure, and does not take risk and fluctuations into account.



Screenshot from Skagen Kon-Tiki, a mutual fund investing in emerging markets  
Source: [skagenfondene.no/Fond-og-kurser/SKAGEN-Kon-Tiki/](http://skagenfondene.no/Fond-og-kurser/SKAGEN-Kon-Tiki/)

### Sharp Ratio

The Sharp ratio measures the performance of a portfolio, by comparing the return and volatility of a portfolio with that of a benchmark asset.

Sharp Ratio =  $\frac{E[R_a - R_b]}{\sqrt{\text{var}[R_a - R_b]}}$  where  $R_a$  is the return of the portfolio, and  $R_b$  is the return of the benchmark asset. The risk free rate is often used as the benchmark asset, for which the Sharp Ratio is equal to  $\frac{R_p - R_f}{\sigma}$

### Sortino Ratio

When exposed to skewed risk, the Sortino ratio may be a good measure, as it does not penalize upward movements. It measures the return ( $R$ ) that is greater than the target return ( $T$ ), and divides by the downside risk.

$$\text{Sortino ratio} = \frac{R - T}{DR}$$

$$\text{where } DR = \left[ \int_{-\infty}^T (T - x) f(x) dx \right]^{0.5}$$

### Treynor Measure

Conceived by Jack L. Treynor to measure the performance of a portfolio by comparing the return with the relative volatility between the portfolio and the market. Also called the “reward-to-volatility” ratio and derived from CAPM.

$$\text{Treynor measure} = \frac{R_p - R_f}{\beta}$$

### Jensen Measure

Also based on CAPM, it measures the *alpha*, the excess return over the expected return of the portfolio.

$$\text{Jensen's Alpha} = R_p - R_B,$$

where  $R_B$  is the benchmark return according to CAPM, equal to  $R_F + \beta(R_M - R_F)$

### V2 Ratio ( $V_R^2$ )

Another measurement of risk-adjusted return, but the V2-ratio penalizes relative drawdowns compared to the market. This is meant to illustrate the psychological impact of poor investment performance, as many investors will abandon an investment strategy when taking losses greater than the overall market.

$$V_R^2 = \frac{\left(\frac{V_n}{V_0}\right)^{\frac{P}{n}} - 1}{\sqrt{\frac{\sum_{i=0}^n \left(\frac{V_i}{V_i^{peak}} - 1\right)^2}{n} + 1}}$$

Here,  $V$  indicates values at specific times ( $0, i$  and  $n$ ),  $P$  is the number of identical periods in a year, and  $n$  being the number of periods in total during the investment.

### Modigliani risk-adjusted performance( $M^2$ )

The  $M^2$  measures the risk-adjusted returns of a portfolio, and based on the Sharp ratio. However, the measurement is given in units of percent return, which makes it easier to interpret.

$$M^2 = \bar{D} \times \frac{\sigma_B}{\sigma_D} + \overline{R_F}$$

One can also use Beta as a measure of risk, and still compare the portfolio return with the benchmark;

$$M_\beta^2 = \bar{D} \times \frac{\beta_B}{\beta_D} + \overline{R_F}$$

To summarize, all of these approaches compare the return of a portfolio with the market risk attributed to it. At first, one may think that what really matters is the percentage return, regardless of the risk exposure. However, due to reasons explained in sections 2.1 and 2.2, as well as portfolio rebalancing, the portfolio volatility is still a vital variable for an investor's portfolio. One must choose an appropriate measurement depending on the types of portfolios we are to compare, but these approaches all return a quantified measurement for the risk-adjusted performance of a portfolio.

*Note that the risk exposure measured by these ratios, are those that are quantitatively measurable by historical data. Risk exposure towards scenarios and incidents that may or may not occur is difficult to measure by historical data. Often, the source of the above-market returns are the risk-premium associated with those assets(e.g. political risk).*

For modelling the volatility adjusted return in chapter 4, we will focus on the Sharp ratio, as it is a quick and simple measurement that is easy to interpret. This is also the reason why it is so widespread and popular in modern day finance.

## Part III Statistical Methods and distributions

### 2.3.1 Normal distribution

The most important continuous probability distribution in modern day statistics, and the foundation of many modern day scientific applications, ranging from manufacturing to meteorology. To find the population density of a random variable,  $X$ , in a normally distributed population with the mean  $\mu$  and variance  $\sigma^2$ ,

$$n(x; \mu, \sigma) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2\sigma^2}(x-\mu)^2}, \quad -\infty < x < \infty$$

When a statistic is normally distributed, the *three sigma*-rule can be ruled to explain the probability of different intervals where we may find the variables.

$$P(\mu - \sigma \leq x \leq \mu + \sigma) = 0,6827$$

$$P(\mu - 2\sigma \leq x \leq \mu + 2\sigma) = 0,9545$$

$$P(\mu - 3\sigma \leq x \leq \mu + 3\sigma) = 0,9973$$

So if the standard deviation( $\sigma$ ) for an index equals 1%, one can assume that the daily change of that index is within  $\pm 1\%$  68,27% of trading days.

### 2.3.2 Student t-distribution

Now usually referred to as just the *t*-distribution, but originally published under the author pseudonym "student", and therefore sometimes referred to as the *Student t*-distribution. Often in statistical calculations,  $\sigma$  is not known and must be estimated based on the sample information. As  $S^2$  is based on the sample, it may fluctuate substantially between samples. Unlike  $Z$ , which is only based on the varying values of  $\bar{X}$ ,  $T$  is based on the variations in both  $S^2$  and  $\bar{X}$ . The result is a distribution with a higher kurtosis than the normal distribution, i.e. fatter "tails". If  $Z$  is a standard normal variable and  $V$  is a chi-squared random variable with  $v$  degrees of freedom,

$$T = \frac{Z}{\sqrt{V/v}}$$

And we get the density function representing the *t*-distribution with  $v$  degrees of freedom.

$$h(t) = \frac{\Gamma[(v+1)/2]}{\Gamma(v/2)\sqrt{\pi v}} \left(1 + \frac{t^2}{v}\right)^{-(v+1)/2}, \quad -\infty < t < \infty$$

So if  $X_1, \dots, X_n$  are independent random variables with mean  $\mu$  and standard deviation  $\sigma$ ,

$$\bar{X} = \frac{1}{n} \sum_{i=1}^n X_i \quad \text{and} \quad S^2 = \frac{1}{n-1} \sum_{i=1}^n (X_i - \bar{X})^2$$

Then  $T = \frac{\bar{X} - \mu}{S/\sqrt{n}}$  has a *t*-distribution with  $v = n - 1$  degrees of freedom. The higher value  $n$  is, the higher the number of degrees of freedom, and the more the *t*-distribution will resemble the normal distribution.



The gamma function can be defined as

$$\Gamma(\alpha) = \int_0^{\infty} x^{\alpha-1} e^{-x}, \quad \text{for } \alpha > 0$$

And the chi-squared distribution is a special case of the gamma distribution, where  $\alpha = v/2$  and  $\beta = 2$ . The density function of a chi-squared distribution will then be given by

$$f(x; v) = \begin{cases} \frac{1}{2^{v/2} \Gamma(v/2)} x^{(v/2-1)} e^{-x/2}, & x > 0 \\ 0, & \text{elsewhere} \end{cases}$$

### 2.3.3 Variance and Standard Deviation

When  $X$  is a random variable with probability distribution  $f(x)$  and mean  $\mu$ , the variance of  $X$  equals:

$$\sigma^2 = \sum_x (x - \mu)^2 f(x)$$

The positive square root of the variance will equal the standard deviation,  $\sigma$ .

When dealing with a sample, and basing the Standard Deviation on the sample data, we must find the Sample Variance and the Sample Standard Deviation:

$$s^2 = \sum_{i=1}^n \frac{(x_i - \bar{x})^2}{n-1} \text{ and } s = \sqrt{s^2}$$

### 2.3.4 Central Limit Theorem

The Central Limit Theorem (CLT) is really a set of weak convergence theorems, but we are most interested in classic CLT used in basic statistics, stating that  $Z$  is the standard normal distribution  $n(z; 0, 1)$  as  $n \rightarrow \infty$ , when

$$Z = \frac{\bar{X} - \mu}{\sigma / \sqrt{n}}$$

Here,  $\bar{X}$  is the mean of a random sample of size  $n$  taken from a population with the mean  $\mu$  and the variance of  $\sigma^2$ . When gathering observations from a non-normal population, this may give inaccurate results, especially with skewed distributions. However, sampling theory states that as long as  $n \geq 30$ , valid results can be expected.

We use CLT when we wish to apply the sample variance (Walpole et al. 2012a):

$$\sigma_{\bar{X}} = \frac{\sigma}{\sqrt{n}}$$

### 2.3.5 Estimating with two means

When regarding two populations with the mean  $\mu_1$  and  $\mu_2$  and variances  $\sigma_1^2$  and  $\sigma_2^2$ , the statistic  $\bar{X}_1 - \bar{X}_2$  is a point estimate of  $\mu_1 - \mu_2$ . We can then assume the sampling distribution of  $\bar{X}_1 - \bar{X}_2$  to be approximately normally distributed with mean  $\mu_1 - \mu_2$ ,

and a standard deviation of  $\sqrt{\sigma_1^2/n_1 + \sigma_2^2/n_2}$ . Therefore, the variable Z will fall between  $-z_{\alpha/2}$  and  $z_{\alpha/2}$ , with a probability of  $1 - \alpha$  given that

$$Z = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\sigma_1^2/n_1 + \sigma_2^2/n_2}}$$

Here,  $\alpha$  is referred to as the level of significance, or the *alpha*, and used as a value judgment. It can be defined as the probability of making a type I error, which again is defined as *rejection of the null hypothesis when the null hypothesis is true* (Walpole et al. 2012b).

So we write:

$$P(-z_{\alpha/2} < Z < z_{\alpha/2}) = 1 - \alpha$$

And substituting for Z (Walpole et al. 2012c):

$$P\left(-z_{\alpha/2} < \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\sigma_1^2/n_1 + \sigma_2^2/n_2}} < z_{\alpha/2}\right) = 1 - \alpha$$

### 2.3.6 Testing a statistical hypothesis

One can test a statistical hypothesis were one first state a null and alternative hypotheses, and choose a fixed level of significance,  $\alpha$ . By choosing a statistical test and establishing a critical region around  $\alpha$ , one can decide if  $H_0$  should be rejected or not.

$$H_0: \theta = \theta_0$$

$$H_1: \theta > \theta_0$$

One can also test when the alternative is two-sided, and were the critical region is split into two presumably equal parts. We call this a two-tailed test, and could for example test whether

$$H_0: \theta = \theta_0$$

$$H_1: \theta \neq \theta_0$$

This considers both if  $\theta < \theta_0$  and  $\theta > \theta_0$ . One usually uses an estimator of  $\mu$ , where the sample distribution  $\bar{X}$  is applied. The appropriate statistical test must be chosen based on the available data and the variable that is tested.

### 2.3.7 Regarding the level of significance

Preselecting a level of significance is important when regarding the risk one faces of a type I error, and the wish to control such error when testing a hypothesis. However, the relationship between the output of a test and the level of significance should be

scrutinized for each individual case, as a simple binary approach of significant/insignificant will not account for values close to the critical region. This is why the P-value approach may be more fitting for some calculations within applied statistics.

### 2.3.8 P-value approach

The P-value can be defined as the lowest level of significance at which the observed value of the test statistic is significant. It gives the users an alternative beyond “reject” or “do not reject”, and provides information regarding a z-value within the critical region. This information can be combined with the subjective judgment of the user to draw a conclusion (Walpole et al. 2012d).

For a two-sided test, and using the Normal Probability Table, when calculating a z-value from the test statistic.

$$P = 2 \times z_{\alpha/2}$$

### 2.3.9 Covariance

Covariance is a value stating how an asset moves compared to another, which a negative covariance means a relatively inverse movement of returns.

$$\sigma_{xy} = E[(X - \mu_x)(Y - \mu_y)] = \sum_x \sum_y (x - \mu_x)(y - \mu_y)f(x, y)$$

When calculating the sample covariance;

$$s_{xy} = \frac{1}{n-1} E[(X - \mu_x)(Y - \mu_y)] = \frac{1}{n-1} \sum_x \sum_y (x - \mu_x)(y - \mu_y)f(x, y)$$

### 2.3.10 Correlation

Similar to covariance, the correlation is a statistical measure of how assets move compared to one another. One usually denotes the correlation as the Correlation Coefficient, which ranges between -1 and +1. If the correlation coefficient equals zero, the movements of the assets are said to have no correlation, and there is no pattern between their movements. The measure of linear association,  $\rho$ :

$$\rho_{xy} = \frac{\sigma_{xy}}{\sigma_x \sigma_y}$$

When we use a data sample,  $\rho$  is estimated by the sample correlation coefficient,  $r$ :

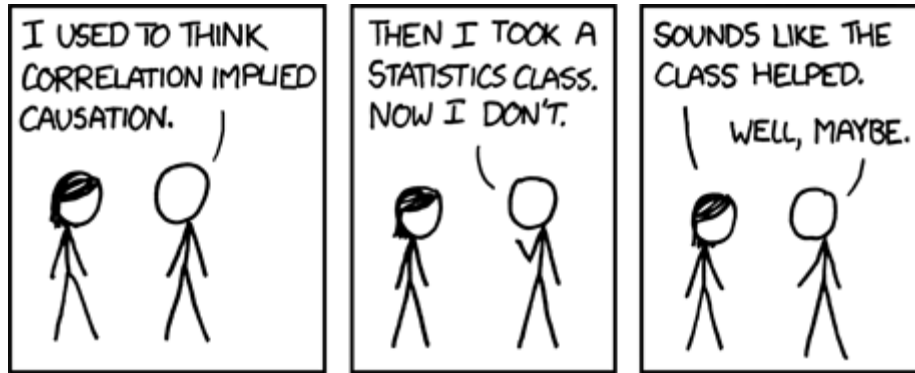
$$r = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}}$$

To further analyze the data, we can find  $r^2$ , the sample coefficient of determination. This number expresses the proportion of the total variation in the values of one variable can be explained by the linear relationship with the values of the other variable.

$$r^2 = \frac{S_{xy}^2}{S_{xx}S_{yy}}$$

To interpret the sample coefficient of determination, if  $r=0,5$ ,  $r^2=0,25$ , and 25% of the total variation of one of the values in our sample can be explained by the linear relationship with the second value.

### 2.3.11 Correlation and causation:



Xkcd.com

“Correlation does not imply causation” is a much used phrase in science and statistics, stating that a mathematical relationship for the movement of two variables does not necessarily prove a logical relationship between the two. A critical analysis, looking at the underlying causes and consequences of each variable, is needed to fully interpret the meaning behind the correlation coefficient. There are no specific criteria or method of calculation one can use to determine whether or not correlation is because of causation, but a high correlation indicates that causation is much more likely. However, even a correlation coefficient of 1 does not necessarily equal causation;

*Announced in 1966, the NFL(National Football League) and the AFL(American Football League) merged to form a new league, which retained the NFL brand. At the beginning of each year, the Superbowl is played to determine a winner of the NFL, and teams originating from both the AFL and NFL have won. Surprisingly enough, there is a high correlation between who wins the Superbowl and the performance of the stock market each year; if a team originating in the National Football League wins the championship, the stock market tends to move up, while the opposite would happen if a team from the American Football League were to win. This happened 12 out of 12 times from 1967 to 1978(Koppett 1978), and achieved a 95% success rate up until 1997. However, there is no causational relationship found between the two variables, and it must simply be regarded as a coincidence.*

### 2.3.12 Distribution of stock prices

Some theoretical stock models suggested a constant rate of drift and variance for stock prices, meaning that it follows a generalized *Wiener process*,

$$dx = a dt + b dz$$

Here,  $a$  and  $b$  are constants, and  $a$  equals the expected drift rate, while  $b^2$  is the variance per unit of time. A problem is that a Wiener process fails to capture one

crucial aspect of stock prices, that the return an investor requires from an asset is independent of the price of the stock and that the percentage return required is independent of whether a stock is currently worth \$10 or \$1000.

To illustrate, if one were to go to *Bloomberg.com* and look up the stock quotes for A- and B-class shares of Berkshire Hathaway, one could see that these stocks, which has the same underlying company, just separated into classes of shares with different nominal values, are perfectly correlated and valued at the same multiples. However, the dollar value of the two stocks are completely different as the A-class shares(BRK/A:US) has a market value of \$192.000,00 pr. share while the B-class shares(BRK/B:US) are only valued at \$128.34 pr. share(price quotes from *Bloomberg.com*, June 1<sup>st</sup>, 2014).

So when focusing on the return of the stock with price  $S$  at time  $t$ , the expected drift rate can be assumed to be  $\mu S$ , where the parameter  $\mu$  is the expected return of a stock. If we were to disregard the uncertainty, setting  $dz$  to zero, the model gives that

$$\Delta S = \mu S \Delta t,$$

and as  $\Delta t$  approaches zero,

$$dS = \mu S dt$$

We can assume that as the expected return of a stock is the same regardless of the current stock price, so the standard deviation,  $\sigma$ , the change in stock prices during  $\Delta t$ , should be proportional to the stock price, leading to the model:

$$dS = \mu S dt + \sigma S dz$$

or

$$\frac{dS}{S} = \mu dt + \sigma dz$$

This is the foundation for the modelling of stock price behavior most used today, the *geometric Brownian motion*(Hull 2012c), where

$$\Delta S = \mu S \Delta t + \sigma S \epsilon \sqrt{\Delta t}$$

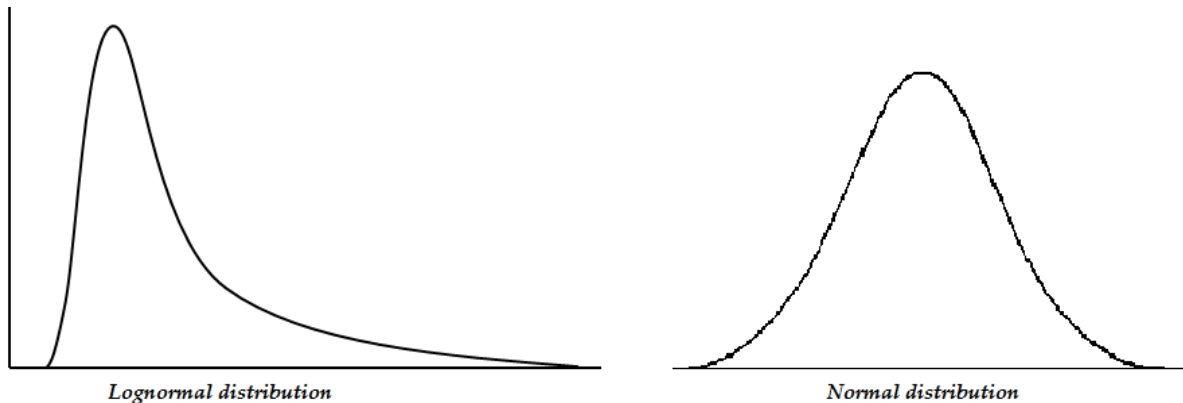
$\epsilon$  has a normal distribution, with a mean of zero and a standard deviation of one, i.e. a *standard normal distribution*. When writing the equation, with respect to the return, and knowing that  $\epsilon$  has a standard normal distribution,

$$\frac{\Delta S}{S} = \mu \Delta t + \sigma \epsilon \sqrt{\Delta t}$$

Which proves that  $\frac{\Delta S}{S}$  is normally distributed, with the mean  $\mu \Delta t$  and a standard deviation of  $\sqrt{\Delta t}$ .

Most modern models, including the Black-Scholes model, utilize the geometric Brownian motion to describe stock price behavior. The price change can be written as  $\ln\left(\frac{S_t}{S_{t-1}}\right)$ , and if the natural logarithm of a random variable is normally distributed, the random variable itself will have a lognormal distribution. A variable in a

lognormal distribution can have any value between zero and infinity, indicating how the value of a stock can grow infinitely, but never be worth less than zero.



The fact that many of today's risk models use historical values and assume a lognormal distribution, makes it easy to illustrate how historical values lead to poor risk management. Using the past and assuming that it is representative for the near future leads to an inadequate view of one's risk exposure, and could easily lead to the demise of an over-leveraged portfolio. Below, I have listed some illustrative examples of how rapidly the risk picture of some assets has changed in recent years, as the historical price patterns are altered:

- If one were to use one year of historical data up until the Lehman Brothers bankruptcy, the probability distribution indicated that the Oslo Stock Exchange would experience a daily 9% drop once every 13 000 years. Still, this occurred on three separate occasions in the fall of 2008. Including these occurrences of 2008, the new and updated probability distribution predicted it to happen once every 13 years (Warren 2009).
- The same happened with Futures contracts on natural gas in 2009, where risk models based on log-normally distributed prices showed that a daily price gain of 7.25% would occur once every 61 years. Suddenly, this occurred on 6 days over a short time period (Loder 2009), altering the risk models so that it would statistically occur once every 52<sup>nd</sup> day (Warren 2009).
- By mid-day on April 15<sup>th</sup> 2013, front-month gold futures had fallen more than 8%, which exceeded 6 standard deviations when assuming normally distributed prices. Following a risk model based on this probability distribution, a drop like that would only occur once every 2 million years (Warren 2013).

Still, normal distribution is assumed for the daily change in the price of a stock, leading to models that differ from that of the real world. This is illustrated in the charts on the next page.

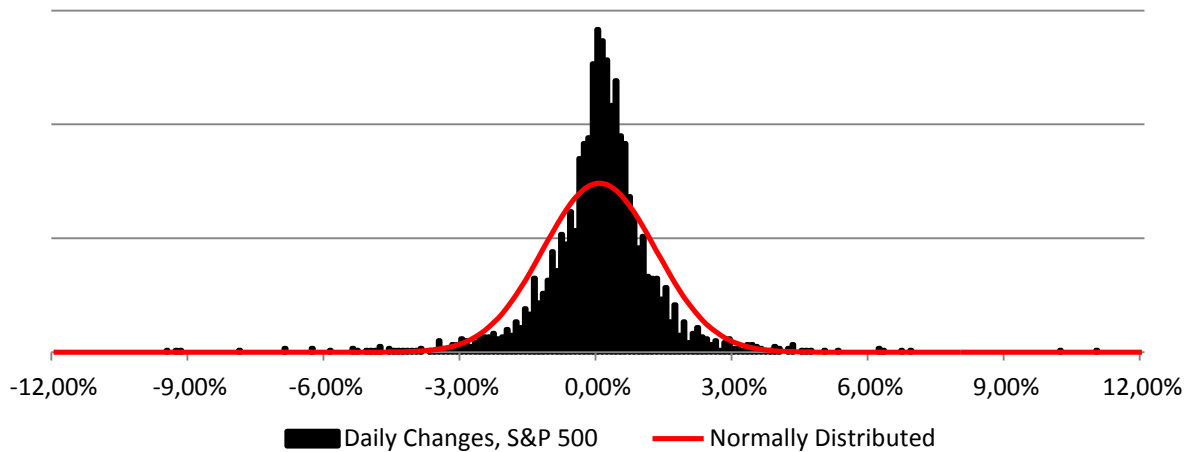


Chart 2.3.1, Daily changes in the S&P 500, 1988-2013

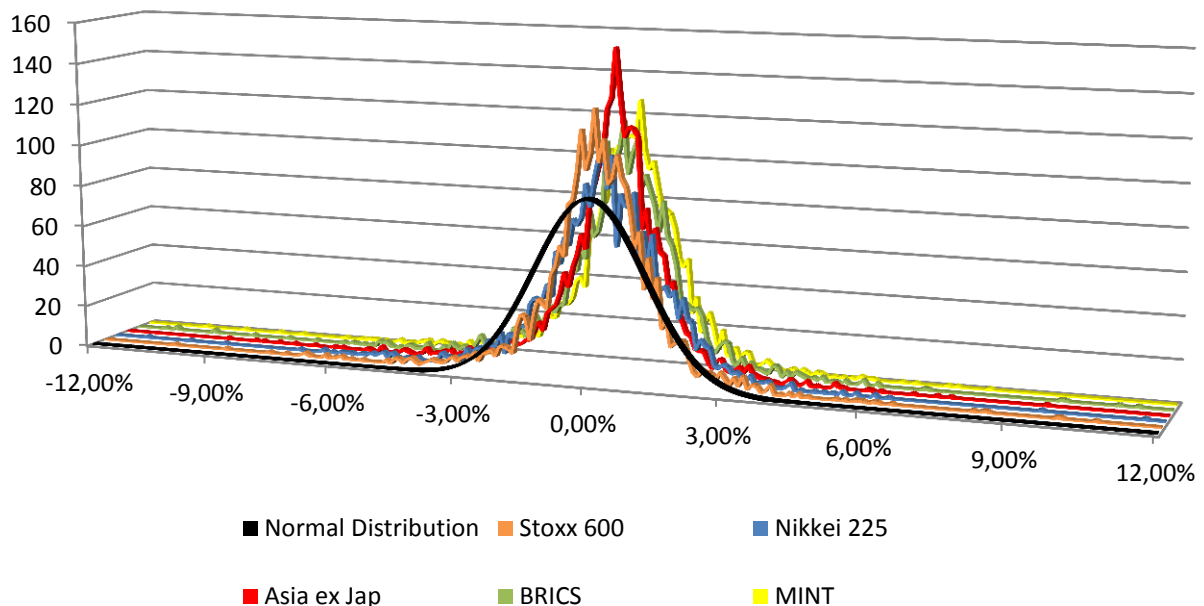


Chart 2.3.2, Daily Changes in stock indices, 2003-2013

We see from both chart 2.3.1 and 2.3.2 that the normal distribution does not cover the historical changes for stock indices, especially for the extreme tail events. It is clear that the normal distribution is an insufficient assumption of the daily changes in stock prices. A more fitted distribution is likely to be skewed, with a higher kurtosis. Basing risk models on the  $t$ -distribution is likely to give a fairer picture of the risk one is exposed to through ones portfolio. Comparing chart 2.3.1 and 2.3.4, a qualitative adjustment of the standard deviation applied may be needed to fit the normal distribution better with the historical data. Probability distributions are logical and mathematical expressions, and one cannot expect historical observations to correlate perfectly with this. For the thesis, we will continue to assume normal distribution, as it is applied by both GARCH(1, 1) and Black and Scholes.

Both chart 2.3.1 and 2.3.2 assumes a normal distribution with a mean of 0,04% and a standard deviation of 1,25%.

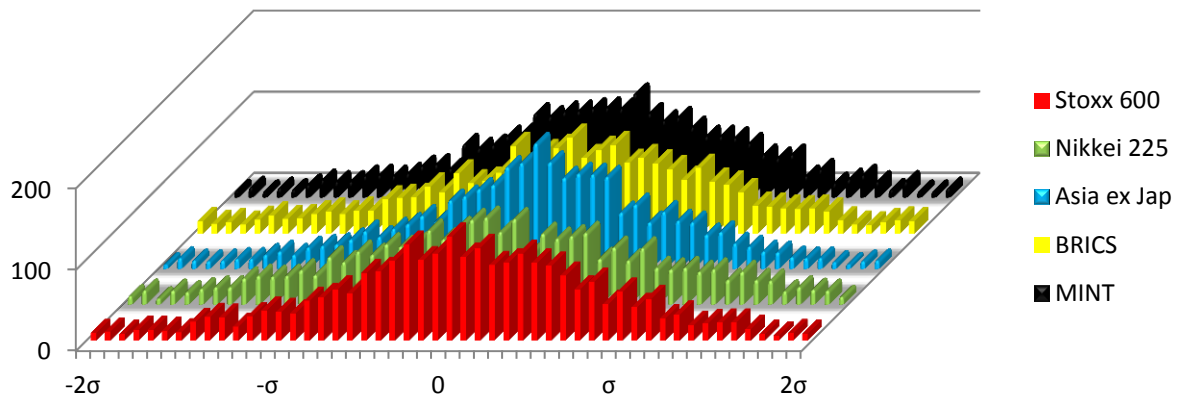


Chart 2.3.3, daily changes in stock indices within two standard deviations, 2003-2013

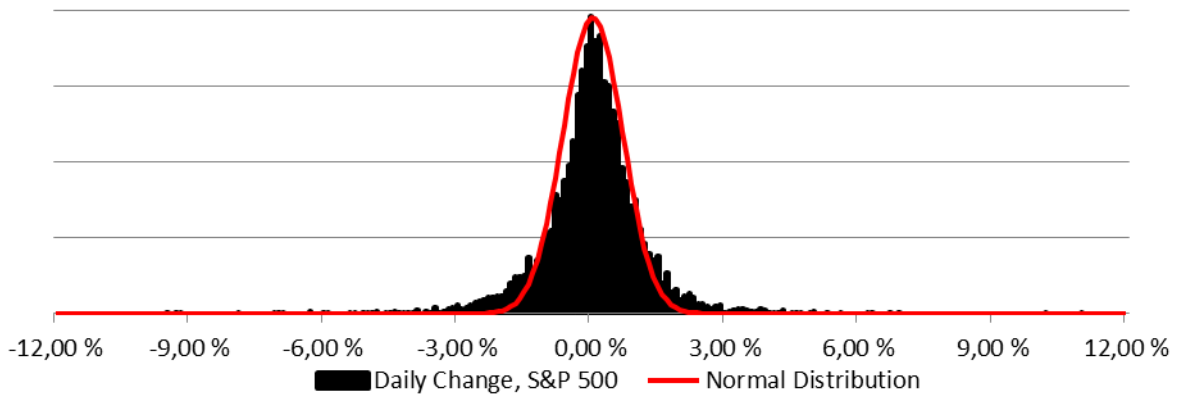


Chart 2.3.4, daily change of the S&P 500, and the normal distribution given that  $\sigma = 0,67\%$

When we set the standard deviation equal to 0,67%, we found the optimal fit when assuming the normal distribution for the daily changes of the S&P 500. Even this failed to include several observations, and the extreme values on the far ends of the tails still fell outside the scope of the distribution.



## Part IV: Estimating future volatilities

### 2.4.1 GARCH(1, 1)

GARCH is an acronym for *Generalized AutoRegressive Conditional Heteroskedasticity*, and is an approach to estimate the future volatility of financial markets. It is much used in financial modelling, and is based on calculating a set of parameters that maximizes the likelihood of estimating future levels of volatility based on historical data. The equation used for GARCH(1, 1) is (Hull 2012d):

$$\sigma_n^2 = \gamma V_L + \alpha u_{n-1}^2 + \beta \sigma_{n-1}^2$$

$\gamma$ ,  $\alpha$  and  $\beta$  are the weights assigned to the variables, and as the sum of the weights must equal 1,  $\gamma + \alpha + \beta = 1$ . To simplify, we will set  $\omega = \gamma V_L$ , resulting in the model

$$\sigma_n^2 = \omega + \alpha u_{n-1}^2 + \beta \sigma_{n-1}^2$$

And to further simplify calculations:

- $\gamma = 1 - \alpha - \beta$
- $V_L = \omega / \gamma$
- $\alpha + \beta < 1$  (required for a stable GARCH(1, 1)-process)

*As this GARCH-model does not consider the sign of  $u_{n-1}$ , other GARCH-models are often preferred when regarding equities. However, as this thesis operates with the sign neutrality from the volatility model, as well as regarding other assets than equities (bonds, gold), we will still apply the GARCH(1, 1).*

As written in section 2.1.3, volatility is mean reverting, an aspect recognized by the GARCH(1, 1).  $V_L$  describes the long-run average level of the variance, and  $\gamma$  describes the weight we assign to  $V_L$ , equal to  $1 - \alpha - \beta$ . From this, we interpret that

- When  $V > V_L$ , the variance has a negative drift.
- When  $V_L > V$ , the variance has a positive drift.

### 2.4.2 Weighting the data

If we were to further derive the GARCH(1, 1) equation from above, and substituting for  $\sigma_{n-1}^2$ , we would get

$$\sigma_n^2 = \omega + \alpha u_{n-1}^2 + \beta(\omega + \alpha u_{n-1}^2 + \beta \sigma_{n-2}^2)$$

We can continue doing this, and we can see that the weighting declines exponentially at a rate of  $\beta$ , where  $u_{n-1}^2$  is weighted at  $\alpha\beta^{i-1}$ . This leads to a decaying relative importance of data, as the data observations gets older. By adjusting the rate of decay,  $\beta$ , we can alter how much relevance you want to put on historical data.

### 2.4.3 Estimating the future parameters

The world is a dynamic place, with the opinions and actions of thousands of random entities each having an effect on the performance of financial markets. Of course, no model would ever be able to perfectly predict the future development of the market, but by recognizing the law of large numbers, one may be able to position themselves to maximize the long-term result by applying probability theory. From part III, we know that the probability of  $u_i$  being observed equals

$$\frac{1}{\sqrt{2\pi v}} e^{\left(\frac{-u_i^2}{2v}\right)}$$

Were we have used  $v$  for variance, instead of  $\sigma^2$ . We then consider the  $m$  observations, and the likelihood of their order in which they are observed

$$L(\omega, \alpha, \beta; \mu) = \prod_{i=1}^m \left[ \frac{1}{\sqrt{2\pi v_i}} e^{\left(\frac{-u_i^2}{2v_i}\right)} \right]$$

As we wish to maximize the probability, it is natural to assume that we want to apply the parameters which may maximize the equation above. Taking the logarithm of the equation, we find that we want to maximize

$$\ln L(\omega, \alpha, \beta; \mu) = \sum_{i=1}^m \left[ -\ln(v_i) - \frac{u_i^2}{v_i} \right]$$

by selecting the ideal parameters. These parameters,  $\omega, \alpha$  and  $\beta$ , can be found in EXCEL, by applying solver tables and maximizing the output from the formula above. The result of the Solver tables can be found in Appendix B.

After establishing the GARCH(1, 1) equations, we can estimate the variance rate for day  $n$  by considering the variance rate at the end of day  $n - 1$ .

$$\begin{aligned} \sigma_n^2 &= (1 - \alpha - \beta)V_L + \alpha u_n^2 + \beta \sigma_{n-1}^2 \\ \Rightarrow \sigma_n^2 - V_L &= \alpha(u_{n-1}^2 - V_L) + \beta(\sigma_{n-1}^2 - V_L) \end{aligned}$$

If we were to consider a day in the future, we can replace  $n$  with  $n+t$ :

$$\sigma_{n+t}^2 - V_L = \alpha(u_{n+t-1}^2 - V_L) + \beta(\sigma_{n+t-1}^2 - V_L)$$

As  $u$  is the continuously compounded return, and independent of the dollar value of the asset, the expected value of  $u_{n+t-1}^2$  is  $\sigma_{n+t-1}^2$ . Substituting, we get the equation

$$E(\sigma_{n+t}^2 - V_L) = \alpha E(\sigma_{n+t-1}^2 - V_L) + \beta E(\sigma_{n+t-1}^2 - V_L)$$

This equation can then be applied over  $t$  days, the resulting product will be an estimate for the volatility at day  $n+t$ , by using the volatility at day  $n$ , based on the historical data up to, and including, day  $n-1$ .

$$E[\sigma_{n+t}^2] = V_L + (\alpha + \beta)^t (\sigma_n^2 - V_L)$$

From this equation, we can derive that the GARCH(1, 1) assumes that the variance eventually reverts back to its long-term average, and that the estimation works best when regarding a given increase in volatility. It is impossible to estimate times of uncertainty mathematically, as the markets are dynamic and unpredictable. If we were to estimate the future volatility  $t$  days from now, and  $t$  is a sufficiently large number, the estimated volatility would naturally be equal to the long-term rate of volatility.

$$\lim_{t \rightarrow \infty} (V_L + (\alpha + \beta)^t (\sigma_n^2 - V_L)) = V_L + 0 \times (\sigma_n^2 - V_L) = V_L$$

## Part V - Alternatives for diversifying a portfolio:

### 2.5.1 Equity:

Investing in equity, i.e. company ownership in the form of stocks, is the most common way of investing in financial markets. To measure the performance of a stock market, a stock index is used as a benchmark, reflecting the performance of the underlying securities. These indices are mathematical compositions of the underlying securities and usually price-based, only considering price movements. Total return-indices include stock splits, right offerings and dividend(pre-tax), and as the name indicates, show the total return of the underlying stocks. If this paper refers to data from stock indices, a total return index will have been used, unless specified otherwise.

When investing in an index, institutional investors and investment banks often purchase all the underlying assets to achieve the exposure mirroring the index. However, this may seem both cumbersome and expensive for a retail investor, especially for those indices consisting of a large number of assets(e.g. the S&P 500). This is one of the reasons why Index ETFs has become widely popular over the last couple of years, as a way for an investor to invest in an index by buying a single security. An Index ETF is meant to mirror the return of the underlying index, before expense and fees. The annual fee is typically between 0,1-0,5% of the NAV, substantially lower than the normal 2% fee a mutual fund charges. One of the most famous ETFs is the Spider ETF, with the ticker SPY:US, which tracks the S&P 500.

*ETF is an acronym for 'Exchange Traded Fund', as the fund issues securities that can be traded daily on an exchange, like a normal stock. A similar product is an ETN, an 'Exchange Traded Note', which also mirrors the value of the underlying, but where the issuer is not required to actually hold the underlying security, meaning that an investor would expose them self to the credit risk applicable to the issuer, without receiving an additional risk premium for this.*

*This may not sound very serious, as the issuers of such funds are usually strong financial companies, with high book values and steady cash flows. However, if you were to ask holders of the Opta ETF funds back in 2008, they may not agree with that. As a subsidiary of Lehman Brothers, the Opta ETN funds were delisted following the bankruptcy, and the holders of those assets were left with unsecured bankruptcy claims(Armstrong 2012).*

When regarding regional diversification, there are thousands of stock indices in the world, representing most regions, countries and sectors. I have selected a few of these, picked to indicate the performance of important markets around the world, markets with varying characteristics and development.

- United States: the US stock market is the most important stock market in the world, and carefully watched by investors across global markets.
  - Dow Jones Industrial Average(DJIA): "the Dow" was first established in 1885, and consists of 30 "blue-chip stocks", stocks of large and well-

established companies that have operated for several years. Historically, the performance of the US stock market has been measured by the Dow Jones Industrial Average, an index dating back to 1896, consisting of 30 of the largest publicly owned companies based in the US. The use of the DJIA as the top indicator of the US stock market has been criticized, as the top 5 components makes up almost 1/3 of the index, making the index an inaccurate reflection of the performance of the market. However, as the companies included in the index are traditionally larger and more stable than the average company in the S&P 500, it can be used as a benchmark for measuring the performance of safer and more mature companies.

- S&P 500: The financial community now often looks to the S&P 500 as the main indicator of the US stock market, an index comprised by 500 large companies with a high market cap and a public float of more than 50%. It is designed to reflect the risk/return characteristics of the large cap segment of stocks listed in the United States, and covers about 75% of the overall capitalization of the publicly traded U.S. equity market. It includes both value and growth stocks within different sectors, and the companies selected for the index is meant to represent their respective industry.

**Top 10 Components:**

**Dow Jones Industrial Average**

Company	Ticker	Industry	Weight (%)
Visa Inc	V	Financials	8,12 %
Intl Business Machines Corp	IBM	Technology	7,17 %
Goldman Sachs Group Inc	GS	Financials	6,74 %
Boeing Co	BA	Industrials	5,36 %
3M co	MMM	Industrials	5,33 %
Chevron Corp	CVX	Energy	4,89 %
United Technologies Corp	UTX	Industrials	4,43 %
McDonald's Corp	MCD	Consumer Services	3,89 %
Johnson & Johnson	JNJ	Health Care	3,78 %
Exxon Mobile Corp	XOM	Energy	3,73 %
			53,44 %

**S&P 500**

Company	Ticker	Industry	Weight (%)
Apple Inc	AAPL	Information Technology	2,97 %
Exxon Mobile Corp	XOM	Energy	2,89 %
General Electric Co	GE	Industrials	1,72 %
Chevron Corp	CVX	Energy	1,65 %
Johnson & Johnson	JNJ	Health Care	1,63 %
Intl Business Machines Corp	IBM	Information Technology	1,60 %
Microsoft Corp	MSFT	Information Technology	1,54 %
Google Inc	GOOG	Information Technology	1,52 %
Procter & Gamble	PG	Consumer Staples	1,51 %
Pfizer Inc	PFE	Health Care	1,48 %
			18,51 %

*Table 2.5.1, Components of DJIA and S&P 500.*

*Source: S&P Dow Jones Indices LLC*

- S&P Small-Cap 600: a stock market index covering the small-cap range of the United States stock market. Smaller companies are usually perceived as riskier than e.g. the Dow, because of less financial stability and operational experience. At the same time, smaller firms are often more nimble, and can easier adapt to economic changes, and positioning themselves for the future.
- NASDAQ 100: an index listing 100 of the largest non-financial companies listed on the NASDAQ, including companies incorporated outside the US.

*As I will use S&P 500 as a benchmark for the US market, and DJIA and S&P 600 to compare the performance of companies within different capitalization segments, I will not use NASDAQ 100 for further comparisons in this thesis.*

- Europe: consists of a variation of financial markets, both emerging and developed. When investors look to invest in the continent, they mainly look to the Eurozone and other developed markets in western- and Central-Europe. To benchmark European performance, we use the index STOXX Europe 600, consisting of stocks from 600 companies of varying sizes across 18 European countries.
- Japan: with the third largest economy in the world, and the largest stock exchange in the world located outside the United States(after NYSE and NASDAQ OMX), the Japanese stock market is by far the most monitored in Asia, with the Nikkei 225 as the main index. The Nikkei 225 is known as one of the most volatile stock market indexes among the developed markets.
- Asia: the MSCI AC Asia Pacific Ex Japan-index represents large and mid-cap companies from four developed markets and 8 emerging ones in the Asia Pacific Region. It is a suitable index to measure the market performance in Oceania and South-East Asia, while excluding Japan.

*This index includes stocks from both China, India and Indonesia, countries included in the BRIC and MINT-indices, which may give them an improperly large proportion of the weighting. However, as the objective of the thesis is to look into the effects of diversification between selective regions and markets, the result will still be representative, as it will only corroborate the correlation between the markets. If we were to calculate how much of a portfolio that should be allocated to East Asia, we must of course use data that reflects the East Asian markets, and the same goes for emerging markets. Both the Indian and Indonesian stock markets counts for a small proportion of the index(< 5%), but one should be aware that China accounts for 17,91%, and this should be taken into account when looking into the correlation.*

- Emerging Markets: To categorize emerging economies, I have divided into two classes, where the first one(BRICS) consists of larger and more developed economies than the second one(MINT). All countries have several challenges in common, such as fluctuating currencies, social inequality, political power struggles and widespread corruption.

- BRICS – Brazil, Russia, India, China, and South Africa: BRIC was an acronym defined by Jim O’Neill in 2001 to represent the advanced development of rapidly growing economies, respectively Brazil, Russia, India and China(Boesler 2013). In 2010, the four countries agreed on including South Africa in the BRIC grouping, renaming them “BRICS”. As of 2013, the five countries represent a combined nominal GDP of US \$15.357 trillion, roughly the same as the United States or the European Union.

The MSCI BRIC-index, a market capitalization-weighted index consisting of MSCIs indices for the respective countries, is a common benchmark for emerging markets. As this thesis wishes to include South Africa, for further geographical exposure, we must design a BRICS-index, re-weighting by including MSCI South Africa. The new weighting is showed in table 2.5.2:

<b>BRICS</b>	<b>Mcap[USD millions]</b>	<b>Weighting</b>
MSCI China	\$ 702 413,59	40,10 %
MSCI S. Africa	\$ 253 362,21	14,46 %
MSCI India	\$ 228 635,32	13,05 %
MSCI Russia	\$ 205 559,55	11,74 %
MSCI Brazil	\$ 361 676,69	20,65 %
	\$ 1 751 647,36	100,00 %

*Table 2.5.2, BRICS-Index. Data: MSCI*

- MINT – Mexico, Indonesia, Nigeria, and Turkey: another brain-child of Jim O’Neill(Boesler 2013), the MINT-classification was presented in 2013 as frontier-markets where investors should turn their attention. Currently, there is no existing MINT-index, but if we assume that an

index would be Market Capitalization-weighted such as the BRIC-index, the weighting would be as followed:

MINT	Mcap[USD millions]	Weighting
MSCI Mexico	\$ 190 194,98	57,24 %
MSCI Indonesia	\$ 86 723,06	26,10 %
MSCI Nigeria	\$ 18 522,07	5,57 %
MSCI Turkey	\$ 36 833,03	11,09 %
	\$ 332 273,14	100,00 %

Table 2.5.3, MINT-Index. Data: MSCI

### 2.5.2 Reviewing the weighting of the indices:

Both the BRICS and the MINT- index have a skewed weighting distribution, and there are big differences between the largest and smallest proportion in each index. This is both due to the size and development of the individual markets, as well as the size of the national economies. As one can see in the table listed below, there are big differences between the size of the national economies and their index weighting. However, as the indices are based on the MSCI BRIC-index, which is the main reference for BRIC-market performance, and this again is based on the individual MSCI indices for each country, I have chosen to keep their model as a base for both the BRICS and the MINT-index.

2013 estimations, CIA World Factbook					
GDP[billion US\$]			GDP[billion US\$]		
Brazil	\$	2 190,00	14,26 %	Mexico	\$ 1 327,00 40,11 %
Russia	\$	2 113,00	13,76 %	Indonesia	\$ 867,50 26,22 %
India	\$	1 760,00	11,46 %	Nigeria	\$ 292,00 8,83 %
China	\$	8 940,00	58,21 %	Turkey	\$ 821,80 24,84 %
South Africa	\$	353,90	2,30 %		
	\$	<b>15 356,90</b>			\$ <b>3 308,30</b>

Table 2.5.4, GDP of BRICS and MINT

### 2.5.3 The background for including BRICS and MINT

As emerging markets are developing, it would be unwise to use historical characteristics of a nation to predict future development. One of the reasons why the BRICS and MINT indices are included is to instead being able to classify emerging markets into categories, in which an emerging market may be placed based on qualitative analysis. Examples of such countries that are currently not included in BRICS or MINT, but may arise as financial markets with developing economies and investor interest over the next decade, are the Baltic countries, Myanmar, Thailand, Tanzania, Kenya and Peru.

## BRICS Total Return index, 2003-2013

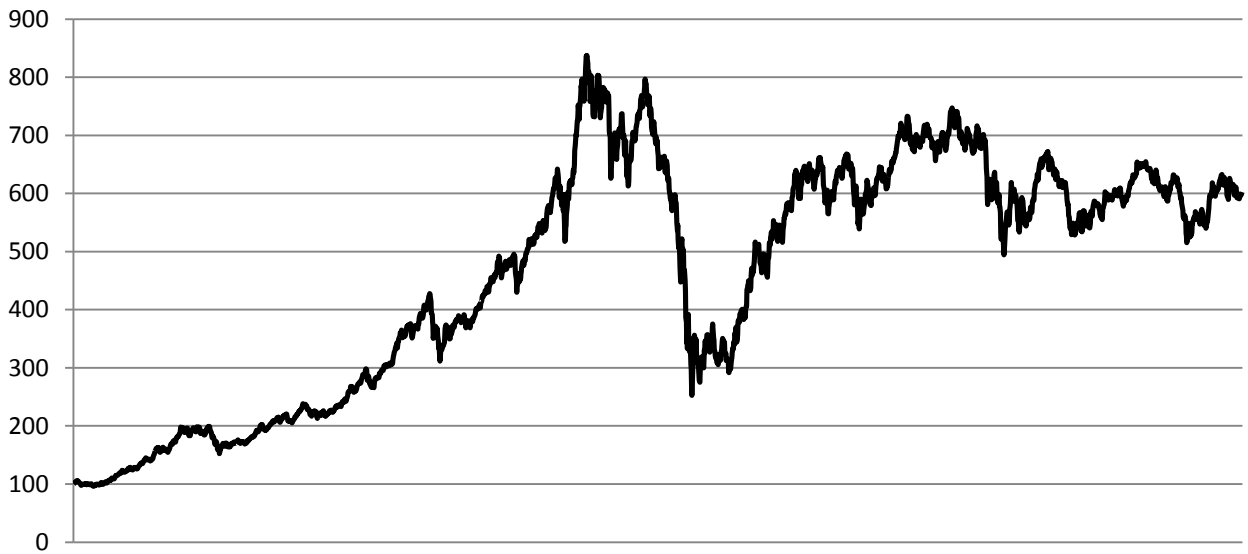


Chart 2.5.1, BRICS Total Return Index

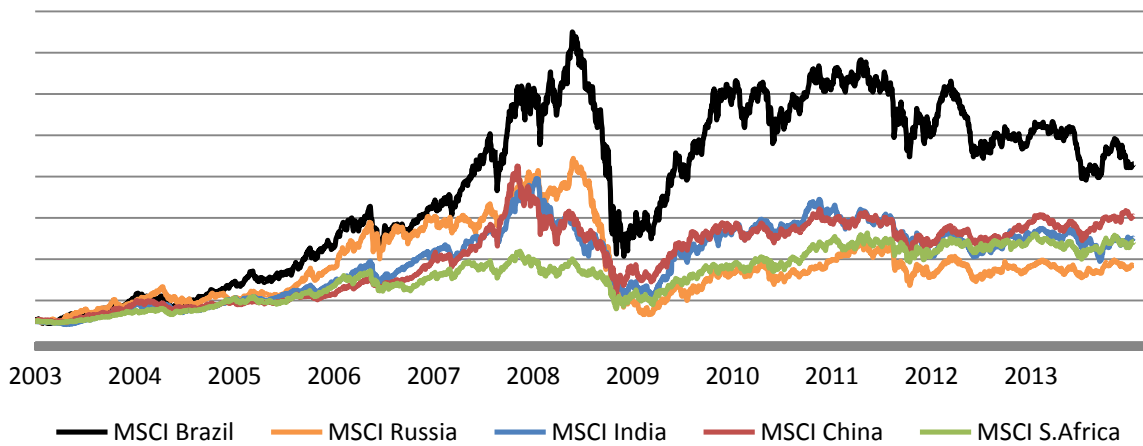


Chart 2.5.2, MSCI Indices of the BRICS countries

	Brazil	Russia	India	China	S.Africa
Brazil	1	0,601	0,954	0,949	0,892
Russia	0,601	1	0,683	0,602	0,498
India	0,954	0,683	1	0,963	0,890
China	0,949	0,602	0,963	1	0,909
S.Africa	0,892	0,498	0,890	0,909	1

Table 2.5.5, Correlation coefficient for the movement of MSCI-indices of the different countries in the BRICS-index.



## MINT Total Return Index, 2003-2013

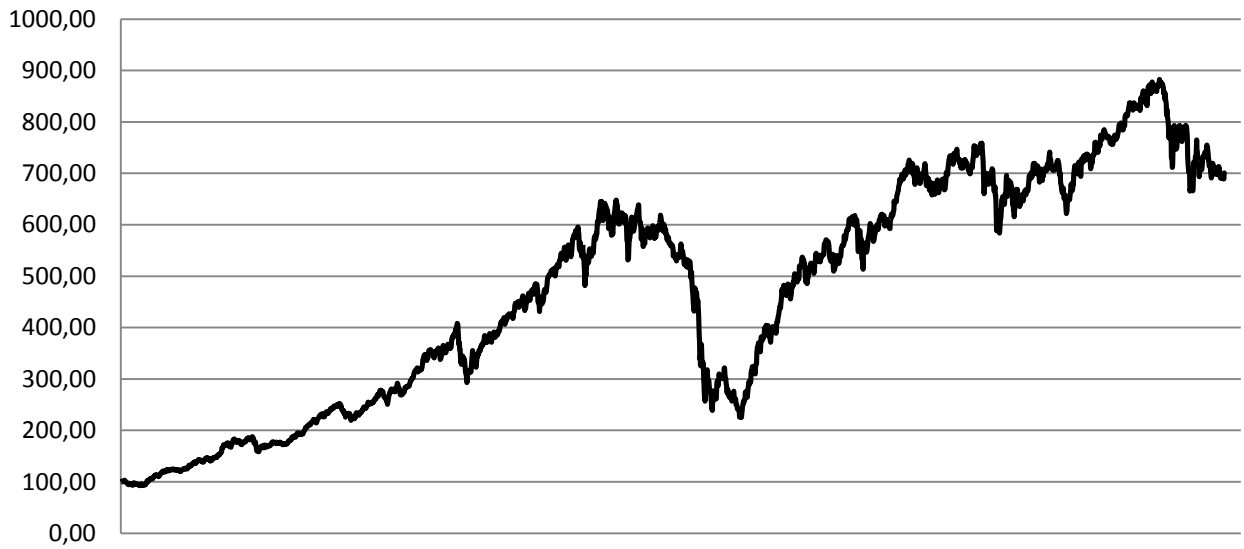


Chart 2.5.3, MINT Total Return Index

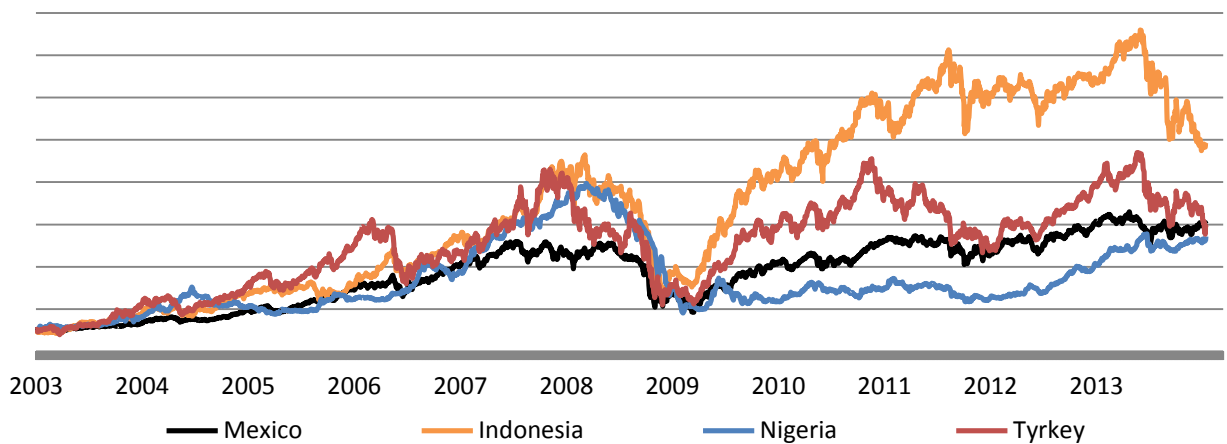
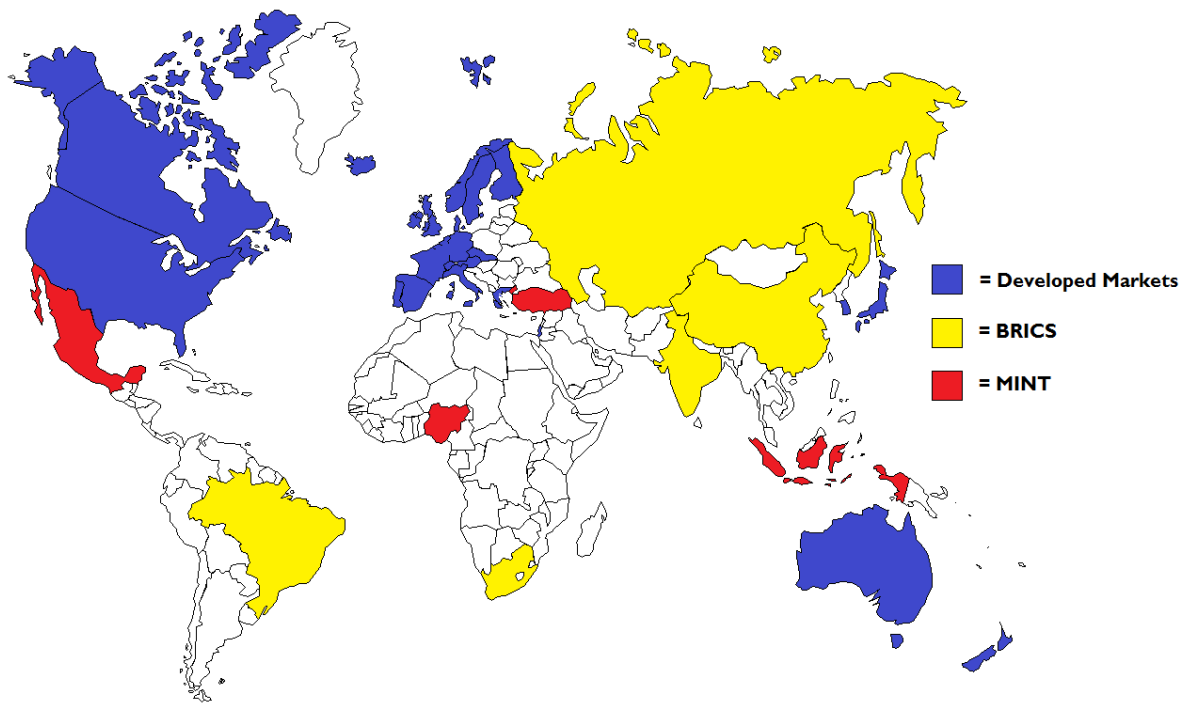


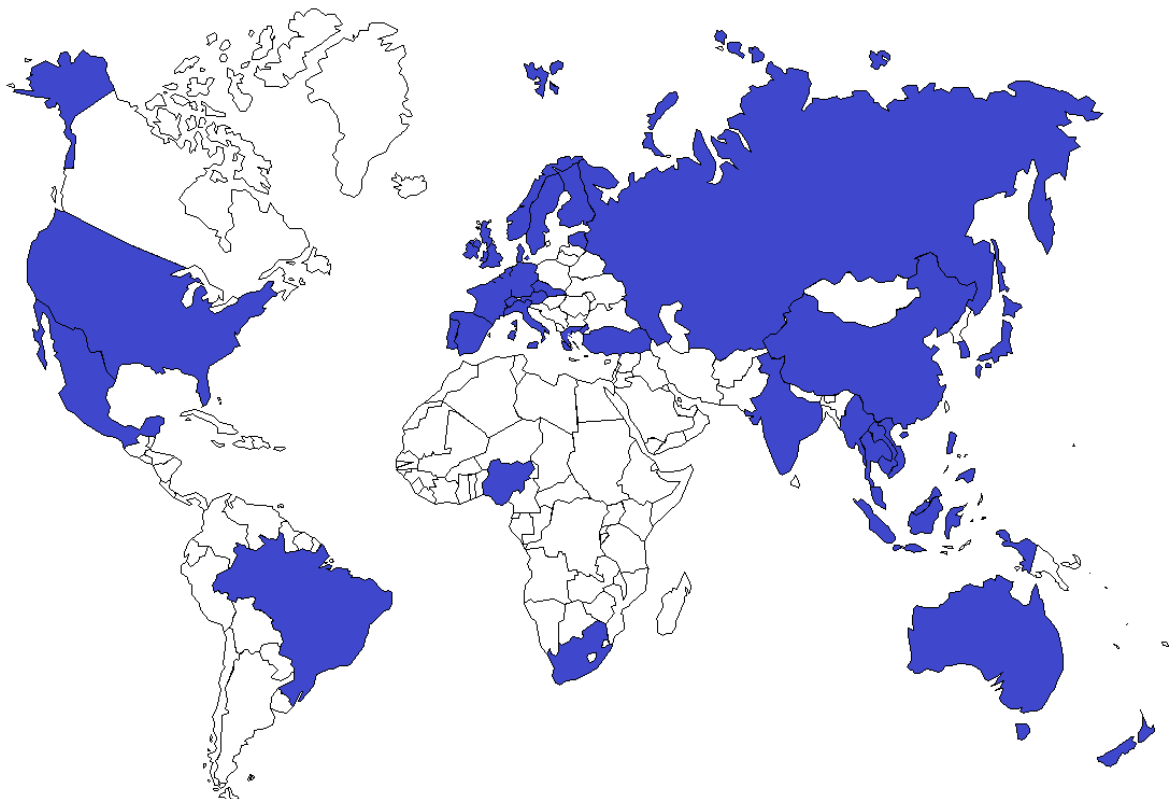
Chart 2.5.4, MSCI Indices for the MINT Countries

	Mexico	Indonesia	Nigeria	Tyrkey
Mexico	1	0,925	0,633	0,931
Indonesia	0,925	1	0,396	0,865
Nigeria	0,633	0,396	1	0,594
Tyrkey	0,931	0,865	0,594	1

Table 2.5.6, Correlation coefficient for the movement of MSCI-indices of the different countries in the MINT-index.



**Map of equity markets included in this thesis:**



<b>Important Gross Domestic Products used in this thesis</b>		
<i>Source: Estimates from CIA World Factbook</i>		
	GDP [billion USD]	Rank
<b>European Union</b>	<b>17030,0</b>	-
<i>United Kingdom</i>	2490,0	6
<i>Germany</i>	3593,0	4
<i>France</i>	2739,0	5
<i>Spain</i>	1356,0	13
<i>Italy</i>	2068,0	9
<i>Portugal</i>	219,3	45
<i>Greece</i>	243,3	42
<i>Ireland</i>	220,9	47
<i>Others</i>	4100,5	-
<b>United States</b>	<b>16720,0</b>	<b>1</b>
<b>Japan</b>	<b>5007,0</b>	<b>3</b>
<b>Asia Pac ex Japan</b>	<b>16471,9</b>	-
<i>Australia</i>	1488,0	12
<i>New Zealand</i>	181,1	55
<i>China</i>	8940,0	2
<i>India</i>	1760,0	10
<i>Singapore</i>	287,4	36
<i>South Korea</i>	1198,0	15
<i>Taiwan</i>	484,7	27
<i>Hong Kong</i>	279,7	39
<i>Others</i>	1853,0	
<b>BRICS</b>	<b>15356,9</b>	-
<i>Brazil</i>	2190,0	7
<i>Russia</i>	2113,0	8
<i>India</i>	1760,0	10
<i>China</i>	8940,0	2
<i>South Africa</i>	353,9	29
<b>MINT</b>	<b>3309,3</b>	-
<i>Mexico</i>	1327,0	14
<i>Indonesia</i>	857,5	16
<i>Nigeria</i>	292,0	37
<i>Turkey</i>	832,8	17
<b>Other important GDPs</b>		
Canada	1825	11
Saudi Arabia	718,5	19
Switzerland	646,2	20
Ukraine	175,5	53

Table 2.5.7, National GDPs

## 2.5.4 Bonds

When a corporation or a government wishes to borrow money, they may choose to issue debt securities called bonds, also known as “fixed income securities”. A regular bond is a security which gives the holder the right to periodical interest payment, and the principal repaid at the expiration of the bond. The bonds face value is the amount originally borrowed, and the amount that will be repaid at the end of the loan. When this paper refers to bond yields, it refers to yields reported from trades in the secondary market, unless specified otherwise.

*A municipal bond (“Muni”) is a debt security issued by a state, municipality or county, and is exempt from several American taxes. This causes the after-tax return of the bond to vary between holders from different countries or tax-brackets (Investopedia 2014a). This thesis will not include municipal bonds in its calculations.*

There are several credit rating agencies who evaluate the credit risk of such bonds, and their assessment strongly influences the yield of a bond, as well as their value in the second-hand market. The three biggest agencies are listed below, as well as their different grading scales.

Bond Credit Rating for Long-Term Bonds				
Description	Investment Grade			S&P Rating(local currency)
	S&P	Moody's	Fitch	Sovereign bonds
Highest Grade/ Best Quality	AAA	Aaa	AAA	Germany
High Grade/High Quality	AA+	Aa1	AA	United States France, China
	AA	Aa2		
	AA-	Aa3		
Upper Medium Grade	A+	A1	A	Israel Poland Mexico
	A	A2		
	A-	A3		
Medium Grade	BBB+	Baa1	BBB	Ireland Italy Iceland
	BBB	Baa2		
	BBB-	Baa3		
Description	Below Investment Grade			
	S&P	Moody's	Fitch	
Speculative Grade	BB+	Ba1	BB	Guatemala Portugal El Salvador Albania Bosnia Greece
	BB	Ba2		
	BB-	Ba3		
	B+	B1	B	
	B	B2		
	B-	B3		
Highly Speculative Grade	CCC+	Caa1	CCC	Argentina
	CCC	Caa2		
	CCC-	Caa3	CC	
	CC	Ca	C	
	C			
Default (Selective Default)	D (SD)	C	D	Grenada

Table 2.5.8, Bond Credit Ratings.

Source: <https://www2.morganstanley.com/wealth/investmentsolutions/creditratings.asp>

Following the financial crisis of 2008, the credit rating agencies were heavily criticized for have given triple-A rating to mortgage-related securities, which later were downgraded to junk-status. They failed to see the poor quality of the

underlying mortgages, and both regulators and investors took legal action against the agencies for their role in causing the financial meltdown of 2007-2008. The agencies ended up basing their legal defense on the First Amendment, claiming that their ratings were simply their opinion, and protected by free speech.

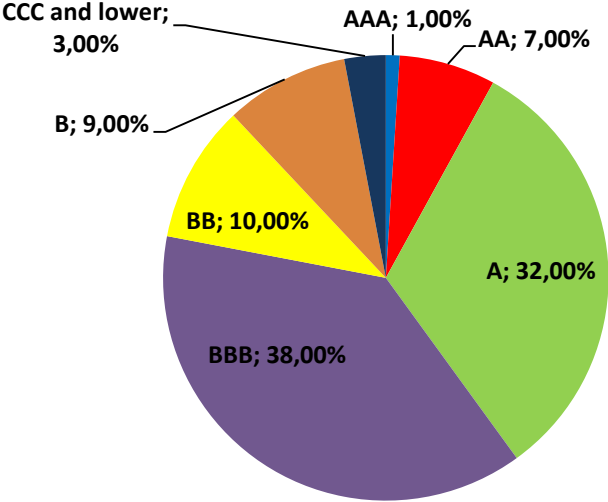


Chart 2.5.5, Global bonds by rating. Source: Bank of International Settlements

In this thesis, I will test how the value of different types of bonds moves with financial markets, especially when facing downward corrections and market shocks. Underneath, I have divided the US bond-market into four categories with appurtenant indices, each representing different aspects of the bond-market for an American investor.

- Short-Term US Treasury Bills**

3 month US Treasury Bills, backed by “the full faith and credit” of the US Treasury, and considered risk-free. T-bills are zero-coupon bonds, sold at a discount of face value(Ross et al. 2011).
- Global Government Bonds – BofA Merrill Lynch Global Government Bond Index**

These are bonds issued by sovereign nations of investment grade, issued and denominated in their own domestic market and currency. They have then been converted to USD, so that currency fluctuations will affect the index performance.

*As this thesis looks into geographical diversification, it would be natural to assume that we would also distinguish between the different government bonds. However, each security would then be tied to the risk associated with the individual country, which is hard to both quantify and predict. It is standard portfolio theory that the majority of the unsystematic risk can be eliminated by diversification, and that at least*

25 individual assets are needed to achieve this. We will therefore instead use an index consisting of bonds issued by various governments, to avoid the unsystematic risk.

The only individual security we use is the U.S. Treasury Bills mentioned in paragraph 1, as it is considered risk-free(including unsystematic risk) and plays an important role in modern day finance(Ross et al. 2011).

- **Investment Grade Bonds – Dow Jones Corporate Bonds Index**

U.S.-issued corporate bonds rated investment grade by Moody’s and/or S&P. The bonds must be issued in the United States, denominated in USD and have an outstanding value of at least \$500 million.

- **High-Yield bonds – Barclays U.S. Corporate High-Yield Index**

Non-Investment grade bonds issued in the United States and denominated in USD. These bonds have more than 1 year to maturity, and at least half of the ratings from the three big credit rating agencies must be rated below investment grade(Ba1 or BB+, and lower).

High Yield bonds will often have a substantially higher rate of return than investment grade bonds. There is no floating distinguishment between the different credit ratings, but a polarized separation between bonds rated higher/equal to, or lower than BBB(Baa). A big reason for this is the mandate that several institutional investors and mutual funds are bound by, as they are limited to investment grade bonds(as indicated by the name). This is an important reason why bonds that have been downgraded below investment grade experiences a sell-off, as they are graded as too much of a risk for the holders. The sell-off leads to the bonds trading at a substantial discount from face-value, which explains one of the reasons behind the high yield.

Similar to for equities, the bond indices applied in this thesis are total return indices, where all the gross coupons received are reinvested in the same bonds underlying in the index. This is done by the following calculations, when  $R_0 = 100$ .

$$R_t = R_{t-1} \frac{\sum_i (P_{i,t}^* + A_{i,t} + CP_{i,t} + G_{i,t}) N_{i,t-1}}{\sum_i (P_{i,t-1} + A_{i,t-1} + CP_{i,t-1}) N_{i,t-1}}$$

Formula notation(Datastream 2014):

- R = Redemption price of the bond
- $P_{i,t}$  = the price of the  $i$ -th bond at time  $t$ .
- $P_{i,t}^*$  = price of the  $i$ -th bond at time  $t$ , if adjusted for any partial redemptions.
- $G_{i,t}$  = value of coupon payments received from the  $i$ -th bond since time  $t-1$ .
- A = the accrued interest to the settlement date.
- N = Nominal value of amount outstanding, if not applicable, then the issued amount.
- CP = an adjustment made for bonds in an ex-dividend period. After a bond goes ex-dividend, CP has a value equaling the next coupon payment.

### **2.5.5 Real Estate**

Several of the larger institutional investors in the world invest in real estate as these are traditionally safe investments with a steady income from rental revenues. Both residential housing and commercial properties offer a wide range of investment opportunities, with different risk exposure and revenue base.

### **2.5.6 Private Equity and Venture Capital**

To diversify an institutions investment and to reduce the correlation between the portfolio and global financial markets, several investors choose to invest in privately held companies. This is often done by putting their money in specialized funds, run by managers that charge a percentage of both the initial investment, as well as the profit resulting from this investment. These funds are usually directed into one of the following forms:

- Private Equity: Investing in mature companies with products and a cash-flow, and by financial restructuring and optimization, increasing the market value of the company.
- Venture Capital: Investing in start-ups and young companies that may, in some cases, be nothing more than a good idea. Characterized by substantial risk, with the potential for high reward.

### **2.5.7 Hedge funds:**

A hedge fund is an actively managed portfolio consisting of advanced investment strategies, using both leverage and derivatives to take a long- or short position on a wide variety of securities. The goal of a hedge fund is to apply their broad mandate to achieve above-market returns regardless of the movements of the market. A hedge fund is usually only open to a limited amount of high-value investors, and the industry has received criticism over the past years as they have failed to beat the market while still charging investors with both management fees (typically 1-2% of the NAV) and performance fees (typically 20% of the annual return).

### **2.5.8 Commodities:**

In 1959, the French economist Gérard Debreu defined the characteristics of a commodity as

*"...its physical properties, the date at which it will be available, and the location at which it will be available"* (Debreu 1959).

A commodity is a tradable good, often raw materials that are used in industrial production and for consumption. Today, most of the global commodity trade does not use physical goods, but trades in futures and forward-contracts on exchanges controlled by the CME Group. These contracts are based on an underlying commodity, and assume physical delivery, meaning that pricing must be based on the commodity being delivered to a geographic point. The CME Group regulates which delivery points are acceptable for each commodity.

**Industry Insight:**

Back in 2005, there was a small hedge fund called Cornwall Capital Management, managed by Charles Ledley and James Mai, two relatively inexperienced investors. They discovered a gross misprice in ethanol futures, and immediately bought two rail cars' worth, a trade big enough to make headlines in the peripheral niche magazine *Ethanol Today*, which they had never heard of before. The trade made a profit, but they were unaware that they had to close out their position. To their brokers' frustration, they ended up having to accept delivery of rail cars filled with ethanol in a Chicago Stockyard(Lewis 2010).

The three most common categories of commodities used in the financial markets are:

- Agricultural and aquacultural commodities: e.g. corn, wheat, coffee, frozen orange juice, salmon.
- Industrial and precious metals: most commonly gold and silver, but also copper, nickel, aluminum, uranium, etc. Gold is a common component in long-term investment portfolios, and has been used as both currency and a valuable for thousands of years. From the 18<sup>th</sup> to the 20<sup>th</sup> century, central banks used gold to back the value of their currency, and several countries still holds large amounts of gold reserves to this day.

Investing in gold is fairly easy, compared to other commodities; it does not rot or decompose, it is solid and traded in gold bars that are easily handled, it does not require much storage room(a 1 kg gold bar = 57,6 cm<sup>3</sup>)(TF Gold 2014), and several banks and institutions offer vaults for safe keeping. Gold has been regarded as a safe haven during market turmoil, and one often seeks to invest in gold to offset drops in currency and financial markets. Silver serves virtually the same function as gold in today's financial markets, but this thesis will only apply gold in its calculations, due to its position as a safe-haven and its long traditions.



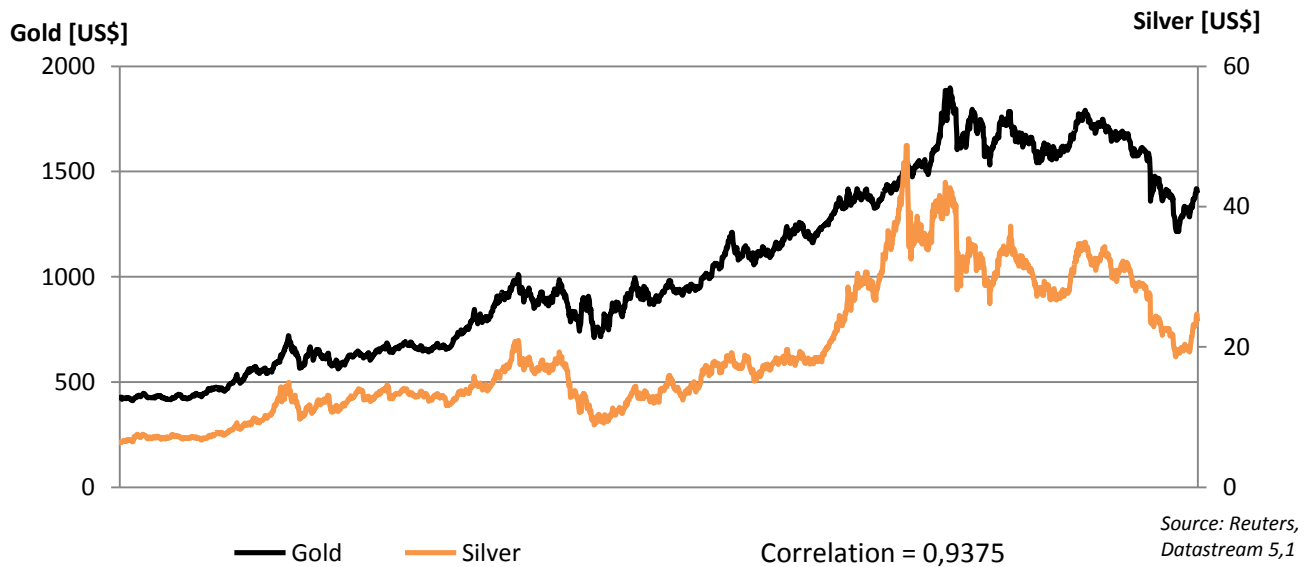


Chart 2.5.6, Price of Gold and Silver, 2003-2013

- Energy: including natural gas, electricity, emission, and most importantly, crude oil. Crude oil is unrefined petroleum product that can be refined into other products such as gasoline and heating oil. It can be bought from a *crude stream*, which consists of oil from one or more oil fields. The price is set from benchmark standards, from which oil from different regions are compared against one another. Crude oil is probably the most followed commodity in the world, affecting several sectors and related commodities(airline fuel, gasoline, heating oil, etc.). There are several reasons why an investor or institution may have natural exposure towards the price of crude oil:
  - National consumption(United States, China) or production(Norway, Saudi Arabia) of petroleum products is a large part of the national economy.
  - Loss-sensitivity towards unrest within global politics, as the threat of supply shocks will usually lead to a spike in prices. This is especially applicable with the political unrest in the Middle East.
  - Both upstream- and oil service companies' revenues is largely based on the price of oil, while the transportation sector will profit from lower prices(fuel costs).

One faces large storage costs if one tries to hold crude oil for speculative purposes, and an investment in «paper oil», that is financial instruments with crude oil as the underlying, will usually mean to assume a long- or short position in rolling futures- and forward contracts, which will face transaction costs. We can conclude that we will avoid including crude oil investments in this thesis, and should only be done by investors when faced with a large natural long- or short position that needs to be hedged.

### 2.5.9 Derivatives:

Over the last two decades, the number of possibilities for an investor to diversify his or her portfolio has become almost endless. Investment Banks are more than willing to help issuing exotic securities, and derivatives are issued to cover almost all aspects of business operations. Derivatives can be divided into main categories:

- Options: an option is the right, but not the obligation, to buy(call) or sell(put) a security at a given time for a given price, from the counterparty of the option. European options can only be executed at one given date, while American options can be executed at any time before the expiration date. Whether an option is American or European is not related to the region for which it is issued, but is only a term describing the possible date of execution.
- Futures and forwards: an agreement to buy or sell an asset at a future date at a given price. Futures are exchange traded and marked-to-market each day, while forwards are OTC contracts with a settlement date at the expiration.
- Swaps: defined by John C. Hull as “An agreement to exchange cash flows in the future according to a prearranged formula”(Hull 2012e), a formula commonly based on market variables such as interest rates or exchange rates.
  - Credit Default Swaps(CDS): a credit derivative that emerged at the forefront of the financial crisis of 2008, where the buyer of the CDS has the right to sell a bond to the seller of the CDS at face value, if a credit event is to occur.

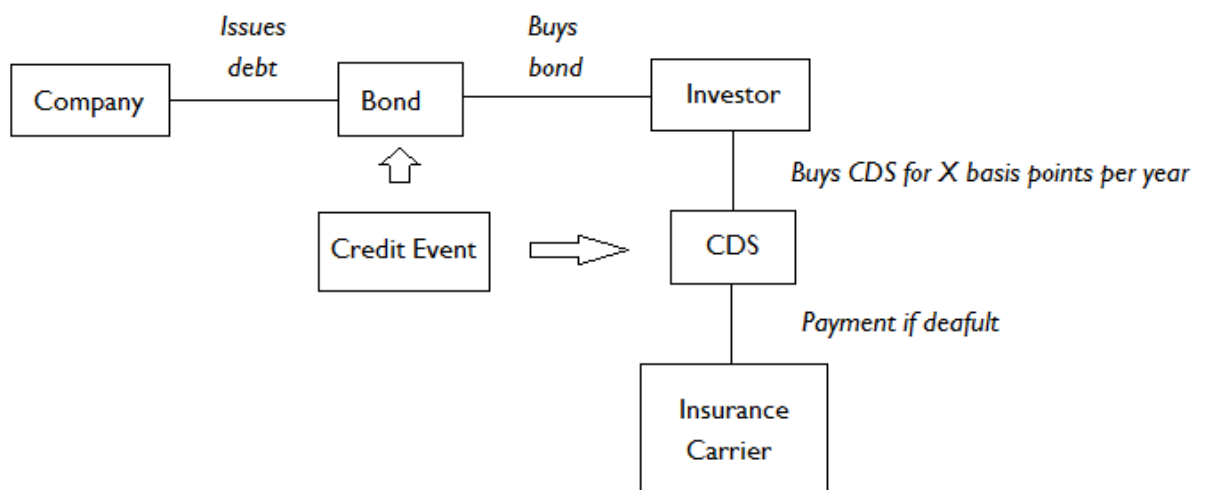


Chart 2.5.7, Illustration of CDS Value-chain

- Swap-lines: fixed exchange rates over a given time-period. Before the credit crisis of 2007, European banks held assets listed in USD to match their dollar exposure of their liabilities. As the “risk-free” mortgage bonds saw a sharp decrease in value, banks around the world needed more USD to reduce their currency exposure as the value of their dollar denoted assets fell, but the supply was limited because of the lack of

credit in the market. As large banks worldwide are closely intertwined, the Federal Reserve understood that it was vital that large global banks had access to USD. However, due to their limited mandate and political restraints, only banks located in the United States would have access to emergency loans from the Federal Reserve. This was solved by major central banks around the world announcing liquidity swap-lines to ensure that European banks had access to USD by letting their respective country's central bank be able to exchange their currency for US dollars, on the condition that the currency would be swapped back at the same exchange rate at a later time(Fed 2014).

- VIX index: As written in part I, the VIX is an index of the implied volatility of the S&P 500. Also known as the “fear index”, it moves with negative correlation compared to the S&P 500 and may therefore seem like a promising way to hedge against a fall in financial markets. To gain exposure to the VIX, one is not required to buy all the underlying options from the VIX, i.e. thousands of put- and call options with varying strike prices, nor do you have to buy VIX futures; volatility based securities has been more and more common over the years, most notably Barclays’ exchange traded fund VXX. However, as VIX-futures usually trades in contango, the cost of buying new contracts with longer maturities is likely to be higher than the income received from selling the contracts with shorter maturity, causing the portfolio to face roll costs about 77% of trading days(Liu 2011).

*Contango: when the future price of a commodity is higher than the expected future spot price. This may be because of costs associated with storing the commodity, or a carry cost of buying it today. The opposite of Contango is called Backwardation.*

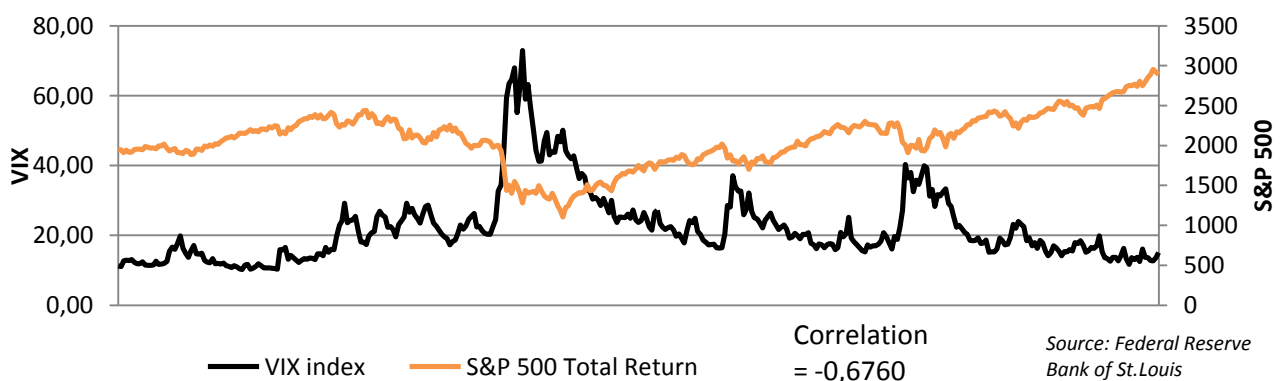


Chart 2.5.8, VIX Index and S&P 500, 2003-2013

Similar volatility indices have been developed for a wide variety of markets, e.g. Crude Oil(OVX) and Chinese equities(VXFXI). There has even been developed a volatility index with the VIX index as the underlying, as the

VVIX-index reflects the volatility of the implied volatility of the S&P 500(CBOE 2014).

### 2.5.10 Currency:

For any investor, as well as governments and corporations, trading and investing in a different currency than your own will open for currency risk exposure. For example, for an investor in the Eurozone, any securities denoted in any other currency than the Euro will face value fluctuations in both the given value of the currency and the exchange rate from which the security is noted. To indicate the currency fluctuations, you can see the exchange rate for some common currency pairs over the last 10 years in chart 2.5.9.

#### Common currency pairs for USD, 2003 - 2013

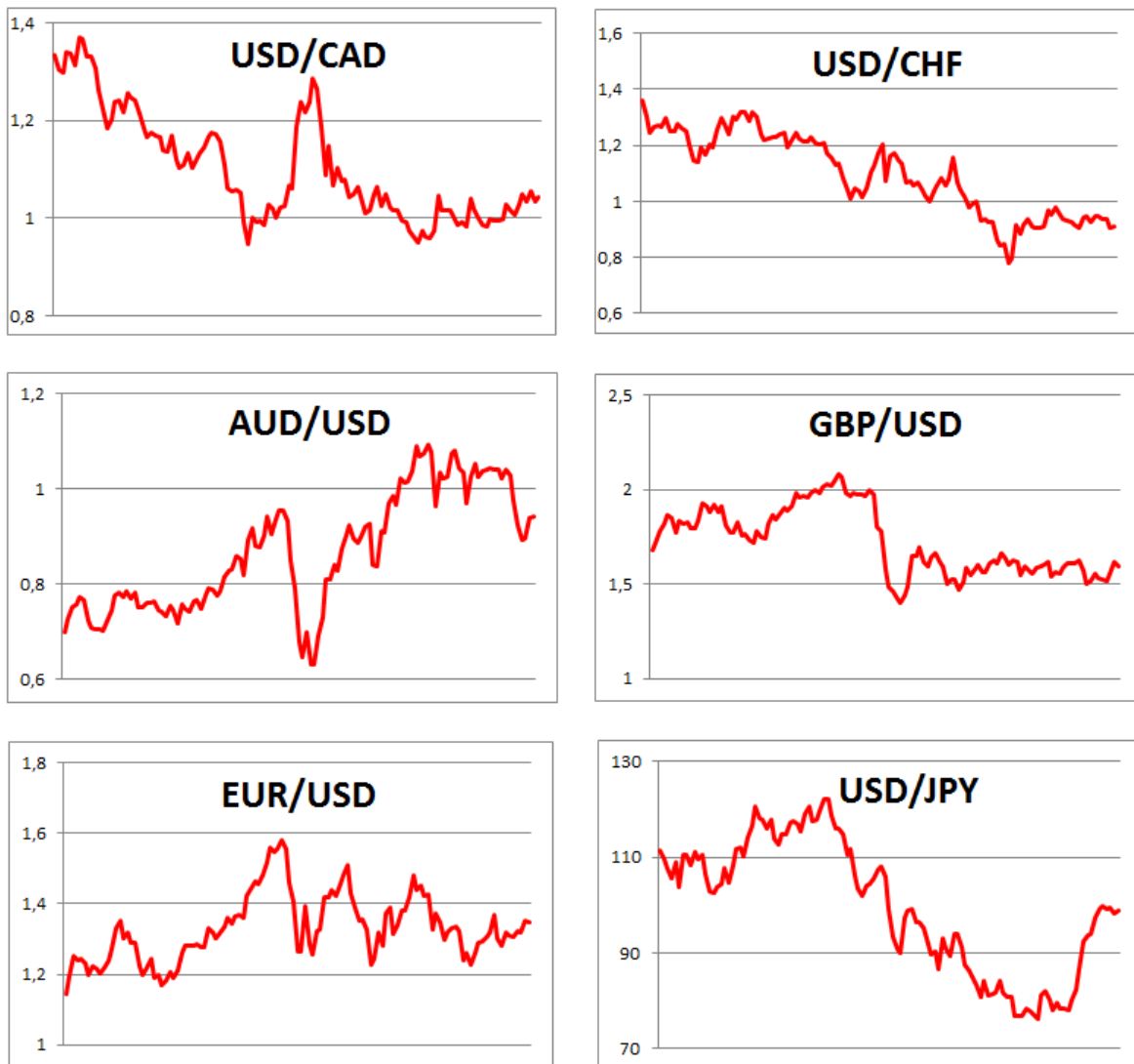


Chart 2.5.9, Currency Pairs. Source: Datastream 5.1

The US Dollar is still the most important currency in the world, used by several central banks around the world as currency reserves, and the currency for which

commodities and several other derivatives contracts are traded. For this thesis, all data gathered has been converted to USD, which means that the volatility of foreign securities may experience a greater fluctuation than those already noted in USD.

#### **2.5.11 The risk-free rate:**

The risk-free rate of return is an important aspect in modern portfolio theory, based on the capital asset pricing model. It is the rate of return of a theoretically risk-free investment, including both default- and currency-risk. The only securities that may theoretically be considered risk-free are short-term government bonds denoted in its own currency. The probability of these governments defaulting on their debts is perceived to be virtually non-existent, and the short maturity of the debt will protect the investor against any significant interest-rate risk.

When investing in USD, US Treasury bills (“T-bills”) are known as the safest investment possible, short-term bonds backed by the “full faith and credit” (Investopedia 2014b) of the U.S. Treasury.

#### **Industry Insight:**

As long as sovereign bonds are denoted in their country’s own currency, a government will have the option to simply print money to pay its debts. As no individual government of the Eurozone has the authority to print currency, the risk of default may increase, especially for smaller nations with budget deficits and large government debts (Greece). When considering Euro-denoted investments, Germany’s sovereign bonds are usually used as a reference for the risk-free return rate. However, as the CDS market also covers German Sovereign Bonds, and the price of a CDS is essentially a risk premium, one can argue that the market does not consider the bond risk-free.

#### **2.5.12 The Federal Reserve System**

Often referred to as the Federal Reserve, and even just *the Fed*, the Federal Reserve System is the system of central banking in the United States, on the basis of the Federal Reserve Act of 1913. The Federal Reserve is mandated by congress to adjust monetary policies in order to balance three key objectives: maximum employment, stable prices and moderate long-term interest rates. There are three main institutions within the Federal Reserve System:

- The Board of Governors, composed of seven members that are presidentially appointed, and currently led by Janet Yellen.
- Twelve regional Federal Reserve Banks, located in major American cities across the nation, each led by its own president.
- The FOMC, the Federal Open Market Committee, consisting of the seven members of the Board of Governors, as well as the twelve presidents of the

regional Federal Reserve Banks. The FOMC is responsible for deciding the monetary policy of the Federal Reserve System.

The Federal Reserve System is both diplomatically and politically independent, and does not need their decisions approved by either the executive or legislative branches of government. They are meant to make the decisions that economically favorable in the long term for the economy of the United States and its citizens.

### **2.5.13 MSCI**

MSCI is an acronym for Morgan Stanley Capital International, known as one of the world leaders in providing index composition of both equities and fixed income securities. Their indices are used by investors all over the world, within all segments. MSCI is no longer a part of Morgan Stanley, but is listed on NYSE as a public company.

### **2.5.14 Black Swan-events:**

The Black Swan theory was created by Nassim Taleb in 2001, and describes an unlikely, unpredictable and unexpected event, that has consequences of large magnitude and severity. Taleb defined the events as depending on the observer, using the metaphor of a turkey. The turkey is living carefree days, being well fed over a longer period of time, until suddenly the butcher ends the life of the turkey. The slaughter of the turkey is, from the bird's point of view, a black swan-event, but not from the butcher's point of view. One should therefore try to identify your areas of vulnerability, to "avoid being the turkey". The financial crisis of 2007-2008 could be considered a black swan-event, as financial institutions across the globe found themselves being closer to "the turkey" than the butcher.

### **2.5.15 Bull- and Bear Markets**

Used to describe the current trend, and degree of optimism in the market. Each is named after how the animal strikes its opponents; a bull would thrust its horns upwards, meaning a rising market with a positive outlook. On the opposite side, the bear strikes its paws downwards, hitting its opponent from the top. A bear market is experiencing declining market values and a negative outlook.

There is also a third option; the 'Wolf Market', developing sideways in a fairly horizontal interval. Named after how the wolf strikes by horizontal paw movement.

### **2.5.16 Limiting the relevant assets for the thesis**

As this thesis looks into volatility and portfolio theory for an institutional investor, including the opportunity to rebalance the portfolio, it is important that all investments included are liquid and traded on an open market. This is to ensure effective price quotes and an active market for every asset.

Regarding the inclusion of commodities, investing in a commodity simply for speculating in a price increase comes with great risk, and is also subject for cost of capital and storage costs, which may be significant for some commodities such as crude oil or agricultural goods. The exception is gold, a precious metal with a history as both a currency and as a valuable, a background that can be traced back thousands of years. Still today, gold is considered a genuine alternative for investors looking to diversify their portfolio and also used as a safe haven for investors fearing a drop in financial markets.

As for geographical diversification, it is hard to find sufficient data for assets other than stock markets, and I will use the indices mentioned in the beginning of this chapter to compare how diversification between regions and countries may benefit an institutional investor.

Presently, the US financial markets are far more transparent and developed than the rest of the world, and this thesis will use the different US securities to compare how diversification between asset classes may affect return and volatility of a portfolio. This includes separating “blue-chips” and small-caps, as well as bonds with different ratings. The idea is that the results from comparing US securities may be an indication of how diversification may benefit portfolios in other financial markets that may have less data available. Especially the bond market of the United States is far more developed than the bond markets in the less developed parts of the world. A deep and liquid bond market is a vital part for building up the financial strength of a nation, as capital can be funneled to companies and governments so that it reaches the investments the market finds the most promising. So if a nation wishes to achieve great financial power, an effective and functioning bond market is needed, and one can assume a rapid development in global bond markets over the next decade.

The Eurozone currently only accounts for 10% of the global bond market, well below what the total size of their corporate sector might suggest. This is largely due to a tradition of bank financing being the primary source of capital for European corporations, a tradition that is likely to change in the wake of the Eurozone debt crisis. Chinese companies has mainly had to depend on financing from government run entities, meaning that projects favored by politicians are those that gets funding. The PBOC(People’s Bank Of China) has worked for a liberation and development of the Chinese bond markets, as its total corporate bonds outstanding is currently at about 9% of the GDP, compared to over 50% in the United States(Irwin 2013d).

As a well-developed bond market gives great added financial flexibility for the corporations of the economy, leading to economic growth and prosperity, we may

assume that global bond markets of the future will closer resemble the current market we experience today for fixed income-securities in the United States.

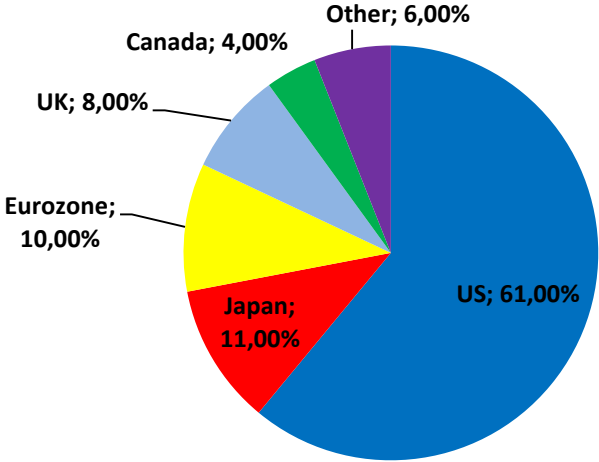


Chart 2.5.10, Proportion of the global bond market. Source: Bank of International Settlements

We have now limited the types of assets available, and are left with a number of stock- and bond indices, to build a diversified portfolio with varying performance and risk. By using assets with different geographical domicile and perceived market risk, fluctuations in portfolio value may be smoothed out, avoiding periods of large valuation drops.

Index	$\mu$	$\sigma$	Avg. Volat	Ann. Return
S&P 500	0,03 %	1,25 %	16,37 %	9,18 %
STOXX 600	0,04 %	1,46 %	19,99 %	10,82 %
Nikkei 225	0,03 %	1,50 %	21,72 %	8,81 %
Asia exJap	0,05 %	1,33 %	18,02 %	14,24 %
BRICS	0,06 %	1,57 %	21,05 %	17,73 %
MINT	0,07 %	1,38 %	19,17 %	19,34 %
Global	0,04 %	1,07 %	14,21 %	9,71 %
Gold	0,04 %	1,24 %	18,15 %	12,12 %
DJIA	0,03 %	1,15 %	15,16 %	9,18 %
S&P 600	0,05 %	1,52 %	21,08 %	12,96 %
US Treas	0,01 %	0,01 %	0,06 %	1,53 %
Glob Gov	0,02 %	0,43 %	6,49 %	5,09 %
Invst Grd.	0,02 %	0,37 %	5,41 %	6,48 %
High Yield	0,04 %	0,36 %	3,79 %	11,75 %

Table 2.5.9, data for indices and assets 2003-2013

The table above shows key data for the different asset indices over the last 11 years.

- Column 1 shows the average daily change in the indices
- Column 2 gives the standard deviation( $\sigma$ ) of the daily changes during the time period
- Column 3 is the average historical volatility for each index over the last 11 years, annualized.



- Column 4 is the annualized geometric return of each index.

*Note that this is based on historical data, and may offer an incorrect estimate of future index development. Especially for emerging markets, the coming decade is likely to look significantly different than the previous one. Still, the BRICS and MINT-indices is likely to give a good indication of how emerging markets in different stages of development is likely to evolve, compared to other markets.*

When simply comparing the rows in table 2.5.9, one may assume that some investments do seem significantly more attractive than others, especially as the volatility of some indices does not necessarily mean a higher annualized return. For the US stock market, the result was fairly as predicted, as the *blue-chip* DJIA has a lower return than S&P 500, and a corresponding lower volatility. The S&P 600 Small-Cap index has experienced the highest return of the three, but also faces a higher volatility.

The MINT index has the highest return in the table, but also has a lower volatility than both S&P 600 and the BRICS index. However, one must still analyze the underlying indices of the index before declaring it a superior investment. The MINT countries are nations that have been facing several challenges over the past eleven years, both political risks, unstable currencies and social unrest. It is natural that investors require a substantial risk premium for investing in these countries, even though these risk factors are harder to measure with volatility and market risk.

Regarding the key data for the bond indices, US Treasury bills returns the lowest rate of return, but then again faces the lowest volatility of them all. This is as expected for these risk-free, low-return bonds. However, I was surprised to see that the volatility of global government bonds was higher than both investment grade- and high yield-corporate bonds, despite a lower rate of return. This may be due to how these are often denoted in their local currency, and the currency fluctuations may be the cause of the relative high volatility. From the data above, both global government bonds and investment grade corporate bonds does seem like an inferior investment compared to high yield bonds, as it has delivered an annualized return of 11,75% with an average historical volatility of 3,79%. From this, it does seem like an index consisting of high yield bonds rated below investment grade may be a great addition to a portfolio, as the number of securities in the index removes much of the credit risk of the individual companies, while returning a double-digit annual yield. The number of holdings may explain some of the difference in volatility, as it is natural to assume that an increased number of holdings should help reduce the diversifiable risk. The Barclays U.S. Corporate High Yield Index consists of 702 individual holdings, while the Dow Jones Corporate Bond Index only has 96 individual holdings included in the index. However, as both indices consist of a relatively large number of companies (>> 25), it is unlikely that this is the cause for the difference in volatility. If so were the case, one could assume that the DJIA would have substantially higher volatility averages than both the S&P 500 and the S&P 600 Small-

Cap, as it only consists of 30 holdings(against 500 and 600, respectively). This is clearly not the case, as is shown in table 2.5.8.

When regarding the time aspect of historical data, this thesis will mainly use data over the previous 11 years, dating back to January of 2003. This is to focus on the time period when financial markets are being characterized by an increased globalization, and the internet causing information to travel between markets within fractions of a second. This will also avoid having the dataset being too affected by the Internet Bubble of 1999 to 2002, as stock indices saw drastic valuations and fluctuations unprecedented in modern times.

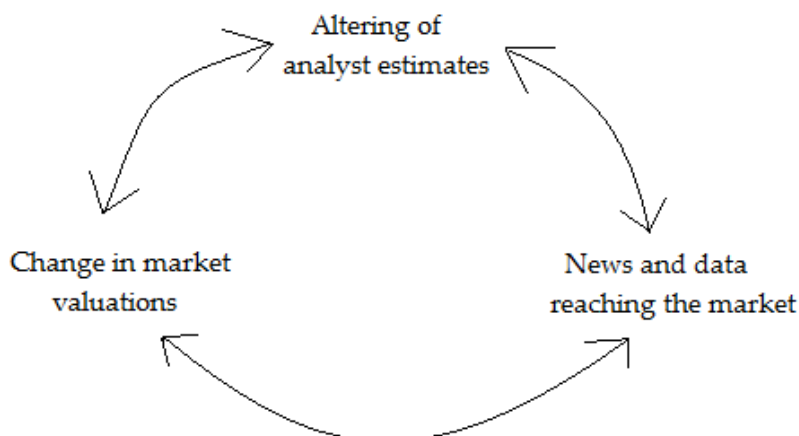
## Chapter 3: Using financial ratios or economic indicators to predict volatility

One of the applications for this thesis was to see how an international portfolio may weight its assets so that the volatility could be minimized without compromising the performance of its returns. But would it not be more ideal if a time of increased volatility could be predicted and prepared for?

Can a shift in volatility be predicted by measurements, so that investors may position themselves for the coming fluctuations, or is it only based on news and data reaching the market, so that volatility is only the reaction to changes in the sum of all information in the market? As stated in section 2.1.4, trading is the cause for volatility, and as the opinion of the market, thus the opinion of the traders is altered by new information being available, volatility should increase. But what if there is an overall nervousness in the market, that there should be a correction happening soon based on historical data and indicators, or that investors are becoming more eager to secure profits by closing out profitable trades that have yielded good returns?

### 3.1 Static measurements, the Price/Earnings ratio:

From 2003 to 2013, the average P/E-ratio for the S&P 500 was 17,35. It is common among journalists and analysts to argue that a market is “historically cheap/expensive” by comparing its P/E-ratio with historical values. As earnings is basically what an investor is looking for in a company over the long term, the ratio of price pr. share to earnings pr. share is a good measurement of how expensive each dollar of annual earnings would be in the market. Of course, as this is based on the earnings reported in the quarterly filings provided by the company, it does not reflect future expectations for the economy, nor possible conditions that may have altered the earnings(e.g. the weather).



One could apply the estimated forward earnings, but this is based on the opinion of the analysts for the next 12 months, which makes it a subjective measurement that is altered continuously as analysts change their opinions. This is a part of a continuous loop of information, as shown in the figure below, and it would be ineffective to use

as an indicator. Uncertainty is reflected in both volatility and analyst estimates, and one may affect the other.

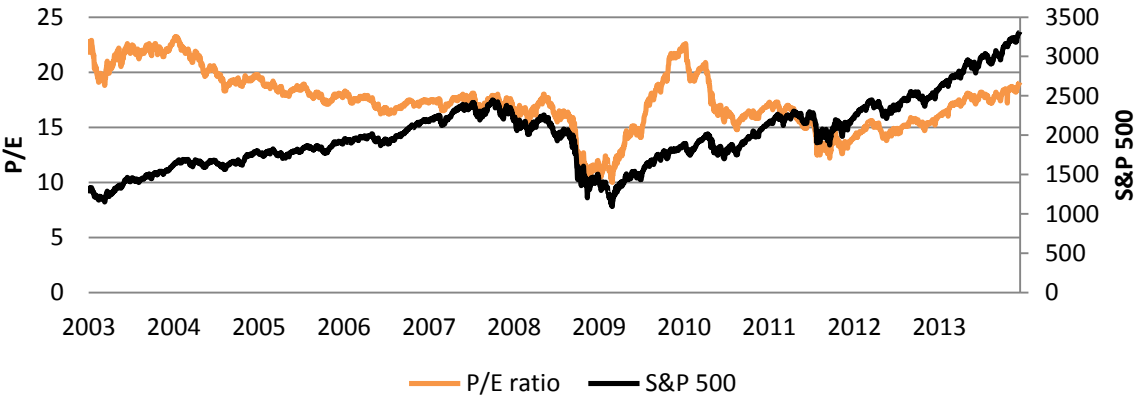


Chart 3.1.1, P/E ratio of the S&P 500

The same applies for the *Shiller PE*, a measurement which utilizes the earnings from the previous 10 years and is known for being an excellent tool for comparing the valuation of indices; it is based on the same type of static data as the Price/Earnings ratio, and therefore cannot be considered a “holy grail” for index valuation.

However, as the market fears the sentiment of the market itself, these ratios are closely watched as many believe that the ratio tends to return to its historical average. How safe does the market feel at a high P/E level, will they be more easily startled than at a below-average ratio? I will consider this by calculating the standard deviation of the implied volatility, when it is close to its mean reverting state under different values of the P/E ratio.

This can be explained as the *Volatility of (implied) volatility*, and is an area of financial statistics that has seen little attention from the financial sector. As a result, there is very little previous research and literature available on the subject, and it is therefore difficult to conclude that the measurement would be appropriate for such calculations.

The hypothesis is that as the Price/Earnings ratio increases, the investor sentiment will start to switch more easily, as the market participants are starting to consider if a downward correction is due. By plotting the P/E ratio from the last 9 years (Start of the VIX) next to the values of the VIX index, one can start to analyze the relationship between the two. I chose the 65<sup>th</sup> percentile of values as the basis, and used the 65% lowest closing prices of the VIX as the dataset for the mean reverting range. This could be confirmed graphically, as this would equal a VIX closing value of 20.16. Calculating this back to a daily volatility, using the formula from section 2.1.2, we get a mean reverting range for the daily implied volatility of 1.27% and below. From chart 3.1.2, we can see that this is fairly consistent with the value that the index seems to be returning to after a spike, which is close to its level of mean reversion.

*I also considered both the median and the average as the basis of the mean, and then adding a given percentage of observations at either side. However, due to the skewed distribution of*

values, and as graphical analysis is needed to confirm the mean area of observations, I rejected these measurements. The median would correspond to a daily implied volatility of 1,08%, while the average would almost equal the 65<sup>th</sup> percentile, at 1,27%.

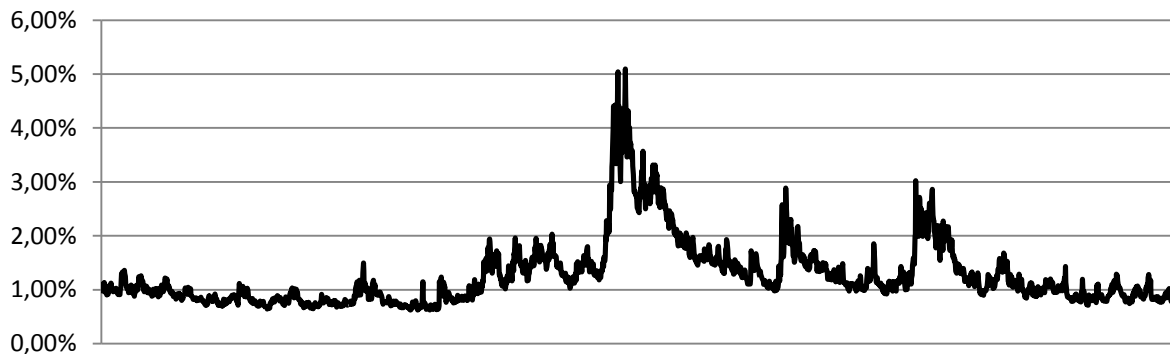


Chart 3.1.2, VIX-index converted to daily values, 2004-2013

I then set up a table of all days over the last 10 years (since the inception of the VIX index) where the VIX index had a value in this 65<sup>th</sup> percentile range, excluding days where the VIX was higher than the mean reverted range. This was so that an individual event that may cause market uncertainty was not to interfere in the data. This gave a data set of 762 observations that, in theory, should avoid much of the significant statistical noise. Grouping the observations by their P/E and calculating the standard deviation of the daily change in the VIX index, I plotted the standard deviation in the table below, as well as the percentage of the observations that were within the mean reverting range.

P/E	Freq.	Total	% Freq	Variance	$\sigma$
<15	33	68	48,53 %	0,0113	10,64 %
15-15,4	47	101	46,53 %	0,0119	10,90 %
15,5-15,9	43	87	49,43 %	0,0089	9,42 %
16-16,4	39	84	46,43 %	0,0127	11,29 %
16,5-16,9	62	135	45,93 %	0,0205	14,33 %
17-17,4	117	253	46,25 %	0,0115	10,72 %
17,5-17,9	159	326	48,77 %	0,0099	9,96 %
18-18,4	73	156	46,79 %	0,0095	9,76 %
18,5-18,9	55	127	43,31 %	0,0085	9,23 %
19-19,4	37	80	46,25 %	0,0074	8,57 %
19,5-19,9	21	63	33,33 %	0,0107	10,34 %
20-20,4	24	48	50,00 %	0,0068	8,22 %
20,5-20,9	8	21	38,10 %	0,0128	11,30 %
21-21,4	5	11	45,45 %	0,0179	13,37 %
21,5-21,9	16	30	53,33 %	0,0067	8,21 %
22-22,4	8	25	32,00 %	0,0114	10,69 %
>22,5	15	26	57,69 %	0,0067	8,21 %
<b>762</b>	<b>1641</b>		<b>46,44 %</b>		

Table 3.1.1, P/E ratio of the S&P 500

By first glance, it seems as both the proportion of days within the range, as well as the standard deviation, is fairly consistent across the P/E values. There are some discrepancies in some of the rows representing high P/E values, for example how the standard deviation varies from 13,37% at the range of P/E 21-21,4, to 8,21% at a P/E of 21,5-21,9. This is likely due to the small amount of data we have available at these ratios. Overall, the data indicates that the hypothesis of an increased volatility of implied volatility as the P/E ratio increases can be rejected.

To increase the number of data available, I have grouped the observations into three larger ranges, as seen in the table below.

Range	Price/Earnings		
	$X < 17$	$17 \leq X < 20,5$	$X \geq 20,5$
Frequency	224	486	52
Tot. Obs.	475	1074	113
Percentage	47,16 %	45,25 %	46,02 %
$\sigma$ of VIX	11,59 %	9,86 %	9,56 %

Table 3.1.2, P/E ratio of the S&P 500

We now have more than 30 observations in each P/E interval, which is sufficient data to get decent statistical measurements, according to section 2.3. Using the aforementioned chapter and its formulas, we can state the statistical hypothesis of:

$$H_0: \sigma_A = \sigma_B$$

$$H_1: \sigma_A > \sigma_B$$

Where  $H_1$  indicates that the volatility of the implied volatility in the P/E interval that is within the mean reverted range for the VIX, is larger for the interval with P/E over 20,5(Interval A), than with the interval with a P/E less than 17(Interval B). As  $\bar{X}_A < \bar{X}_B$ , it would be mathematically meaningless to assume that one could prove that  $\mu_A$  is greater than  $\mu_B$ , based on the observations we have available. We will still test a two-sided hypothesis regarding the statistical significance of the data.

We apply an appropriate level of significance,  $\alpha = 0,05$ , with the corresponding  $z_{\alpha/2} = -1,96$ . This value stems from the normal probability table, and so

$$P \left( -z_{\alpha/2} < \frac{(\bar{X}_A - \bar{X}_B) - (\mu_A - \mu_B)}{\sqrt{\sigma_A^2/n_A + \sigma_B^2/n_B}} < z_{\alpha/2} \right) = 1 - \alpha$$

Or

$$P \left( -z_{\alpha/2} < Z < z_{\alpha/2} \right) = 1 - \alpha$$

Since we are testing  $H_0: \sigma_X = \sigma_Y, \rightarrow \mu_X = \mu_Y, \rightarrow$  resulting in  $\mu_X - \mu_Y = 0$

By using all applicable observations within respectively interval A and B, we calculate that  $\sigma_A = 9,25\%$  and  $\sigma_B = 11,63\%$ . One can now calculate the value of Z:

$$Z = \frac{(0,0956 - 0,1159) - 0}{\sqrt{0,0925^2/52 + 0,1163^2/224}} = -1,354$$

A Z-value of -1,354 is within the range of  $\pm z_{\alpha/2} (\pm 1,96)$ , meaning that there is insufficient evidence in the data to reject  $H_0$ . The result of the test of significance is that there is insufficient evidence to conclude that the volatility of (implied) volatility is significantly different between the P/E intervals.

*The test has been carried out properly, giving an answer that confirms what one would understand just by looking at the table on the previous page; one still cannot decisively conclude that  $\mu_A$  is greater than  $\mu_B$ , but there is no support in the data from the last 10 years. We can treat this as a two-tailed test when we look at how the statistic variables is spread around the hypothesis that  $\mu_A - \mu_B = 0$ , and the range of  $\pm z_{\alpha/2}$  is spread out evenly on both sides of  $\mu$ . So even if we were to switch the  $\bar{X}$  values, so that  $\bar{X}_A - \bar{X}_B = 0,0203$ , the Z-value would still be within the range of  $\pm z_{\alpha/2} (\pm 1,96)$ , making the data insufficient to conclude either way.*

**3.2 The dividend yield** is the annual rate of dividend payments for the index as a whole. When a company decides their dividend payment, they consider their cash flow and earnings, as well as assessing how secure the company is about the future. There are also legal requirements that a company must meet before dividends can be paid. So one can justify that a company's annual dividends gives an indication of how safe of an investment a company is, as it is founded in both the financial statements and the confidence of its board of directors. However, this is a better measurement for stocks in the individual companies, as several companies apply their own fixed dividend policy, and this must be taken into account. Some companies refuse to pay out dividends, as they are experiencing growth or they believe that the reinvestments of the company can create shareholder value better than the individual shareholder. Examples of such companies are Google(GOOG), Amazon.com(AMZN) and Berkshire Hathaway(BRK-B). Several companies also have pegged their dividend payout policy at either a percentage of the current stock price, or as a given percentage of the annual result. If a company were to announce that their dividend would be smaller than what the current dividend policy predicted, that company will often be punished by a substantial drop in stock prices, so a dividend cut is a controversial decision to make for a company's board of directors.

Of course, one could make the argument that by reviewing chart 3.2.1, one can see a jump in dividend yield of the S&P 500 too levels above 3% right before the bull market following the financial crisis. It is tempting to argue that if a dividend policy were to exceed 3%, this is a sign that the stock market is now historically cheap. This would be an oversimplification, and would fail to see the underlying panic in financial markets in late 2008. As assets across the line collapsed, no one could

envision what would happen to the global economy as the crisis developed. There was a very real fear that this could be the end of the global financial system as we know it, and to interpret the static unit of measurement, a dividend yield of 3%, as a buy signal could have led to an annihilation of most the stock portfolio.

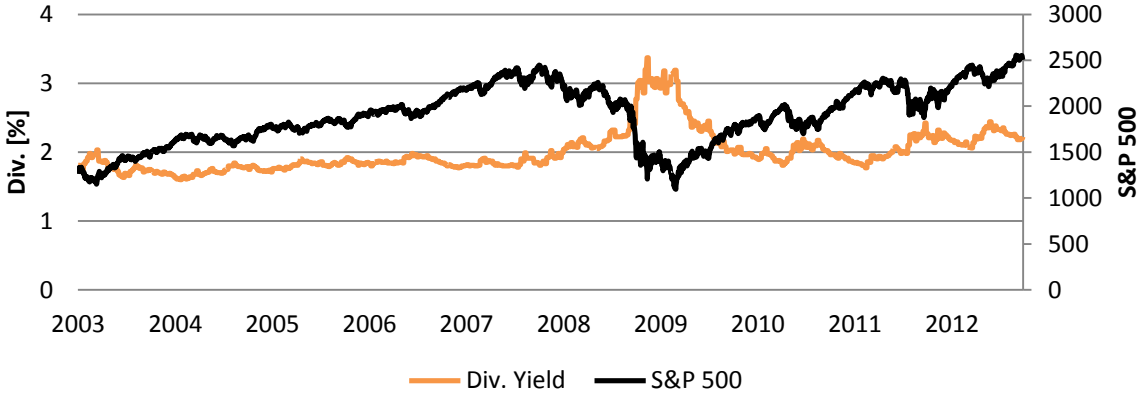


Chart 3.2.1, Dividend yield of the S&P 500

So the result of this subsection is that there is currently no indication of a real relationship between the volatility and the static ratio measurements of P/E and dividend yield.

**3.3 TED-spread**

The TED-spread is the price difference between three month futures contracts on Eurodollars and T-bills, contracts with identical time for expirations, and where the price spread is denoted in basis points. Eurodollars is the term used for dollar deposits in banks outside the US, meaning that the money is deposited out of reach of both the regulations and the potential aid of the Federal Reserve. As the TED grows, the risk of corporate default is considered to be increasing, as investors seek to the risk-free T-bills. TED is an acronym combining the ticker symbols for T-bills(T) and Eurodollar(ED) futures.

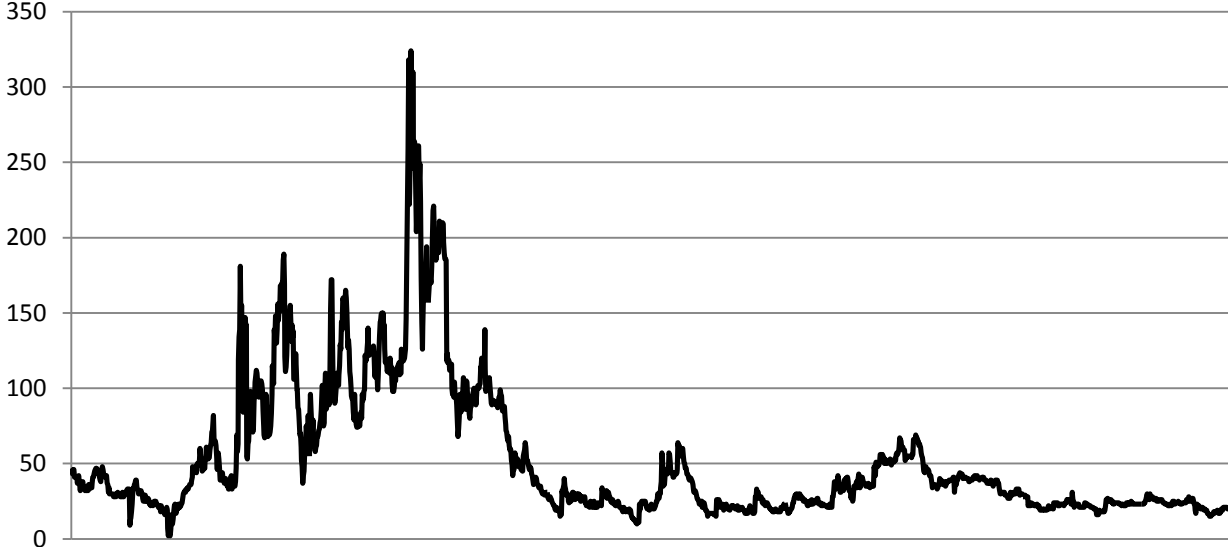


Chart 3.3.1, TED spread from 2006 to 2013



By using data from Reuters Datastream, we plot the TED-spread in graph 3.3.1 over the years it has been available. It is clear that the spread has been stable in an interval between 20 and 70 bps. for most of the time period, with the exception of late 2007 and the next two years, i.e. the financial crisis. Underneath, chart 3.3.2 shows the TED spread from august 2007 to august 2009, with some important monetary events marked in.

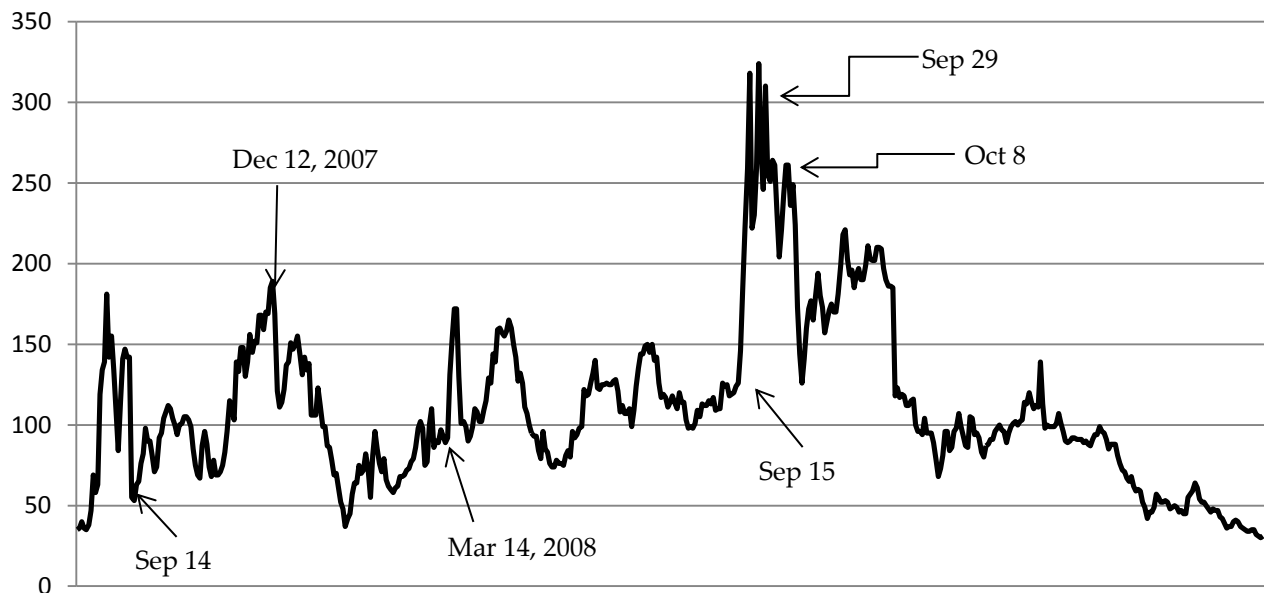


Chart 3.3.2, TED spread during the financial crisis, Aug 07 to Aug 09

- September 14, 2007: After the British bank Northern Rock experienced a run on the bank, Bank of England must intervene to avoid bankruptcy.
- December 12, 2007: The Federal Reserve, Bank of England and ECB announce liquidity swap-lines, which also included Canada and Switzerland, to provide up to \$24 billion of US dollars to the European banking system.
- March 14, 2008: The Federal Reserve puts up \$30 billion, so that Bear Sterns can be acquired by J.P. Morgan and avoids bankruptcy.
- September 15-16, 2008: Lehman Brothers files for bankruptcy, followed by AIG needing an \$85 billion emergency loan from the Federal Reserve.
- September 29, 2008: The aforementioned liquidity swap-lines are extended by \$330 billion, and also expanded to include the central banks of Australia, Denmark, Norway and Sweden.
- October 8, 2008: History's first ever globally coordinated action of monetary policy, as central banks of the United States, Eurozone, Great Britain, Canada, Sweden and Switzerland all announce that they will cut interest rates, with the intention of keeping them at a historically low level for the foreseeable future.

As one interprets chart 3.3.2, it is clear that that the TED spread increases when announcements are made that may be interpreted as negative by the market, and the

other way for positive announcements. The global financial markets are so closely intertwined that negative events occurring in the United States, as seen with the rescue of Bear Sterns and the Lehman bankruptcy, also leads to capital being relocated to the riskless treasury bills. The TED spread could therefore be a promising indicator of financial risk aversion for global markets, as even domestic uncertainty in the United States causes capital to flow into American banks.

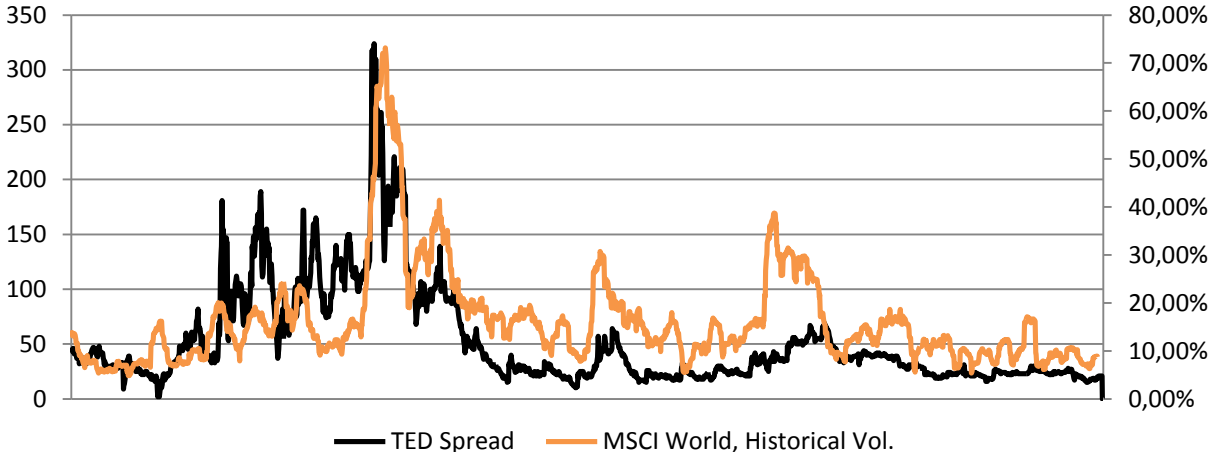


Chart 3.3.3, TED and the volatility of the MSCI World, Aug. 2006-2013

We can conclude that regardless of the source of the uncertainty, capital flows into United States and the reserve currency of the world. Note that an increased spread does not necessarily mean that the value of the Eurodollar futures are falling, but that the relative spread against the US Treasury bills are increasing, which could simply mean a surge in demand for risk-free securities denoted in \$US.

The MSCI World index is a broad equity index, well suited for representing the global equity markets, and the historical volatility of the index is plotted above. As expected, one can see spikes in the TED spread at times with great volatility. However, I was surprised with how low the correlation was, with a correlation coefficient as low as 0,629. I tried to shift the graph by a number of days, to see whether the TED could be an early indicator when available capital is shifted into risk-free US\$ assets. One then faces the issue that historical volatility is based on the past twenty-one trading days(1 calendar month), and the big impacts on the volatility values may be diluted across several days.

To avoid the dilution, I listed the daily changes of the MSCI World over the given period, and compared it with changes in the TED spread. I only considered days when the change exceeded a certain value, indicated by column 1 in table 3.3.1. The number of observations when the change exceeded the value in the “Δ TED” column is listed in the *n* column, and the last four columns indicate how many days the MSCI World has been offset. To interpret the table, in the “0 days” column you can see the average change in the MSCI World on days when the TED has increased by more than 10%. The “1 day” column shows the average change in the MSCI World the *day after* the current change of the TED, and the same principle for the 2- and 3-day columns. As one can interpret from table 3.3.1, my hypothesis regarding the

possibility that the TED may react earlier to uncertainty than the stock market can be disregarded, especially when using only daily data. If this was the case, the “day 1” column would show a relatively high, negative value for the days that the TED Spread reacts upwards. The average daily change for the MSCI World Index was 0,02%, with a standard deviation of 1,21%.

		Offset of MSCI World for x days			
$\Delta$ TED	n	0	1	2	3
10 %	154	-0,317 %	-0,044 %	0,055 %	-0,036 %
15 %	72	-0,251 %	0,236 %	0,114 %	-0,062 %
20 %	44	-0,240 %	0,194 %	-0,250 %	-0,302 %
25 %	26	-0,003 %	0,179 %	-0,206 %	-0,005 %

Table 3.3.1, TED and MSCI World with daily offset

However, when reversing the offset, calculating the average daily change for the MSCI World for “-1 days”, we find that the average daily change of the MSCI World equals -0,42% on the day before a spike in the TED Spread of 15% or more. This is higher than all the average daily changes in the table above, and may actually indicate the opposite of my hypothesis, that the stock markets reacts faster than the TED spread.

As further mentioned in section 4.5, financial data available through DataStream is unfortunately based on daily observations, showing the closing price of each day. Since markets around the world are open at different times due to the time difference, and the only changes we can register by this data is what has changed at any given time in the 24 hours between the closing of the market, it can be difficult to establish a response pattern between markets when regarding time periods less than 24 hours.

### 3.4 Moving Average

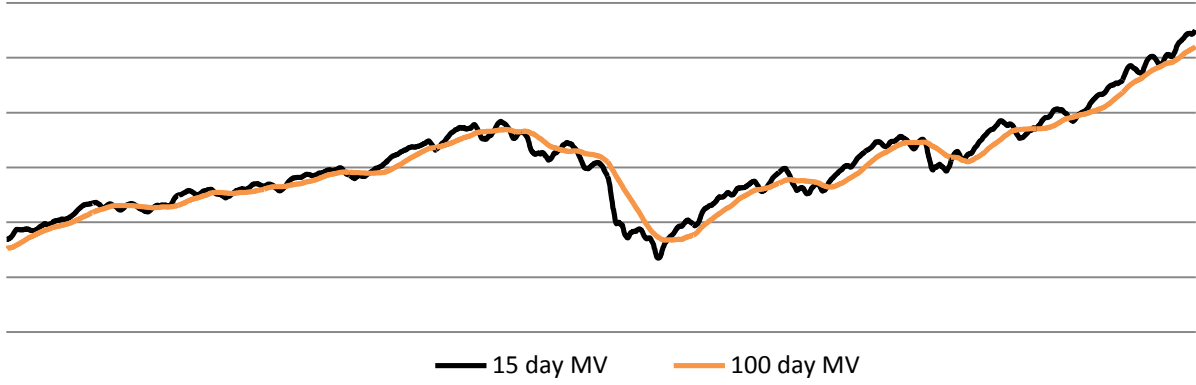


Chart 3.4.1, 15- and 100 day moving average of the S&P 500, 2003-2013

Moving Average is one of the most used tools in technical analysis, using average values over a given time period to “smooth” out the curves and cancelling out stochastic “noise”. The idea is to compare short- and long-term moving averages to determine the momentum of price movements. When the short-term average crosses

the long-term, this supposedly indicates a shift in the market momentum, and a further trend in that direction is indicated.

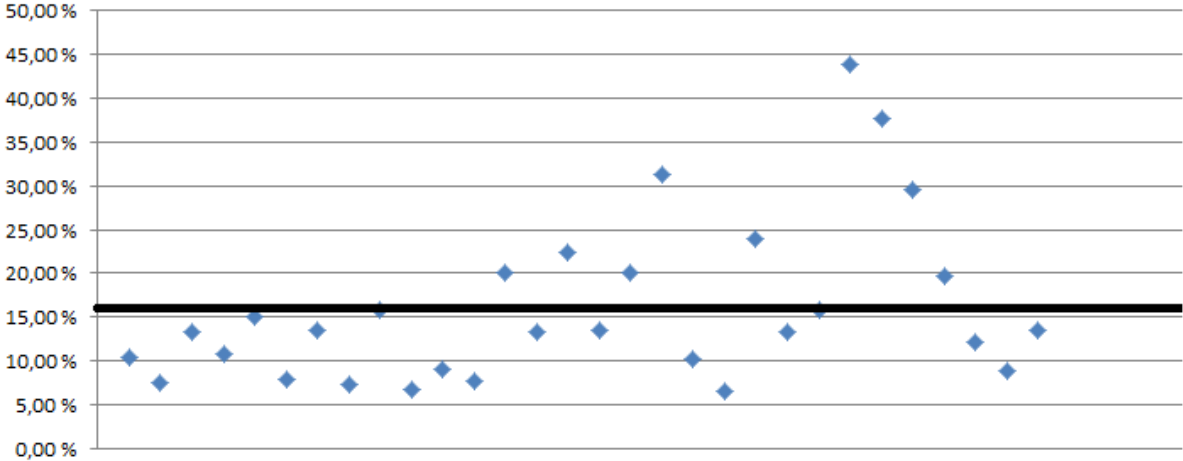


Chart 3.4.2, Volatility plots following momentum shifts

Above, I have plotted historical volatility of the S&P 500 over the 30 days following all “momentum shifts” over the last 10 years, as well as the average historical volatility of 15,26%. The plot shows no obvious correlation between momentum shifts and volatility, and only 9 out of 30 momentum shifts is followed by above-average volatility. Although four of the plots indicate a substantial jump in historical volatility, these are just 13% of all the momentum shifts, and it would be unwise to conclude that one could design a volatility adapting strategy based on these momentum shifts.

**3.5 DJ UBS - Dow Jones UBS Commodity Index**

The Dow Jones-UBS Commodity Index is composed of futures-contracts for a wide variety of commodities, and is meant to represent industrial activity in the form of demand for raw materials. The DJ UBS is included in this comparison to see if the long-term growth rate of the index and the stock market correlates, and that a bull-market may prove to be unwarranted if the industrial demand doesn’t follow.

One can make the argument that the commodity market are less affected by market psychology and future expectations, as financial contracts are based on the genuine supply and demand of the underlying commodity. Besides legal restrictions for manipulation of supply and demand, there are the costs and practicalities of storing large amounts of a commodity, as well as the time value of money. This limits the market participant’s ability to manipulate commodity prices for speculative gains.

When analyzing the relationship between the DJ UBS and the S&P 500, we look at the long-term trends and larger drops in stock market value. As the DJ UBS-index has only existed since 1991, the S&P 500 has only experienced two bear-markets during the lifetime of the DJ UBS. The first bear-market was the Internet Bubble of 2000 and 2001, where the market experienced extreme valuations at high multiples. The bull market was considered to be unfounded in economic variables, and the spread between the S&P 500 and the DJ UBS was substantial. Eventually, the companies had to report massive losses and non-existing sales, leading to the Nasdaq Composite

dropping 78%. Following the bear market, the indices converged again towards the financial crisis.

For the financial crisis of 2007-2008, the economy was booming as the stock market rose, and the DJ UBS-index saw a similar performance as the S&P 500. When the value of the S&P 500 decreased from the current all-time high of 1,576 in 2007, the DJ UBS kept increasing, before collapsing as the market panic spread. If we compare the two indices from 1991, they have always converged back to similar levels.

For present time, there is a clear difference in the index performance, similar to the Internet Bubble at the start of this millennium. This should not be considered a definite indication that we are experiencing an asset bubble, but may indicate that investors should become more risk-averse, if we are considering the historical relationship between the indices. If industrial activity and the demand for commodities are severely underperforming compared to the stock market, this may indicate a bull market that's not supported by the economic growth.

*What determines the price of a commodity? Both supply and demand plays an important part, and can affect the price in either direction. The cost of extracting commodities has generally risen over the past decades, as the recovery areas are located in harsher environments, with increasing costs of labor, machinery and rigs. The demand of the commodity is linked to the amount of the individual raw material used, which is usually linked to the state of the global economy.*

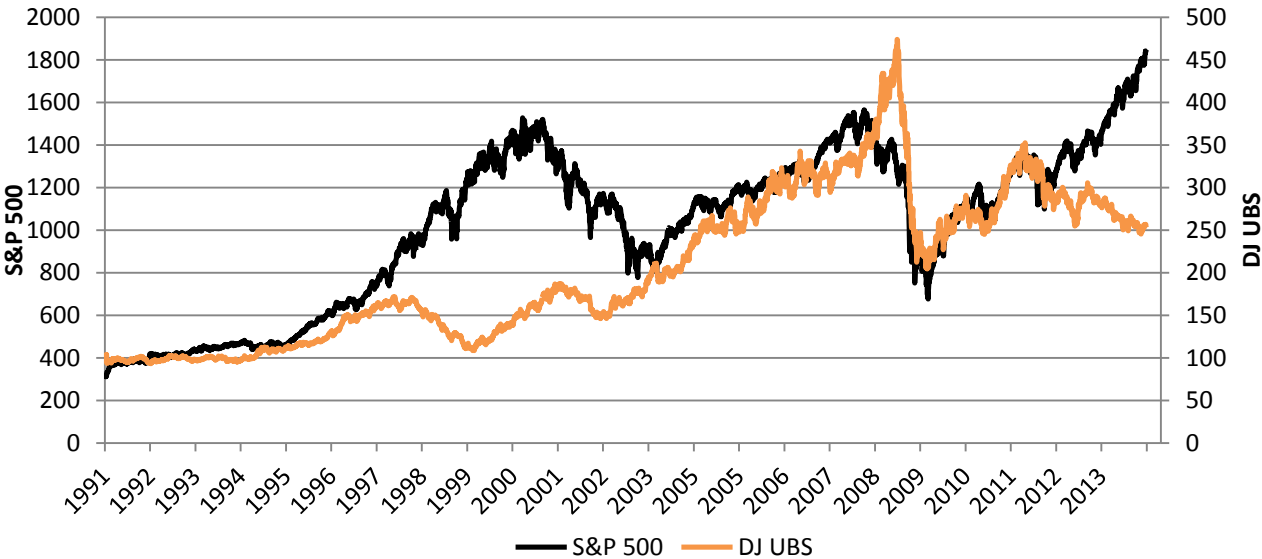


Chart 3.5.1, The performance of the S&P 500 and the DJ UBS

### 3.6 Price of Gold

Traditionally a safe-haven for an investor seeking to diversify their portfolios, as the demand of gold often increases as uncertainty reaches global financial markets. There are several other factors that affect the price of gold, as it is a tradable commodity on its own, and its price is not simply a reflection of market uncertainty, such as CDSs or the VIX. Still, it is worth looking into the relationship between the volatility of the stock market and the fluctuations in the price of gold.

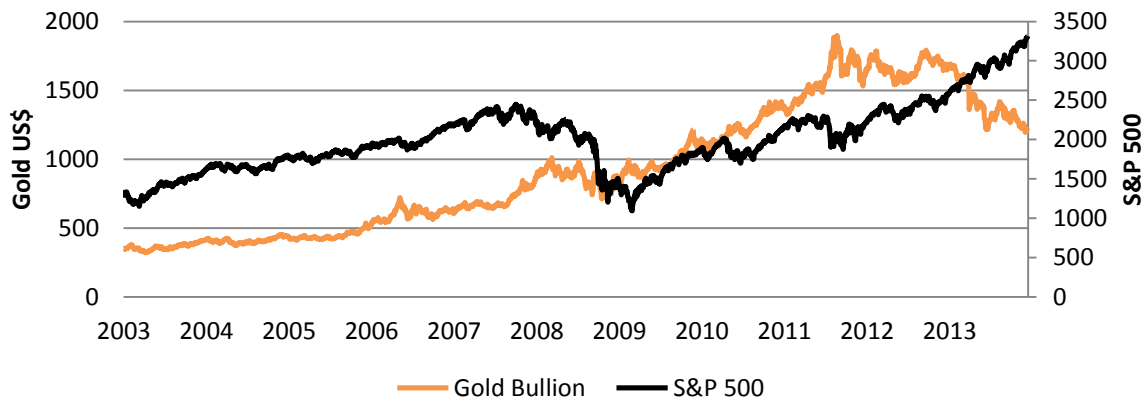


Chart 3.6.1, The price of Gold and the S&P 500, 2003-2013

When looking at the relationship between the price of gold and stock market volatility, my hypothesis is that if the implied volatility reaches a certain level, the price of gold may see a spike upwards, as investors seek to diversify their portfolio away from equities. I doubt that movements in gold prices can be an indication of an increased implied volatility, as investors will often try to sell off a portion of their equities prior to seeking diversification by commodities. This would also correspond to the result from the section of the TED spread, that equities are the first assets investors seek to sell when facing the fear of falling markets.

I listed the changes from day<sub>i</sub> to day<sub>i+3</sub> for both the price of Gold and the value of the VIX, and listed the table as the change for asset A when the change in asset B exceeds X percent for a single day. I excluded the rows with insufficient data ( $\leq 30$ ), as this would result in data with a substantial amount of statistical noise.

As gold changes X%, following daily changes in the VIX					
X% change	Day i	i+1	i+2	i+3	n
-3 %	1,55 %	-0,65 %	0,84 %	-0,46 %	55
-2 %	0,31 %	-1,01 %	0,11 %	0,05 %	146
-1 %	0,44 %	-0,58 %	-0,04 %	-0,07 %	386
1 %	0,10 %	-0,07 %	0,18 %	0,01 %	456
2 %	1,08 %	-0,55 %	0,50 %	-1,06 %	115
3 %	-0,37 %	-1,20 %	-0,14 %	-1,58 %	33

Table 3.6.1, value change for the VIX

As the VIX changes X%, following daily changes in the price of gold					
X% change	Day i	i+1	i+2	i+3	n
-15 %	-0,15 %	0,00 %	-0,41 %	-0,24 %	33
-10 %	-0,07 %	0,39 %	-0,16 %	-0,06 %	116
-5 %	-0,02 %	0,21 %	0,05 %	0,06 %	437
5 %	0,01 %	-0,15 %	0,02 %	0,05 %	426
10 %	-0,24 %	-0,17 %	-0,01 %	0,16 %	158
15 %	-0,18 %	-0,08 %	0,12 %	0,30 %	62
20 %	-0,26 %	-0,20 %	0,18 %	0,28 %	32

Table 3.6.2, Price change of gold

Mark that table 3.6.1 through 3.6.4 lists data for substantial alterations in both positive and negative direction.

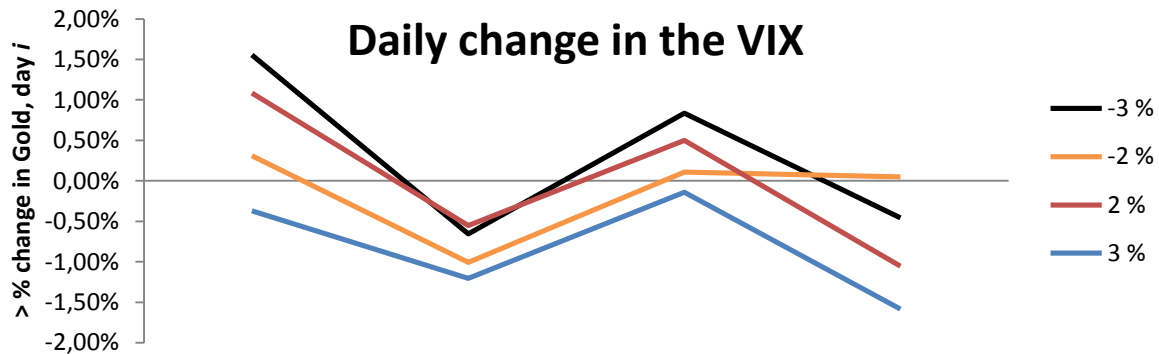


Chart 3.6.2, Daily change in the VIX

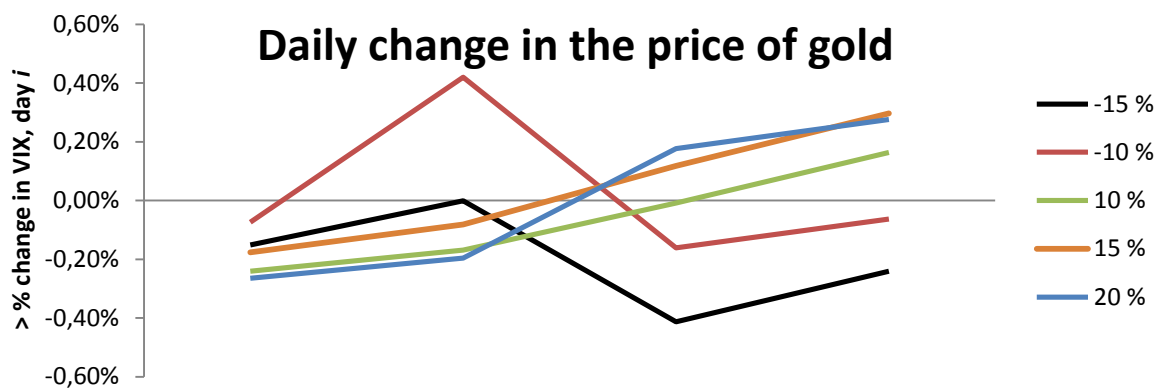


Chart 3.6.3, Daily change in the price of Gold

The average daily change for the price of gold( $\mu$ ) is 0,04% with a standard deviation( $\sigma$ ) of 1,26%, and the corresponding numbers for the VIX index is  $\mu = -0,01\%$  and  $\sigma = 6,60\%$ . At first glance, we can interpret that all changes in the tables are within the standard deviation of the current variable. Applying the Central Limit Theorem, we can create a test of a hypothesis, looking at the alterations in the value of gold or the VIX index, with regards to significant movements of the other asset.

Changes in the VIX in the days following significant movements for the price of gold:

$$H_0: \mu = -0,01\%$$

$$H_1: \mu \neq -0,01\%$$

Changes in the price of gold in the days following significant movements for the VIX:

$$H_0: \mu = 0,04\%$$

$$H_1: \mu \neq 0,04\%$$

$$P\left(-z_{\alpha/2} < \frac{\bar{X} - \mu}{\sigma/\sqrt{n}} < z_{\alpha/2}\right) = 1 - \alpha$$

$$P\left(\mu - z_{\alpha/2} \frac{\sigma}{\sqrt{n}} < \bar{x} < \mu + z_{\alpha/2} \frac{\sigma}{\sqrt{n}}\right) = 1 - \alpha$$

For a significance value of  $\alpha = 0,05$ ,  $z_{\alpha/2} = 1,96$ . Using the given expected value( $\mu$ ) and standard deviation( $\sigma$ ) from the previous page, we can calculate the noncritical regions for each row. The intervals for those regions are given in the tables below.

<b><math>\Delta VIX</math>, with regards to X% <math>\Delta Gold</math></b>			
<b>X% change</b>	<b>n</b>	<b><math>\mu \pm (1,96 * \sigma) / \sqrt{n}</math></b>	
-3,00 %	55	-1,73 %	< x < 1,73 %
-2,00 %	146	-1,06 %	< x < 1,06 %
-1,00 %	386	-0,65 %	< x < 0,65 %
1,00 %	456	-0,60 %	< x < 0,60 %
2,00 %	115	-1,20 %	< x < 1,20 %
3,00 %	33	-2,24 %	< x < 2,24 %

*Table 3.6.3, change in VIX with regards to Gold*

<b><math>\Delta Gold</math>, with regards to X% <math>\Delta VIX</math></b>			
<b>X% change</b>	<b>n</b>	<b><math>\mu \pm (1,96 * \sigma) / \sqrt{n}</math></b>	
-15,00 %	33	-0,71 %	< x < 0,71 %
-10,00 %	116	-0,40 %	< x < 0,40 %
-5,00 %	437	-0,22 %	< x < 0,22 %
5,00 %	426	-0,23 %	< x < 0,23 %
10,00 %	158	-0,35 %	< x < 0,35 %
15,00 %	62	-0,53 %	< x < 0,53 %
20,00 %	32	-0,72 %	< x < 0,72 %

*Table 3.6.4, change in Gold with regards to VIX*

Comparing the tables, we recognize that all the observational averages in table 3.6.1 and 3.6.2 are within the intervals in table 3.6.3 and 3.6.4. This means that when basing the statistical test on a 0,05 level of significance, we can conclude that the changes do not differ significantly from the  $\mu$ .

### 3.7 Review of chapter 3

Through chapter 3, the economic ratios and financial data was either found to be unsuitable, or no obvious relationship was found that supported the notion that it could be used as an indicator of future changes in volatility levels. However, section 3.5 looked at the relationship between commodity prices(DJ UBS) and stock prices, and found a potential indicator of an overvalued equity market. During the life-span of the DJ UBS, there has been three periods where its movements has differed substantially from the S&P 500; we are currently experiencing one of these periods now, and the other two was during the Internet bubble of 2000-2001 and the financial crisis of 07-08. For later research, it would be interesting to see how these indices will develop over the next 10 years.



# Chapter 4: Methods, Modeling and Analysis

## 4.1 Data sources:

As a student of the University of Stavanger, one has access to Reuters Datastream 5.1 through the University Library. Datastream offers daily closing values on stocks, bonds and commodities across the world, and indices on a wide variety of securities and assets across most markets. It also offers key economic data, as well as exchange rates and interest rates. Combined, this gives the students the opportunity to use both bottom-up and top-down approaches to analyze economic trends and relationships all over the world.

## 4.2 Modeling geographical correlations:

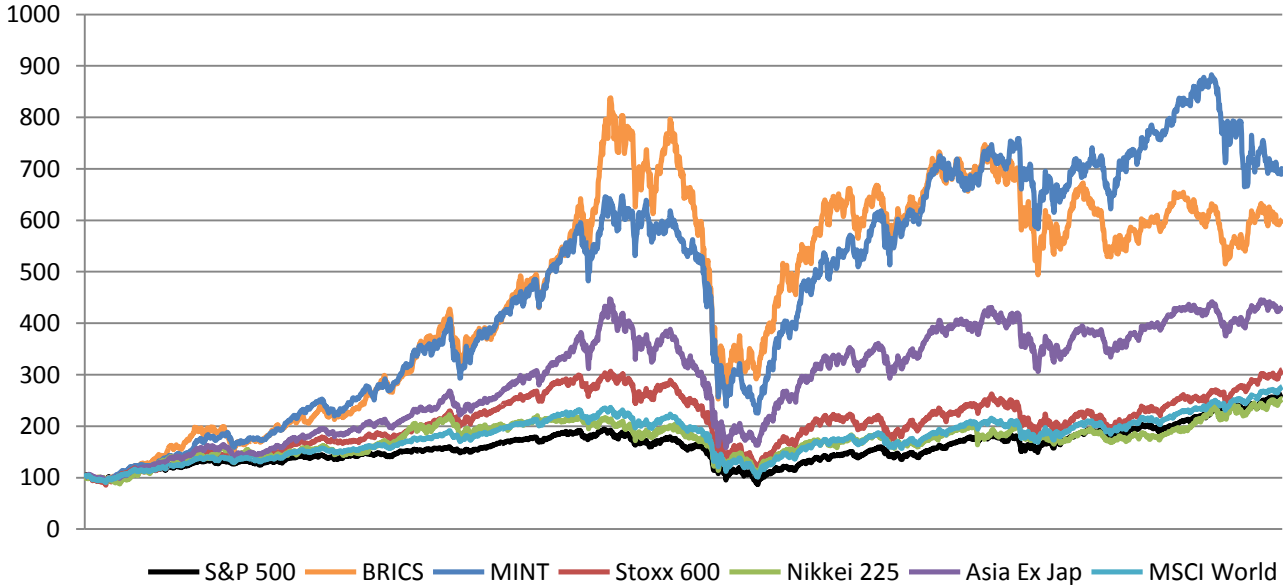


Chart 4.2.1, Geographical entities and the MSCI World, 2003-2013. Source: Reuters Datastream 5,1

	S&P 500	BRICS	MINT	Stoxx 600	Nikkei 225	Asia Ex Jap	MSCI World
S&P 500	1	0,982	0,823	0,859	0,888	0,837	0,963
BRICS	0,982	1	0,855	0,830	0,699	0,955	0,793
MINT	0,823	0,855	1	0,800	0,742	0,981	0,859
Stoxx 600	0,859	0,830	0,800	1	0,926	0,874	0,963
Nikkei 225	0,888	0,699	0,742	0,926	1	0,799	0,945
Asia Ex Jap	0,837	0,955	0,981	0,874	0,799	1	0,902
MSCI World	0,963	0,793	0,859	0,963	0,945	0,902	1

Table 4.2.1, Correlation between geographical entities. Source: Reuters Datastream 5,1

Global financial markets are closely intertwined, and an increased globalization has made the economies of the world dependent on one another. Some smaller countries may face currency effects or political instability, and the following market uncertainty may be contained to that specific country or region. On the other hand, some economies are so vital to the global economic growth, that negative indicators

may affect markets worldwide, causing downturns across continents and asset classes.

Calculating the long-term correlation between geographical entities is easy enough, and is presented in the table above. One should also regard the correlation between the volatility of the entities, as well as look into how the volatility correlates when subjected to a market altering event. I have selected several such events over the last 11 years, and will test how some of the most closely related markets move, as well as the global stock market, bonds and gold.

	S&P 500	BRICS	MINT	STOXX 600	Nikkei 225	Asia ex Jap	MSCI World
S&P 500	1	0,862	0,800	0,916	0,721	0,891	0,977
BRICS	0,862	1	0,913	0,857	0,741	0,952	0,874
MINT	0,800	0,913	1	0,827	0,690	0,890	0,828
STOXX 600	0,916	0,857	0,827	1	0,685	0,909	0,967
Nikkei 225	0,721	0,741	0,690	0,685	1	0,745	0,730
Asia ex Jap	0,891	0,952	0,890	0,909	0,745	1	0,912
MSCI World	0,977	0,874	0,828	0,967	0,730	0,912	1

Table 4.2.2, Correlation between volatilities of the different markets. Source: Reuters Datastream 5,1

### 4.3 The characteristics of Market Capitalization segments for U.S. Stocks

It is clear that some companies are considered safer than others, while the prospect of high return and growth opportunities can draw investors towards smaller companies with higher debt ratios and lower cash flows. For the U.S. stock market, this segmentation can be analyzed by the indices Dow Jones Industrial Average(DJIA), the S&P 500 and the S&P 600 Small-Cap Index(more information on these in section 2.5.1).

Table 3.2.1. lists the *beta*( $\beta$ ) for the days the S&P rose more than 1,25%(equal to  $1\sigma$ ), while days with a corresponding fall is used for table 3.2.2. This is used to measure how the stock indices moved as the general U.S. stock market(S&P500) experienced above-average movements in either direction. The tables gave fairly similar data, as the beta-values showed a higher sensitivity for the S&P 600 than the DJIA. It seems as if the indices can be interpreted as high- and low-beta stocks, as the movements of the indices seem fairly proportional to each other, regarding both positive and negative days. Both blue-chip and small-cap stocks follows the S&P 500 with varying magnitudes, as they follow the market trends with varying sensitivity. This is supported by the S&P 500 having a correlation coefficient of 0,983 and 0,981, respectively with the DJIA and the S&P 600.

Positive days		
Data compared to the S&P 500, for days when the S&P 500 rose more than its standard deviation(1,25%).		
	DJIA	S&P 600
Correlation	97,66 %	86,97 %
$\beta$	0,92	1,15

Table 4.3.1, MCap Segmentation for positive days

Negative days		
Data compared to the S&P 500, for days when the S&P 500 fell more than its standard deviation(1,25%).		
	DJIA	S&P 600
<b>Correlation</b>	97,51 %	87,63 %
<b><math>\beta</math></b>	0,90	1,14

Table 4.3.2, MCap Segmentation for negative days

When regarding the performance over the past eleven years, the difference between the S&P 500 and the DJIA is insignificant. However, the S&P 600 has returned a significantly higher percentage, while at the same time experiencing a higher volatility. This is as expected, as the increased risk causes investors to demand a risk premium. The risk attributed to the individual company in the index can be diversified away, and as the index is comprised of 600 different stocks, much of the additional risk exposure from the small-cap segment can be attributed to the additional sensitivity to market altering events and economic downturns.

Data over the last 11 years(2003-2013)			
	S&P500	DJIA	S&P600
<b>Average historical volatility:</b>	16,37%	15,16%	21,08%
<b>Annualized return:</b>	4,54%	4,53%	9,88%

Table 4.3.3, Performance data for MCap Segments

The DJIA and the S&P 500 has relatively similar performance data over the past eleven years, especially compared to the S&P 600 Small-Cap Index. A good explanation for this could be that even though the stocks included in the DJIA are considered safe “blue-chip” stocks, the S&P 500 still only includes mature companies of a certain size, and used index weighting to dilute the significance of smaller companies in the index. For example the Meredith Corporation(MDP:US), which has a current MCap. of \$1,95bn. only accounts for 0,0114% of the index. On the other side, Exxon Mobile Corp(XOM:US) is currently worth \$437bn, and accounts for 3,117% of the index, the biggest component of the S&P 500.

The source of the data here is Bloomberg.com for May 1<sup>st</sup>, so weighting data for XOM will differ from those given in table 2.5.1.

In section 4.8.1, we look closer at their performance during the financial crisis of 2007-2008(tables in appendix A), a performance we found to be proportional and linear throughout the crisis. Looking at charts 4.3.1 and 4.3.2, the index performances are illustrated. The general relationship between the indices is repeated during the financial crisis, with a correlation coefficient of 99,75% and 97,91%, respectively, for the DJIA and the S&P 600.

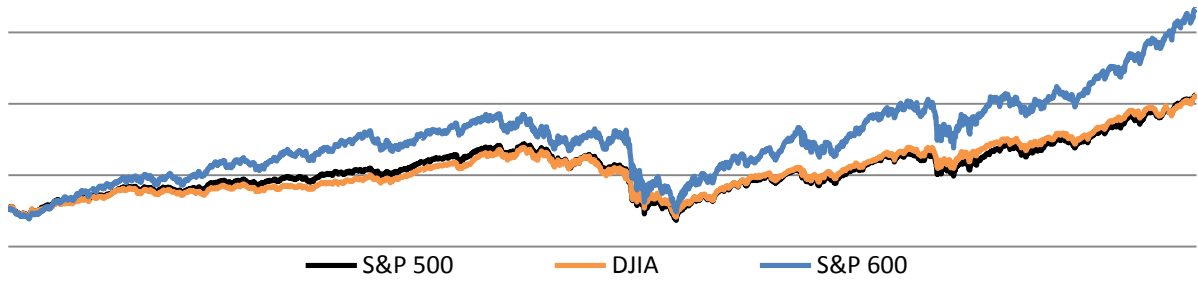


Chart 4.3.1, Index performance from 2003 to 2013

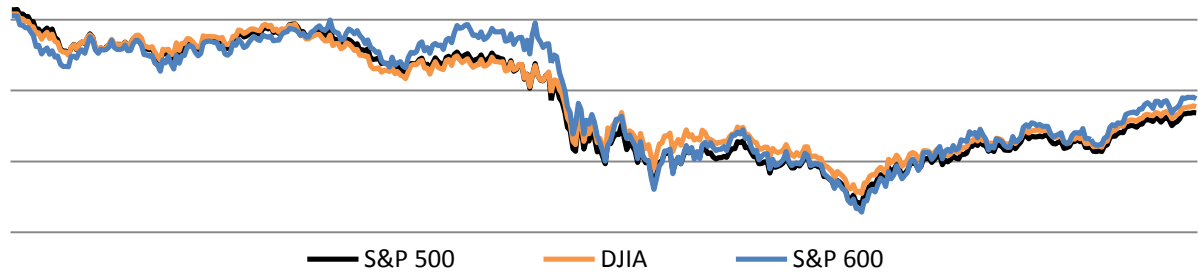


Chart 4.3.2, Index performance during the financial crisis of 2007-2008

Currently, several journalists and analysts are claiming that the small-cap segment of the stock market is overvalued (Light 2014), with the Price/Sales ratio at an all-time high and an annual gain of 41,3% in 2013. The spread relative to the S&P 500 is also historically high, which based on historical data would support the claim of overvaluation.

Because of the close correlation between the indices, as well as no obvious difference in what would count as a market altering occurrence, I have chosen to omit the capitalization segments from the portfolio calculations at the end of this thesis. This is justified in the data observations for the different market altering events, as all three indices experience similar fluctuations, with slightly different magnitude.

#### 4.4 The development of EM volatility

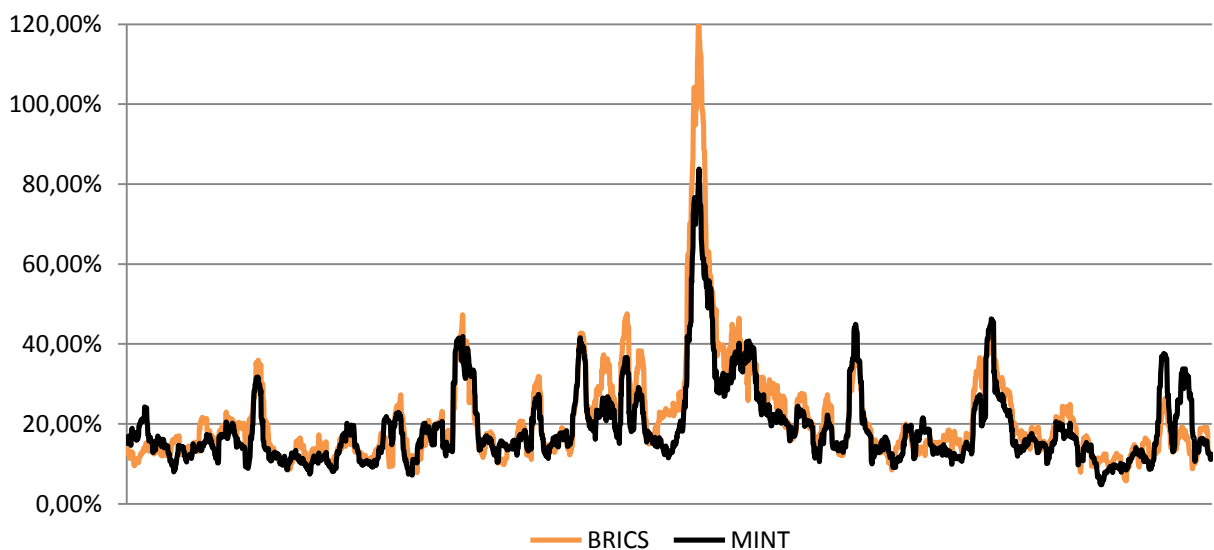


Chart 4.4.1, BRICS and MINT, historical volatility 2003-2013

As nations and their financial markets becomes more developed, it is natural to assume that the market risk, and thereby the mean reverted level of volatility for the stock market decreases. As the markets develops, more long-term investors will enter the market, and future index movements becomes less volatile and more predictable, compared to those markets that are underdeveloped.

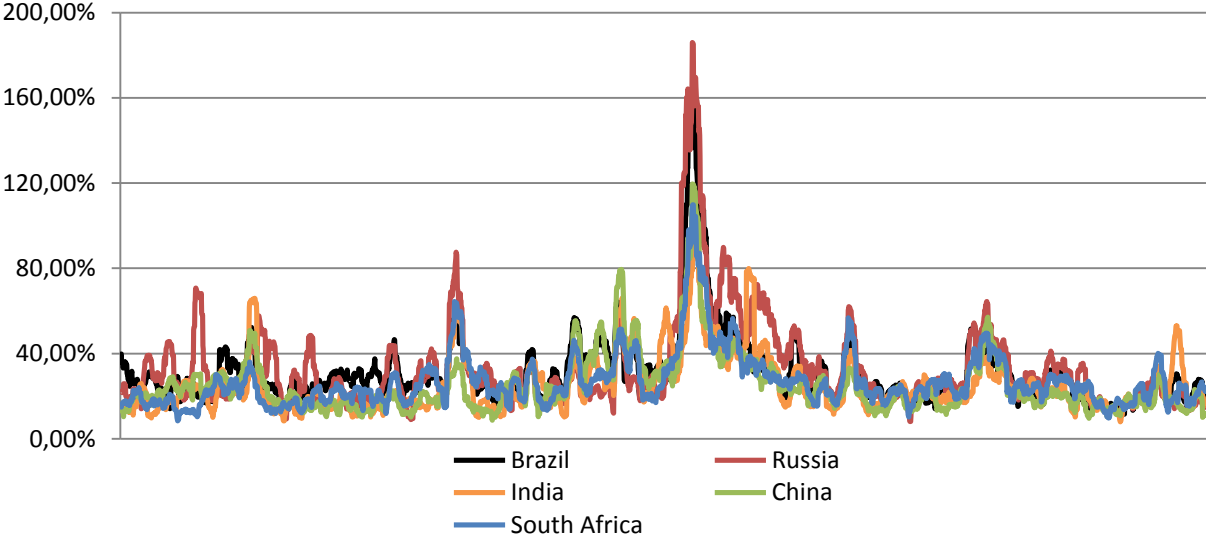


Chart 4.4.2, BRICS, historical volatility 2003-2013

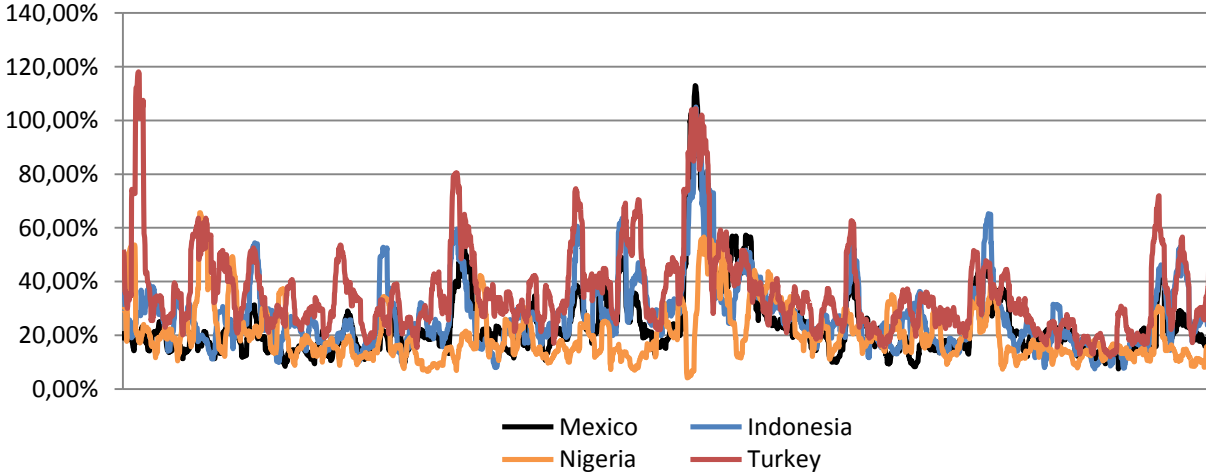


Chart 4.4.3, MINT, historical volatility 2003-2013

From the graphs above, there is no obvious trend in the observations indicating a decreasing level for mean-reversion. A reasonable explanation for this may be that the countries included in the BRICS and MINT index did not develop as many expected, as especially the BRICS-countries failed to address several of the structural challenges that the country faced at the beginning of the millennium. So based on data for the last 11 years, there is no obvious change in the volatility levels.

**4.5 An issue regarding daily data**

During the opening hours of a financial market place, the value of the securities traded there can be considered as a continuous variable, as any trade can potentially alter the price of an asset in a fraction of a second. To properly analyze the reaction

pattern across markets, one would ideally use continuous data over each trading day. However, this would require an extreme amount of data, and we must base our results on the daily data that Datastream has made available, which will effectively make the data discrete variables.

A different problem is the regional time differences, which causes different opening hours across markets. This is important to include when analyzing the reaction patterns across markets, as an incident occurring in the afternoon in the United States will only move Asian and European markets the following day. One must therefore take into account the time at which the incident occurs when investigating the reaction in other markets.

*To further complicate things, the United States passed the Energy Policy Act in 2005, which extended their daylight savings time, leading to DST lasting four to five weeks longer in the United States than in the rest of the world, altering their openings hours relative to other markets. However, we will assume that this does not change the procedure mentioned above, as the displacement would only be for one hour during those 4 weeks every year.*

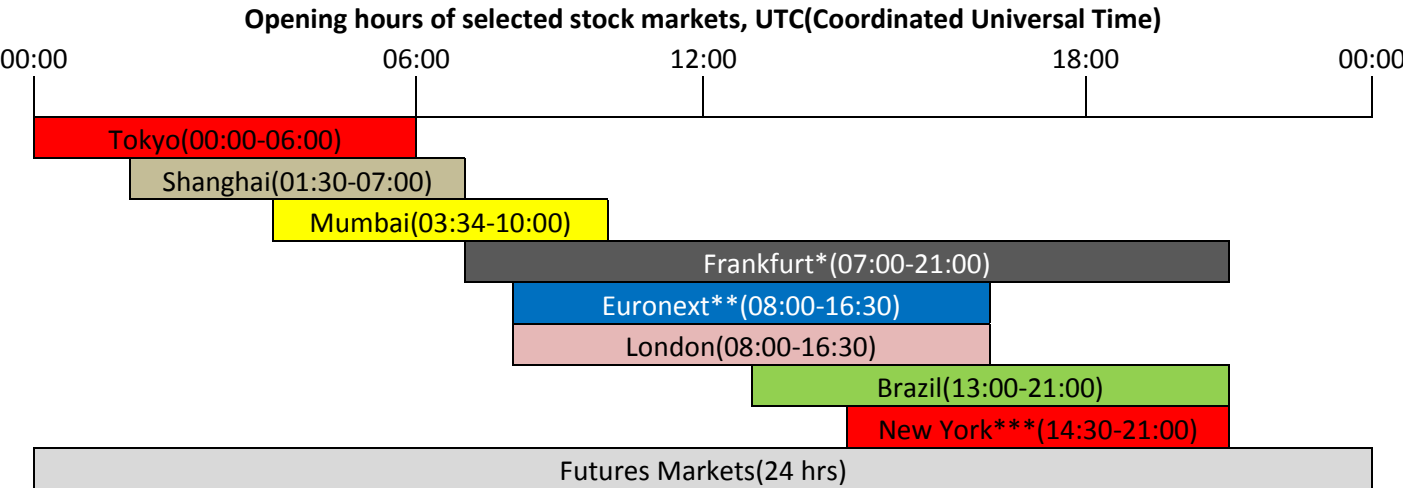


Chart 4.5.1, Opening hours of stock markets  
 \*After 19:00, Xetra-system and trading floor is closed, Eurex is open.  
 \*\*Euronext, located in Amsterdam and including the French, Dutch, Belgian and Portuguese stock market  
 \*\*\*NYSE and NASDAQ

Another issue when analyzing daily index data is reviewing exactly what could be altering the market on any given day. As the values of stocks are sensitive to all sorts of data, one cannot interpret the effect one index has on another analogous. To review what may affect the global stock market on the days reviewed in this chapter, the daily summary from *CNN Money; Markets & Stocks* has been analyzed to review statements and rumors that may affect financial markets.

**4.6 Criteria for an event to be selected**

The background for selecting the events is that they may lead to a sudden spike in volatility, as the newly discovered uncertainty reaches the market participants

around the world. Some of the biggest events of the last decade are included in this list, although the reader may find some seemingly important events left out:

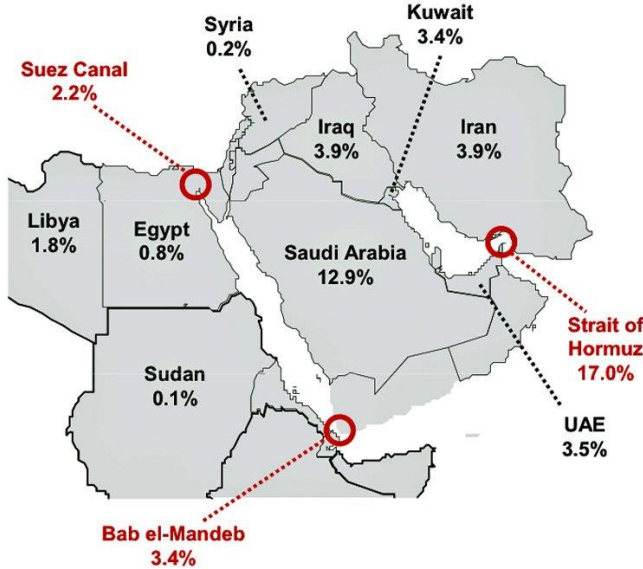
- Some types of situations may be of the type where the seriousness would escalate over time and have no clear point in time( $t_0$ ) where the event could be classified as market altering. Pandemics are an example of such incidents, and over the last 10 years the world has been through SARS, the Avian flu and the Swine flu. The fear of a worldwide pandemic is more than enough to cause uncertainty in financial markets, but the volatility is more likely to spread alongside the development of the viruses, both in seriousness and in global outreach.
- Some incidents could be categorized as only affecting financial markets of less global importance. For example the 2003 Bam earthquake in south east Iran, causing more than 26 000 casualties, and laying entire villages in ruins. Iran has a fairly isolated economy, and I did not consider this event to have a big impact on global markets. A similar event left out of the thesis was the assassination of the Serbian prime minister, Zoran Đinđić, on March 12<sup>th</sup>, 2003.
- If a market altering event could be expected, the market participants would adapt to it, and volatility would increase as uncertainty arose when the incident approaches. Such events could be the appointments of central bank presidents, or the United States presidential elections of 2004, 2008 and 2012.
- Some events were caused by accidental market alterations or illicit behavior, where the losses were recovered within a short time period. The 2010 DJIA Flash Crash, and the “Obama is Dead” Tweet(Fox News Twitter feed was hacked, and announced that President Obama had been assassinated) are examples of such sharp market declines that were recovered within minutes, and will therefore not have an impact on the historical dataset.

#### **4.7 Why is the Middle East so important?**

Financial markets in the Middle East are still considered miniscule compared to global standards. The amount of capital being allocated to investments in the Middle East is still limited, and the risk premium demanded by investors is still high. But when it comes to global energy security, the Middle East stands for a substantial proportion of the world’s supply of petroleum, and unrests and conflicts has a major influence on the world’s energy prices. The access to affordable energy is an important factor for economic growth, and developments that might threaten the supply of oil & gas also has the ability to hurt economic growth.

**Middle East Energy Production & Chokepoints**

Percent of global liquid fuel production, 2012\*



Major Producers		Major Consumers	
Percent of global total, 2012		Percent of global total, 2012	
Saudi Arabia	13%	China	5%
United States	12%	United States	21%
Russia	12%	India	4%
		China	11%
		Saudi Arabia	3%
		Japan	5%
		Brazil	3%

Source: JP Morgan Funds, 'Q2 Guide to the Markets'

Middle East, but MSCI offers national indices for Egypt, Israel, Lebanon, Tunisia and Qatar, as well as more regional indices in the *MSCI Jordan, Egypt & Morocco-index*, and the *MSCI GCC*. GCC is an acronym for the *Gulf Cooperation Council*, an economic union of Arab states surrounding the Persian Gulf. Countries included in the GCC are Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the UAB.

Several terrorist organizations have established themselves in the region, and are supported by local governments and parts of the population (Iran, Lebanon, Somalia, Gaza Strip). Anti-Western attitudes and religious differences contribute to tensions, both domestic and across borders. Even miniscule events may trigger a chain reaction, leading to revolutions or military interference by western forces.

This is why middle-eastern financial data is included for some of the incidents below, to see how the market uncertainty in the region correlates with those of more developed nations. There is a limited amount of data available

for several of the markets in the

**4.8 Global/Regional market altering events**

**4.8.1 The 2007-2008 Financial Crisis**

From 1997 to 2006, the American housing market saw a significant price increase, far beyond the increase in average household income. Low interest rates and easy access to financing, with little or no requirement for collateral, helped fuel the market even further, while Wall Street upheld an unstoppable appetite for CDOs. As the growth of the housing market started to cool down, several subprime lenders filed for bankruptcy, which led to a freeze in the liquidity of housing assets. The lack of liquidity made valuation harder as there was no fair market value, and concerns were raised regarding the reserves of banks and financial institutions. The interbank market saw a complete stop, largely due to uncertainty regarding each other's solvency.



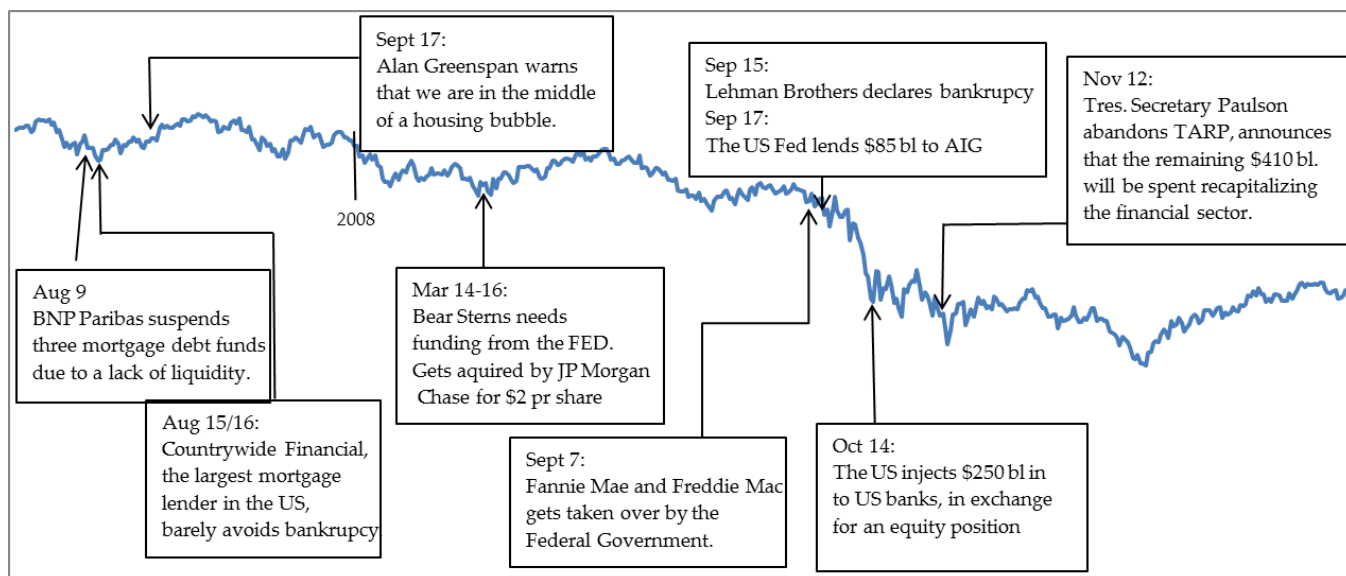


Chart 4.8.1, S&P 500 during the financial crisis of 2008-2008

A liquidity crisis quickly started to turn into a solvency crisis, and as the confidence in the financial system started to disappear, the world was faced with economic contraction and a market sell-off. Even the money market experienced vast amount of capital being extracted, causing the price of the money market assets to drop, and money market funds had to declare that they were no longer able to pay face value on deposits (*breaking the buck*). This again caused a run on money market funds, which triggered a vicious cycle when the value of commercial papers dropped even further as they were sold off to free up capital for investors. Had it not been for Bernanke and the Federal Reserve stepping in as market-maker for the assets on September 22<sup>nd</sup>, 2008 with the AMLF (Irwin 2013a), businesses all over the world would have had trouble funding their day-to-day operations.

*The money market is a means for short-term borrowing and lending (Irwin 2013b) and is often used to place money for a shorter period, or lending to fund operational expenses. The market consists of financial instruments with high liquidity and short maturities, and is considered a safe place to invest. As it traditionally has a slightly greater return than bank deposits, normal people often use it as a means for savings.*

*The AMLF was one of several programs initiated by the Federal Reserve during the fall of 2008. It is an acronym for “Asset Backed Commercial Paper Money Market Mutual Fund Liquidity Facility”, where the Fed was to channel liquidity into the money markets while avoiding the legal restrictions of intervening in financial markets (Irwin 2013a). The Federal Reserve Bank of Boston would lend capital to banks in the United States, designated for buying securities in the money market. The banks could then pledge them to the Federal Reserve to remove the banks risk exposure.*

*TARP is an acronym for ‘Troubled Asset Relief Program’ (Irwin 2013c), and is actually a group of programs, designed to give the US Treasury the power to buy \$700 billion worth of illiquid mortgage-backed securities, to attempt to restore liquidity for money markets and key institutions.*

Central banks of the world joined into an unprecedented, coordinated action to provide liquidity support to banks and financial institutions, but the global economy still experienced a decline in international trade, a surge in unemployment rates and a tightening in the credit markets.

From the data listed in appendix A, we recognize that stock indices across the world fell around 50%, and geographical diversification would have had little or no effect. This confirms the data from the correlation matrix (table 4.2.1), as global markets “followed” the stock market of the United States downwards. When one studies the table displaying the data for the various asset classes, we see that a diversification through varying asset classes would actually reduce the portfolio volatility substantially.

The Dow Jones Industrial Average saw less of a decline than the S&P 600, as mature companies with healthy finances were preferred over smaller companies with limited cash flows. Not surprisingly, both T-bills and Gold increased in value during the financial crisis, especially gold as demand spiked when investors sought after non-financial assets. We also saw that high yield-bonds decreased substantially in value, as the credit risk was considered to grow significantly during the crisis.

What is more surprising is the increase in the value of both Global Government bonds and Investment Grade corporate bonds, especially when considering the increase in \$US affecting foreign sovereign bonds. Note that some of this increase may be due to a drop in interest rates, which would increase the value of bonds. However, this will still help with the diversification of the portfolio, as a negative economic outlook is likely to decrease both interest rates and the value of stocks.

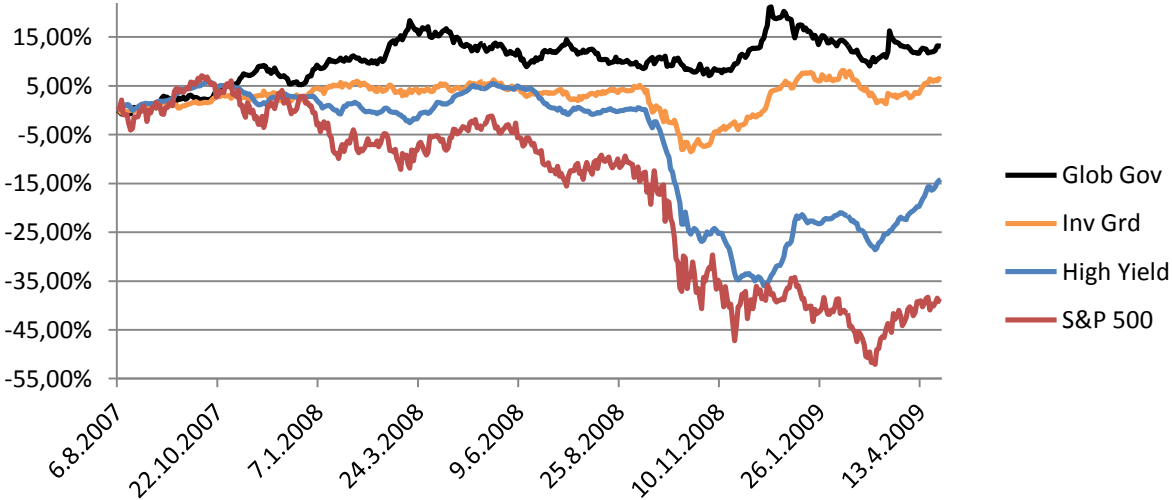


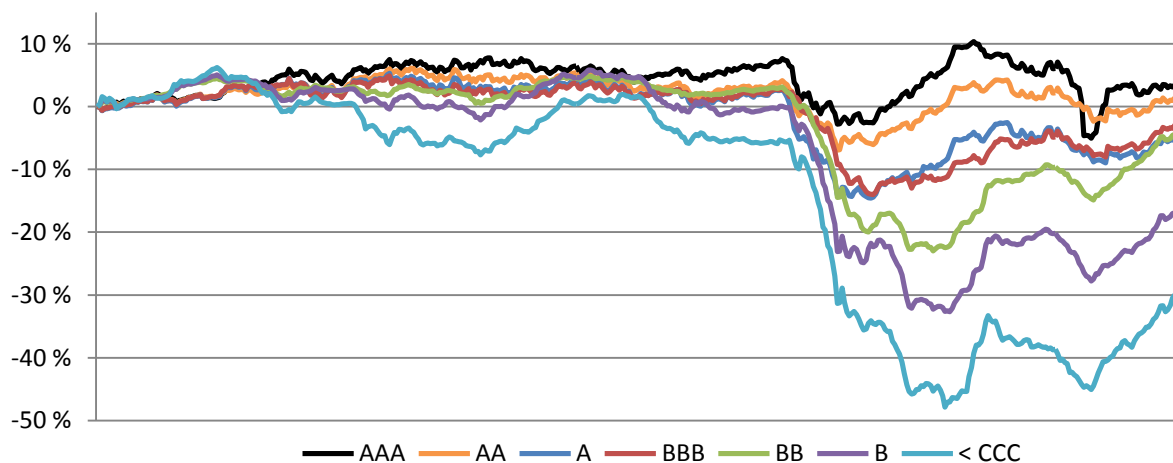
Chart 4.8.2, The performance of bond indices during the financial crisis.

A relevant question regarding today’s investment environment, is if an economic downturn would actually cause interest rates to decrease. The ECB has a current deposit facility rate of 0,0%, and the Federal Reserve’s effective Federal Funds rate is at 0,09%, giving little or no room for decreasing rates. This, combined with the increased interest rate risk affiliated with

*the projected increasing interest rate, may indicate that investors should reduce their exposure to fixed income-securities, compared to historical allocation.*

As the yield on fixed-income securities varies substantially depending on the credit rating of the bond, we should also look into how the performance differs for the different credit ratings within both rating segments of bonds.

From chart 4.8.2, we see that the real decline in the value of corporate bonds does not happen until the time around the Lehman bankruptcy. Even as the S&P 500 saw a 15% decline, corporate bonds were trading fairly flat from the day BNP Paribas made their announcement. However, as credit tightened and the money market dried up, corporate bonds, and especially those rated below investment grade, saw a sharp decline, causing the Barclays U.S. Corporate High-Yield index to drop 35% from its pre-crisis level. From chart 4.8.3, one can conclude that the decline in values followed the credit ratings, and especially for those rated below investment grade the decrease in value became severely steeper from rating class to rating class.



*Chart 4.8.3, The performance for bonds of different ratings during the financial crisis.*

It was remarkable how quickly the value of those bonds rated at BB or higher started to coincide as the recovery started, and a more speculative investor may find several investment opportunities in a similar high-volatility environment. However, this thesis will still limit its focus to the relationship between investment- and non-investment-grade, and the performance characteristics of different rating grades may be a topic for a later thesis.

*Note that as these are fixed-income total return-indices, they should ideally see a slight increase every month as the holder of a bond receives monthly coupon payments.*

In chart 4.8.4, I have plotted the VIX index against the high yield bond index, to see whether their fluctuations occurred around the same time.

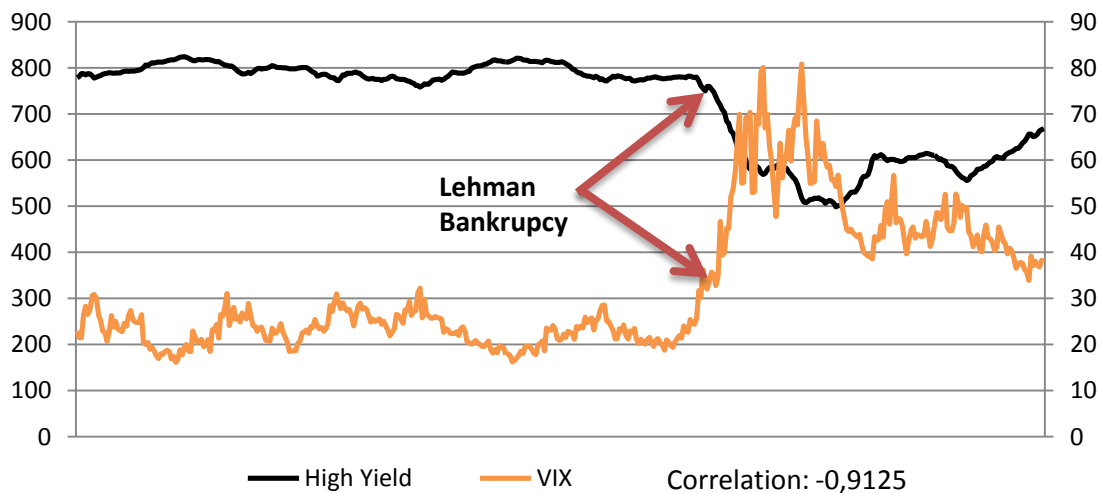


Chart 4.8.4, *The relationship between the VIX index and high yield bonds.*

It is interesting to see the close relationship between the two indices, with an almost perfect negative correlation. As the crisis develops, both indices are valued in a relative narrow interval, but the prices of high yield bonds collapsed as the market uncertainty spiked. It would seem as if one could in this case interpret the market uncertainty as a binary measurement, where high yield bonds are experiencing fairly stable prices until the uncertainty reaches a level where systemic risk causes a fair of an overall increased credit risk. This would also explain why investment grade corporate bonds are experiencing a decline in the same time period, but their prices are substantially more stable. From this, it would be tempting to conclude that taking a long position in the VIX index(VXX) would be a great way to hedge a portfolio against a decline in the value of high yield bonds. However, as stated in section 2.5.9, investing in the VIX index is not a long-term option for an investor, and we must see whether Gold is a better asset to offset the portfolio volatility. The correlation coefficient between the prices of Gold and High Yield-bonds was found to be -0,05, and there was no obvious opportunity to use Gold to offset the drop in bond prices. The risk-free US Treasury bills experienced low volatility and stable prices even during the worst parts of the prices, and may be a good investment combined with high yield-bonds to reduce portfolio volatility. However, the low yield will often cause investors to avoid a large long-term exposure to Treasury Bills.

In the section about the Eurozone crisis, we compared the performance of different bond indices as the debt crisis developed, and found a stronger relationship within the high yield-segment than in the investment grade segment. By plotting those indices during the financial crisis as well, we see that European investment grade bonds are hurt very little by the crisis, and that its value actually increases after the Lehman Brothers-bankruptcy. The performances of all indices are fairly similar, until the sell-off begins in mid-September. It seems as if investors are seeking to safer investments, and that European investment grade bonds becomes an increasingly attractive investment as the crisis unfolds. However, the opposite happens to European high yield-bonds, as they drop almost 40% in value as investors seek to

reduce their risk exposure. The fear of systemic risk and global solvency issues caused investors to sell off their riskier fixed income-assets, even though their exposure to the crisis itself and the U.S. housing market may be limited.

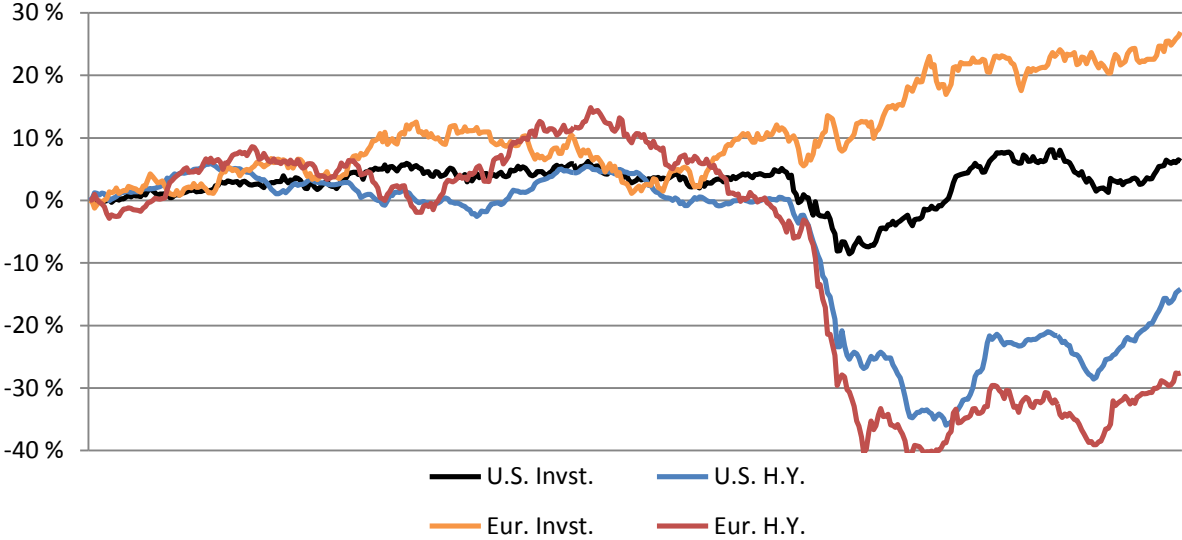


Chart 4.8.5, U.S. and European bond indices during the financial crisis.

Note that a portion of the increase in European investment grade bonds may be because of the lowering of ECB interest rates during the crisis. A portion of the decrease in the value of European high yield-bonds may be due to currency alterations, as the value of the dollar increased compared to the Euro. As this thesis applies dollar-denoted indices, currency fluctuations will affect the data observations for assets not denoted in \$US.

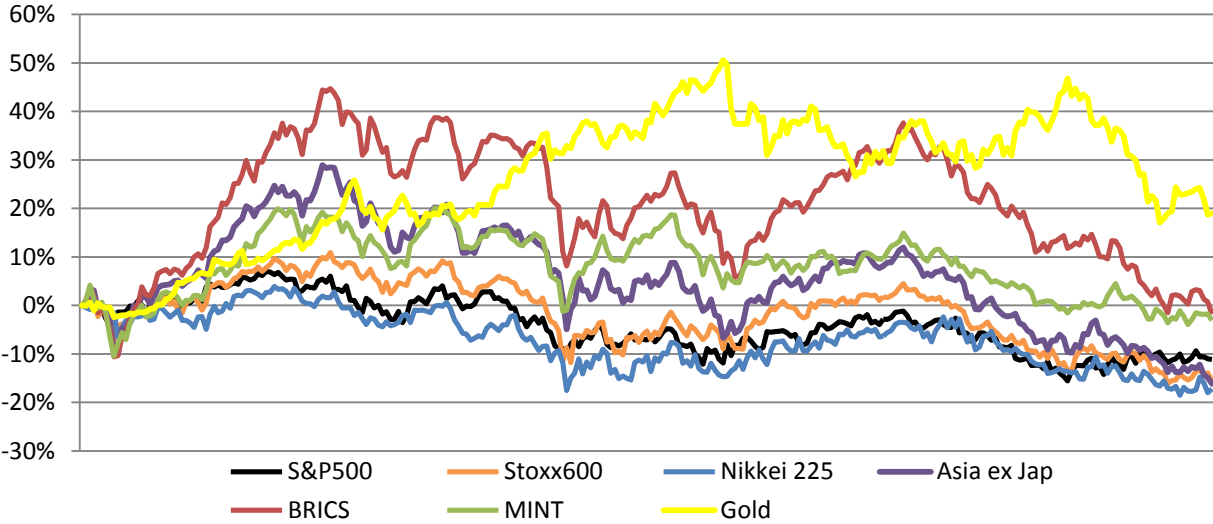


Chart 4.8.6, Indices in the months before the Lehman Bankruptcy, Aug 07-Sep 08

Analyzing the index movements before the bankruptcy, financial markets were still uncertain how this crisis would play out. Due to the United States dominant position as the biggest economy in the world, other markets feared the effects a worsening U.S: economy would have on their own domestic markets. One can see how the developed markets of Europe and Japan closely correlate with the S&P 500, following its up- and downtrends with varying magnitude. Emerging markets were

experiencing less of a correlation, but due to their economies exposure to the U.S. consumer, and the general U.S. economy, they still followed the overall movements of the developed markets, ending the prelude of the financial crisis with their stock markets breaking almost even.

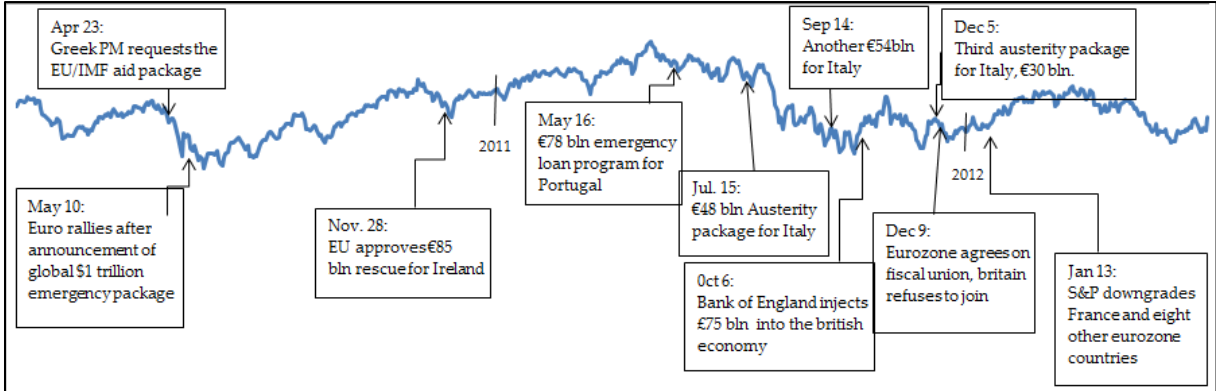
Gold were seen as a safe way of diversifying away from financial markets, and rose with a clear negative relationship to other markets. It ended the same time period up over 20% at about \$800 an ounce, and traded at an all-time high at \$1011 per ounce on March 17<sup>th</sup>, 2008.

**4.8.2 Eurozone crisis**



*Screenshot from Bloomberg News: "The European Debt Crisis Visualized".*

When the euro was introduced as a common currency and monetary policies of the Eurozone was placed under the ECBs supervision, sovereign debt interest rates converted to a more equal level, basically allowing countries with less disciplined fiscal policies and higher levels of debt(e.g. Greece) to exploit the stability of more developed economies, mainly Germany. The Eurozone consisted(2012) of 16 very different countries, with large variations in culture, language and economic discipline, and the Euro were to gather them under the same monetary policy, without a common governance or fiscal policy. As borrowing conditions became more favorable, some Eurozone countries imposed high debt levels on themselves, expecting the low interest rates and easy access to credit to continue for the foreseeable future.



*Chart 4.8.7, Stoxx Europe 600 and important events during the Eurozone Debt crisis, 2010-2012.*

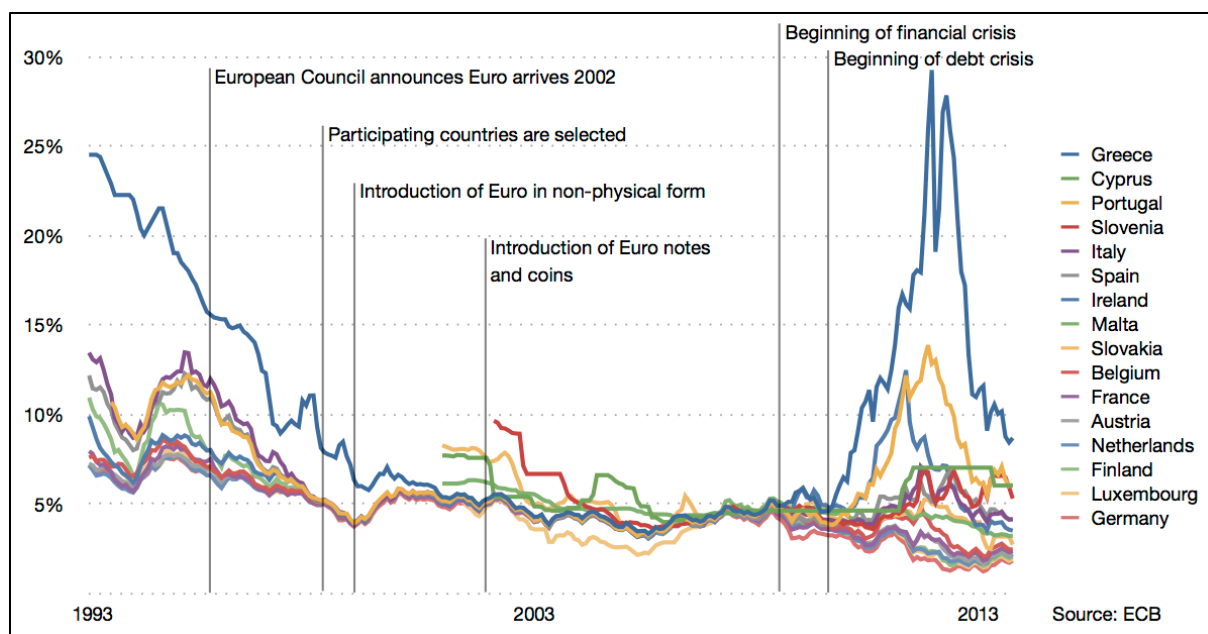


Chart 4.8.8, Eurozone sovereign bond yield, 1993-2013.

However, as the financial crisis started to develop and the access to credit was tightened worldwide, it became more and more obvious that poor fiscal policy choices and the need for bailouts in the private sector had made significant tolls on the solvency of some of the nations. The yield spread on sovereign bonds skyrocketed, and several European nations were forced to seek aid from ECB and IMF. Iceland was hit especially hard, having all three of their privately owned banks collapsing, quickly needing financial aid from IMF and several neighboring countries. Luckily, Iceland had the option of devaluating their own currency, a luxury not available for the Eurozone countries. Especially the PIIGS-countries; Portugal, Ireland, Italy, Greece and Spain, saw a substantial jump in bond yields, and still struggles to this day with high unemployment ratings and a poor real estate-market. As a part of the aid agreements, several countries had to accept strict requirements on austerity measures, which further limited economic growth, and was the backdrop for widespread demonstrations and public outrage.

*PIIGS was an acronym used to describe the five debt-stricken countries of the Eurozone; Portugal, Ireland, Italy, Greece and Spain. The ECB officially used the slightly less offensive acronym GIPSI to describe the five countries, but this abbreviation never became everyday speech among the media or the public.*

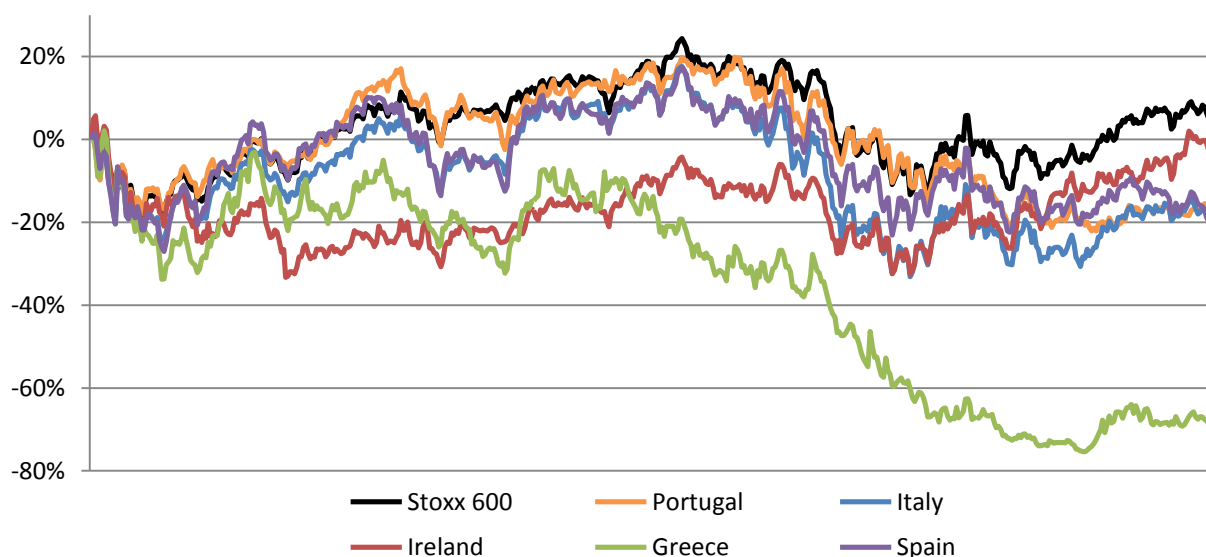


Chart 4.8.9, PIIGS stock indices during the Eurozone crisis, 2010-2012

As the problems in the Eurozone started to accumulate, European stock markets experienced a slight increase, and the broad Stoxx 600 index ended the crisis about 6% over the pre-crisis level. This was still disappointing compared to global markets, with the S&P 500 increasing more than 20%. As the European Union is a major part of the global economy, it is natural that negative news and data affects global stock markets, as a collapse of the Euro as a currency would probably cause a collapse of systemic proportions, making it a significant source for systemic risk. On negative days and periods of an increased volatility, the global stock market followed the European market downwards, but with a lower momentum. The correlation of volatility of the Stoxx 600 and the Nikkei 225 was only 23,36%, compared to 84% and higher for the other indices. This may indicate that the Japanese stock market fluctuated independently of the European market, as much of the focus is turned to the domestic economy and the current situation. The average volatility during the crisis was actually lower than for the overall time period (last 11 years), but the correlation with the value of the Stoxx 600 was still 76,14%, indicating that it followed the European market downwards, but to such a low amplitude that it did not affect the volatility to a high degree.

For European stocks, we see from chart 4.8.9 that the stock market of the PIIGS countries declined more than the rest of Europe, and especially the Greek stock market lost the majority of the index value. The Euro Stoxx 50 index, consisting only of markets within the Eurozone, declined almost 7% as the PIIGS countries counted for a larger proportion of the index. Table A.6 listed the English and Swiss stock markets, nations not in the Eurozone, but still largely exposed to the economy of the Eurozone countries. They both experienced high correlation with the Euro Stoxx 50 in both index performance and volatility, but with a lower momentum. They ended the crisis up 13 and 16% respectively, but with a volatility about 3 percentage points above the 11 year average.



*It may seem as if the overall increase in global stock market indices was exceptionally high, considering that one of the most important economical regions in the world were experiencing a debt crisis with contracting economies and high unemployment. It is important to remember that the markets were still at a level far below those reached before the financial crisis of 2007-2008, and still only about half way through the current post-crisis bull market we are currently experiencing. This is a reasonable explanation why the S&P 500 increased 21,36% while the Euro currency was on the brink of collapse.*

To follow up the bond comparisons for the financial crisis of 07-08, chart 4.8.10 shows the performance of selected bond indices during the Eurozone crisis. From chart 4.8.8, the yield on sovereign bonds rose substantially for all PIIGS countries, and the risk premium compared to safer Eurozone bonds(Germany) grew to levels similar to those from before the introduction of the euro. Two new bond indices have been included, to compare the different segments of corporate bonds, and their performance during the Eurozone crisis.

- Barclays Euro Aggregate: Euro denominated bonds, mainly domiciled in the Eurozone. Includes both corporate and government related securities rated at an investment grade.
- BOFA ML Euro High Yield: Euro denominated bonds, rated below investment grade(junk bond status).

When comparing the historical data of the European bond indices, the high yield bonds had a higher volatility than the investment grade bonds, in line of what we expected, and the opposite of what we found in the U.S. bond market. This supports the notion that the volatility measurements for the U.S. bond indices may be index-specific, and not representative for their respective segments of credit ratings. Regarding table A.7, the historical volatility of both European bond indices were actually lower during the Eurozone crisis than what measured over the past eleven years. I first thought that this was due to extreme fluctuations during the financial crisis of 2007-2008, but even when these observations were omitted, the average historical volatility of the BOFA ML Euro High Yield were only reduced to 10,45%(down from 10,78%). As both European bond indices increased more than 10% in value during the crisis, with similar or lower volatility than average, it seems as if the overall corporate bond market came through the crisis without seeing the sell-off and investor uncertainty that we experienced during the financial crisis of 2007-2008. Studying chart 4.8.10, one can clearly see that European high yield-bonds saw periods of sharp declines as the European stock market had similar declines. Global Government bonds and Investment grade corporate bonds of the U.S. went practically unharmed through the crisis, and investors remained certain that these investments were low-risk, even as markets started to fear for the future of the Eurozone. U.S. High Yield bonds saw a drop in value at around the same time periods as the European high yield-segment, but with a distinctly lower momentum.

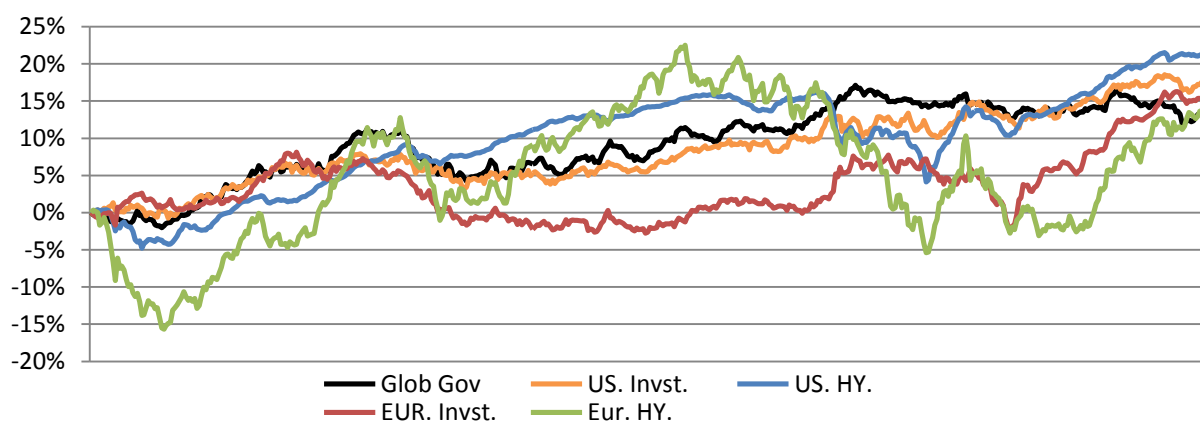


Chart 4.8.10, Bond indices during the Eurozone crisis, 2010-2012

When stating that sovereign government bonds went unaffected by the crisis, this refers to the broad index consisting of bonds from several nations. Sovereign bonds from the PIIGS countries, and especially Greece, declined substantially as investors required an increased risk premium.

The same applies when we compare the performance of stock indices, as individual stocks and sectors may have severe reactions both up- and downwards. Especially for terrorist attacks, the travel industry and airlines may experience a significant drop in stock prices, as consumers are less inclined to travel.

## Natural disasters having a negative effect on financial markets

### 4.8.3 The Japan Earthquake

Date: March 11<sup>th</sup>, 2011

Where: East Japan

Markets that may be affected: Japan, the rest of Asia

On 14:46 on Friday the 11<sup>th</sup> of March, an earthquake with a 9.0 magnitude struck approximately 70 kilometers east of Japan. The tremors of the earthquake caused severe damages in mainland Japan, but the tsunami caused by the shifting of the tectonic plates is what this day will mostly be remembered for: waves that reached heights of up to 40 meters and travelled as far as 10 km inland. The tsunami then caused a nuclear catastrophe, as the Fukushima Nuclear Power Plant experienced a level 7 meltdown on three of its reactors, causing the evacuation of all civilians within a 20km radius of the power plant. The World Bank estimated the total economic cost at about US\$ 235 billion (Nakamura 2011), and The Bank of Japan offered ¥15 trillion on March 14<sup>th</sup> to the banking system as a measure to calm the market by fueling additional liquidity into the market.

The data is listed in table A.8. Due to the undramatic nature of the first reports coming out of Japan, the seriousness of the catastrophe and potential for nuclear disaster did not become clear during the market opening hours on Friday, and most stock indices were trading relatively flat. When the market opened on Monday morning, the Nikkei 225 saw a severe drop at more than 6%, followed by a 10% drop on Tuesday. Surprisingly enough, Monday saw no severe reactions in the major global stock markets, and all listed indices were within their standard deviations,

except for Thailand who experienced a 2,31% increase. The drop on Tuesday however, was too severe to ignore, and global markets fell between -1% and -4%(see A.8). On Wednesday, the Nikkei experienced a rebound with a 6,30% increase, but this did not spread across other markets, indicating how the developments in Japan were relatively independent from other markets during this catastrophe. It seems as the financial markets did not believe that the developments would have any substantial negative effect on the performance of other economies, despite the substantial size of the economy of Japan.

Data observations for Thailand and Australia were included, as these are countries with large economic exposure towards Japan. They followed global markets downwards on Wednesday with a similar magnitude, and generally acted similar to other emerging markets.

Japans proportion as trading partner		
	Import	Export
Thailand	20,0 %	10,2 %
Australia	7,9 %	19,3 %

Table 4.8.1, Japan’s share of trading, Source: CIA

At the beginning of April, a little more than three weeks after the earthquake, the Nikkei 225 had fallen almost 8% from March 10<sup>th</sup>. The loss was recovered by the beginning of May, even though it remained clear that the radiation and the change in Japanese energy policies was going to have long term effects on the Japanese economy. Regarding global markets, both March and April were good months for many of the important stock indices, which may explain the quick recovery for the Nikkei 225. Even Thailand and Australia ended March up 5,55% and 7,33%, further rising to 10,62% and 13,40% by May 2<sup>nd</sup>.

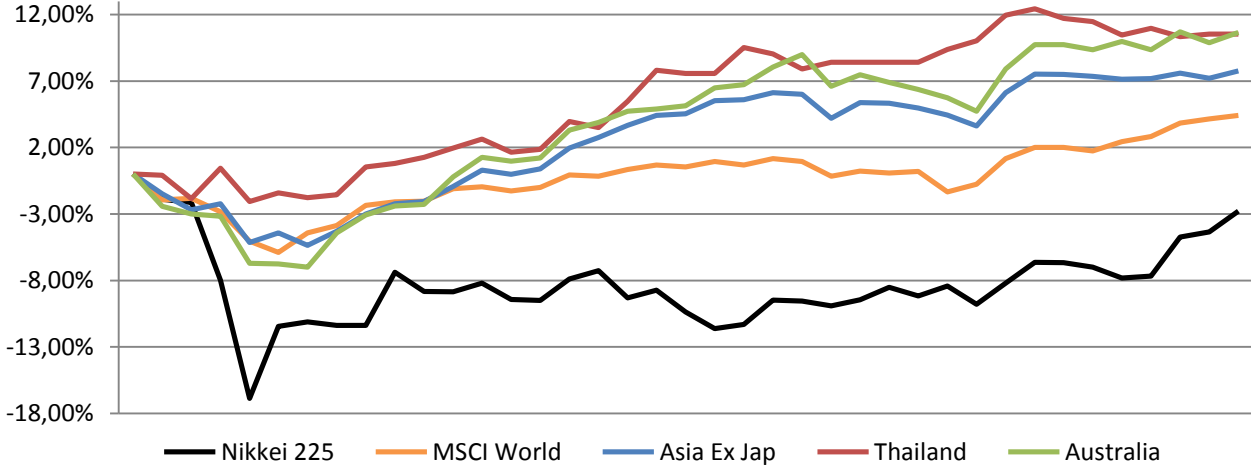


Chart 4.8.11, Selected stock indices, March 10<sup>th</sup> – May 2<sup>nd</sup>

**4.8.4 Hurricane Katrina and Rita**

Date: 29<sup>th</sup> of August and 24<sup>th</sup> of September, 2005

Where: The Gulf Coast, U.S.

Markets that may be affected: U.S., Global

Hurricane Katrina first formed south of Florida on August 23, and passed Florida as a category 1 hurricane, before entering the Gulf of Mexico. Here, the warm weather strengthened the hurricane rapidly, growing it into a category 5 hurricane, before it weakened back to a category 3 by the time it struck land again. The gulf coast had to endure severe destructions from Florida to Texas, but the biggest catastrophe of all happened in New Orleans, Louisiana. As the levee system collapsed, large parts of the city were flooded, and entire neighborhoods were destroyed. Final estimates have the death toll at 1,833, and total property damage at US\$81 billion (Knabb et al. 2005).

A few weeks later, the area was struck again, this time by hurricane Rita, which re-flooded lower Louisiana and caused severe damage along the gulf coast. As the gulf coast is home of much important oil infrastructure, energy prices saw a spike due to the fear of a collapse in the supply of Crude Oil. In addition, about 500.000 people became unemployed following the hurricanes, slowing the GDP growth substantially (Hurricane Rita 2014).

From table A.9, we see that financial markets went practically unchanged during and after the hurricane. Even the VIX index stayed in the interval between 12 and 14, a historically low level. While death tolls and damage estimates rose, financial markets stayed relatively unharmed, also as hurricane Rita hit a few weeks later. Three months after the second hurricane, the S&P 500 had risen 4,8%, as neither the short term uncertainty nor the long term consequences had any substantial negative effect on financial markets.

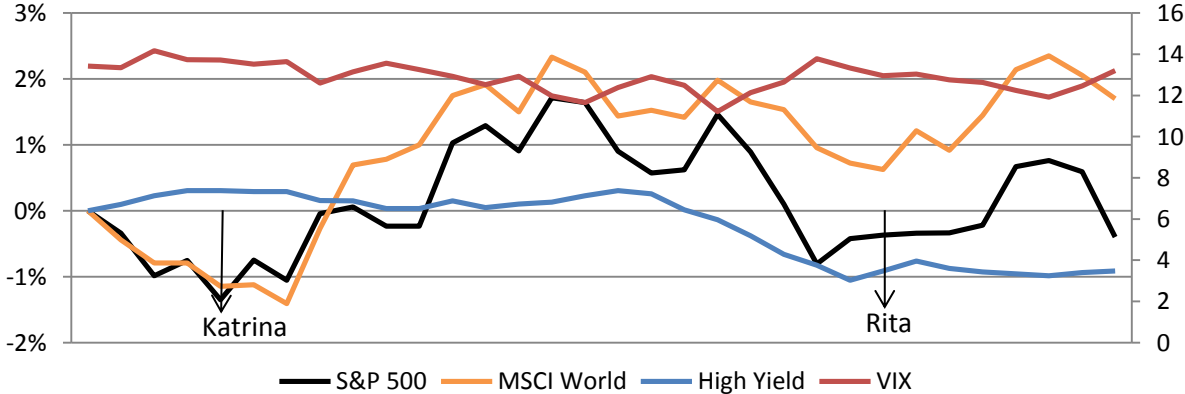


Chart 4.8.12, Stock and bond indices during hurricanes Katrina and Rita.

### 4.8.5 Deepwater Horizon Oil Spill

Date: April 20<sup>th</sup>, 2010

Where: The Gulf of Mexico

Markets that may be affected: U.S. Markets

On the evening of April 20<sup>th</sup>, the oil rig *Deepwater Horizon* exploded and sank, initiating an oil spill from the Macondo Reservoir that lasted for 87 days (USGS 2011), until the well could be capped. The U.S. Government estimated the total discharge at 4.9 million barrels (USGS 2011), and massive environmental damages to the gulf and the gulf coast.

The associated parties, as well as the media, took weeks before they realized how severe the accident and the consequences were. On the following day, the S&P 500 traded flat while the Stoxx 600 fell 1,07%. Over the following days, the Stoxx 600 declined -3,57%, and the S&P 500 followed with a -1,56% drop. However, this decline seems too severe to be based simply on the oil spill. Looking at the stock prices of BP, the operator of the oil field, it had fallen 13,21% by April 30<sup>th</sup>. The Stoxx 600 is an equally weighted index, so BP only accounts for 1/600<sup>th</sup> of the index, and it is difficult to justify the decline of the Stoxx 600 with this. Especially when considering that the Stoxx 600 fell more than 12% the following week, one can assume that there is a different reason for the increased volatility.

Looking to Europe, the reason for the drop can be found on April 23<sup>rd</sup>, as the Government of Greece were forced to formally ask for financial aid from the European Union and the IMF. So the data for the weeks following the accident, the focus of the market was on Greece and the European Union, and an oil spill that initially seemed insignificant could not justify the increased volatility of global markets. The S&P 500 traded relatively flat for both following trading days, with an increase of 0,23% and 0,71% on April 21<sup>st</sup> and 22<sup>nd</sup>, and even U.S. markets did not seem to react to the accident.

#### **4.8.6 Reviewing the market reaction to natural disasters**

The only natural disasters included here occurred in highly developed nations with strong economies, and received massive media attention over the time span of the disaster and its aftermath. It seems as if the initial reaction for financial markets were miniscule, as markets did not fear that the domestic economy would be affected. This occurred for all three catastrophes. Following the earthquake and radiation crisis in Japan, stock markets around the world fell significantly, as it became clear that the consequences was going to affect the economy of Japan.

### **Key terrorist attacks that received global attention and caused fear throughout financial markets:**

#### **4.8.7 Istanbul bombings**

*Date: November 15<sup>th</sup> and 20<sup>th</sup>, 2003*

*Where: Istanbul, Turkey*

*Markets that may be affected: Turkish markets, FTSE 100, Global markets*

On November 15<sup>th</sup>, two trucks filled with explosives attacked two synagogues in Istanbul, and the Islamic militant group IBDA-C claimed responsibility. Five days later, two additional trucks exploded, in front of the British Consulate and the regional headquarters of the British bank HSBC. Total casualties for the two attacks amounted to 57 people dead and another 700 wounded. The ISE(Istanbul Stock Exchange) was forced to close down on November 20<sup>th</sup>, and did not reopen until December 1<sup>st</sup>(Christofis et al. 2010). The Turkish Central Bank was forced to announce that they would take measures to support the lira which were declining.

#### **4.8.8 Madrid Bombing**

*Date: March 11<sup>th</sup>, 2004*

*Where: Madrid, Spain*

*Markets that may be affected: Spanish Markets, European markets*

Three days before the general elections in Spain, several bombs went off on the morning commuter train to Madrid, killing 191 and injuring 2,050. This was the first attack by Al-Qaeda in western-Europe, and caused fear that the terrorist organization was establishing themselves in Europe.

#### **4.8.9 London Bombing**

*Date: July 7<sup>th</sup>, 2005*

*Where: London, UK*

*Markets that may be affected: British, as well as US and other European markets.*

During the morning rush hour, a series of coordinated suicide attacks hit public transportation in central London, taking the lives of 52 civilians and injuring an additional 700. On the day of the attack, several European stock markets were down up to 4%, but much of the loss was recovered before the end of the trading day(London Bombings 2014).

#### **4.8.10 Mumbai Attacks**

*Date: November 26<sup>th</sup> to 29<sup>th</sup>, 2008*

*Where: Mumbai, India*

*Markets that may be affected: Indian Markets, Emerging Markets*

Mumbai was hit by twelve coordinated attacks, against among other things, a hotel, a hospital and a Jewish community center, with one of the attacks lasting a total of four days. A total of 164 people were killed, including 10 of the 11 attackers, plus more than 600 non-fatal injuries. The only surviving attacker, Ajmal Kasab, admitted upon interrogation that the attackers were supported by ISI, Pakistani Intelligence, which led to increased tensions between the two atomic nations(Navhind 2012). He was later executed by hanging.

For this attack, I was going to compare the financial markets, as well as the markets of India and Pakistan, as this event hurt the relationship between the countries, and could cause financial turmoil as the markets feared an escalation in the conflict between the nations. However, as this was in the middle of the financial crisis of 2007-2008, the data observations were inconclusive, as global stock markets experienced a sell off, and indices across the world were dropping. The main Pakistani Stock Index, the KSE 100, even halted trading, putting the index value of Aug 27<sup>th</sup> as the bottom-limit, and not allowing trading to occur at levels that would move the index beneath this (Sharif 2008). Securities were also limited to a daily trading range of 5%, which made the data observations inconclusive.

This was partially due to the global financial crisis, as well as the political instability in the country following the resignation of President Musharraf, and the awaiting of the upcoming elections.

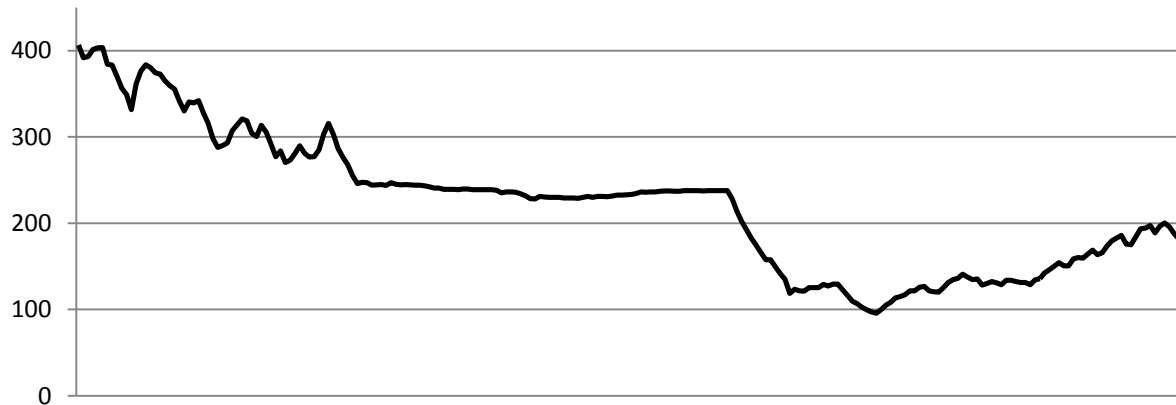


Chart 4.8.13, The KSE 100 stock index during the fall of 2008

#### 4.8.11 Bomb at Times Square

*Date: May 1<sup>st</sup>, 2010*

*Where: Times Square, New York, US*

*Markets that may be affected: US, Global*

A car bomb was discovered when smoke was spotted coming out of a vehicle, and the NYPD was alerted. The bomb had failed to explode, and were disarmed without casualties. Even though the attack was unsuccessful, the attempted attack shocked the US, as it was only a coincidence that the bomb did not explode, causing massive destructions in the middle of Manhattan. The perpetrator was both born and trained in Pakistan, and the incident caused massive discussions on the US-Pakistani relationship, and how the US may have responded to a successful terrorist attack.

#### 4.8.12 Boston Marathon Bombings

*Date: April 15<sup>th</sup>, 2013*

*Where: Boston, Massachusetts*

*Markets that may be affected: US, Global*

As the city's annual marathon race was coming to an end, two bombs exploded close to the finish line, killing 3 people and injuring hundreds. Two Chechen brothers were behind the attacks, where as one was killed and the other later arrested. This was the first successful terrorist attack of substantial proportions on U.S. soil since September 11<sup>th</sup> 2001, shattering the belief that the homeland was safe for Americans.

#### 4.8.13 Reviewing the market reaction to terrorist attacks

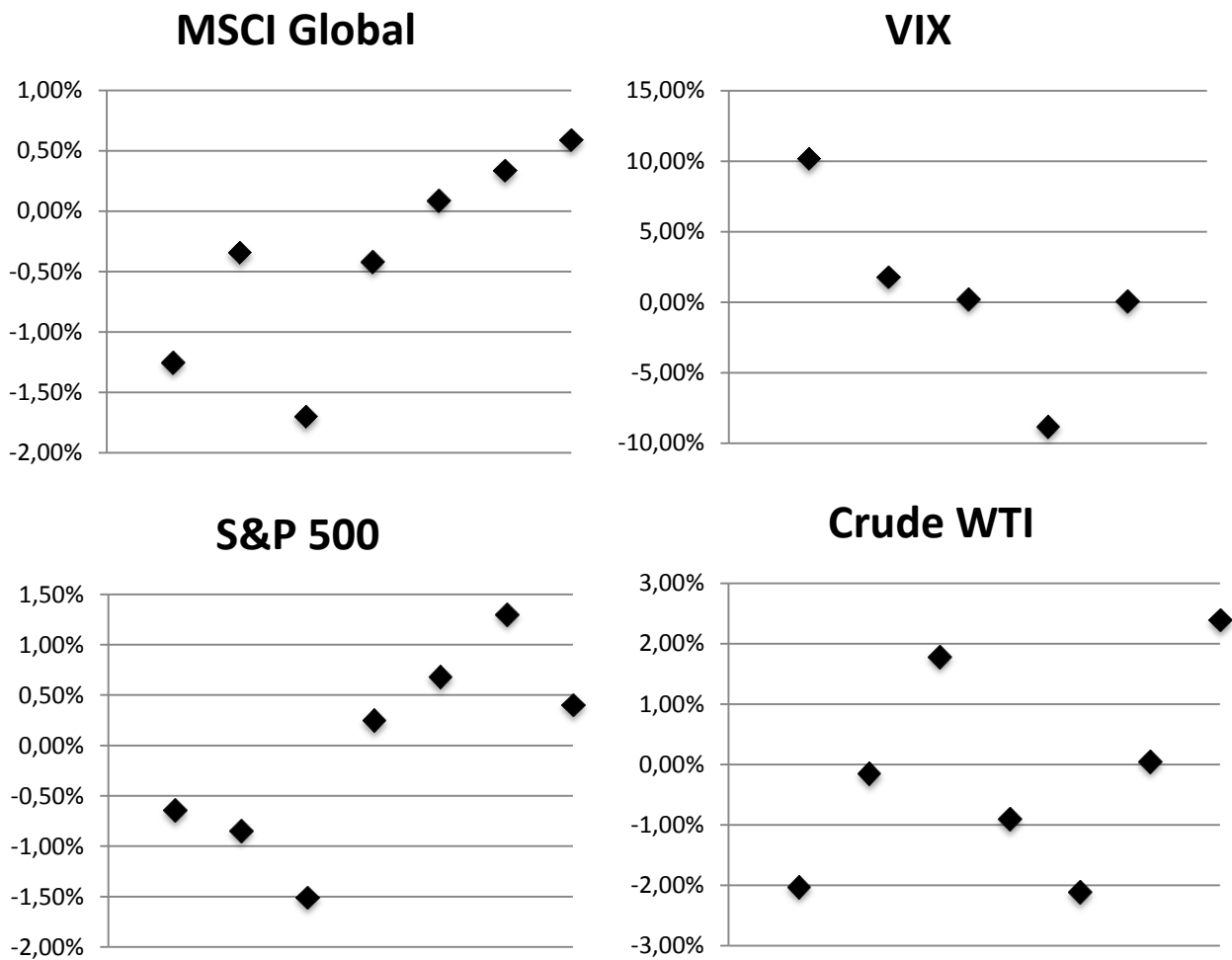


Chart 4.8.14, Changes in selected indices on the trading day following a terrorist attack

Reviewing tables A.11 to A.16, index performance for the days following major terrorist attacks are listed. Generally, major, global indices are very little affected by terrorist attacks, as market participants believe that the consequences for the global economy are limited. The stock index of the nation in which the attack occurred, usually experiences a substantial decline, but the loss is usually recovered after a few weeks, as the initial uncertainty linked to the potential consequences of the attack disappears. This effect is especially clear with emerging markets, as one can see from the 11% the ISE dropped after the Istanbul bombings (table A.11). Still, as long as one applies diversification to avoid too much exposure to the stock market of a single country, much of the value fluctuation is absorbed by the regional index the affected country is included in. When reviewing the attacks in the U.S. (table A.14 and A.15), the S&P 500 seems unaffected by the attacks, probably due to the fact that the citizens of the United States have been aware of the terrorist threat for several years, and that macroeconomic consequences of an attack is likely to be small, if any.



The Madrid bombing was the only attack where all relevant indices experienced a substantial decline. A likely explanation for this may be the reaction of the market, as they feared that Al-Qaeda would establish themselves as a threat on the European continent, changing the scenery for the war on terror. A paradigm shift in the fear of terrorism could slow economic growth, as one feared an escalation in terrorist attacks against targets on European soil.

When analyzing terrorist attacks over the last decade, it is hard to omit the terrorist attacks that occurred on September 11<sup>th</sup>, 2001. As the World Trade Center and the rest of lower Manhattan was a core area for U.S. finance, NYSE was closed for the following days, and fell 5% when it reopened on September 17<sup>th</sup>. By September 21<sup>st</sup>, it had fallen with more than 11%, and the MSCI World followed downwards with a drop of more than 12%. Compared to the attack on World Trade Center on February 26<sup>th</sup> 1993, the S&P 500 only decline of -0,31% on the next trading day. This could indicate that as the attacks directly affects financial markets, the decline becomes much greater, as the short-term effects for the financial system becomes uncertain. This is similar to the experience after the Istanbul bombings, when the ISE was forced to close.

Regarding other assets, neither the price of Gold nor the Middle Eastern stock indices had a recurrent reaction to terrorist attacks. More surprising is the lack of systematic movements in the price of oil, as a price jump is expected to occur due to the increased uncertainty in the supply of crude oil from the Middle East. A reason for this lack of volatility may be that we are assessing the data observations for the daily spot price of WTI, oil dealt in Cushing, Oklahoma, as this is the world's most watched oil price index, and the one most analysts and journalists refers to. The increased demand in oil contracts and the need to secure delivery for consumers may rather be reflected in price jumps for OTC contracts, as well as futures and options.

#### **Industry Insight:**

In section 2.5.8, I mentioned the characteristics of commodities. For oil, there are several benchmarks, as the location and quality of the oil are important variables for those that trade in oil. WTI stands for "West Texas Intermediate", and is of light and sweet quality, traded at the price settlement point in the town of Cushing in Oklahoma. Examples of other benchmarks are Brent Blend(North Sea), Dubai and Bonny light(Nigeria).

As one can see, the stock market's reaction to terrorist attacks is limited, which supports previous research done by Johnston & Nedelescu(2005) and Suleman(2012). Smaller markets and individual companies may face larger drops, but proper portfolio diversification can minimize this risk. Especially sectors exposed to travel and tourism are sensitive to terrorism and instability. If a terrorist attack was either of a massive scale(nuclear or destroying vital infrastructure) or were to affect the financial system, the long-term consequences may be dire. This is one of the things

that caused the market drop after September 11<sup>th</sup>, as financial activity in New York City was brought to a halt for four trading days.

**Geopolitical events**

It is natural that the fear of war can affect financial markets, as it limits economic growth and increases government spending. However, the fear of war is often exaggerated, as diplomacy leads to a peaceful solution, or the conflict is briefly fought out. The uncertainty before and during the fighting will cause weaker markets, while a bull-market often takes place as the war-related risk diminishes. Some speculators takes advantage of this, as they buy up assets in the beginning and during the fighting, and then sell as the rest of the market is buying as they increase their risk exposure. This led to the saying:

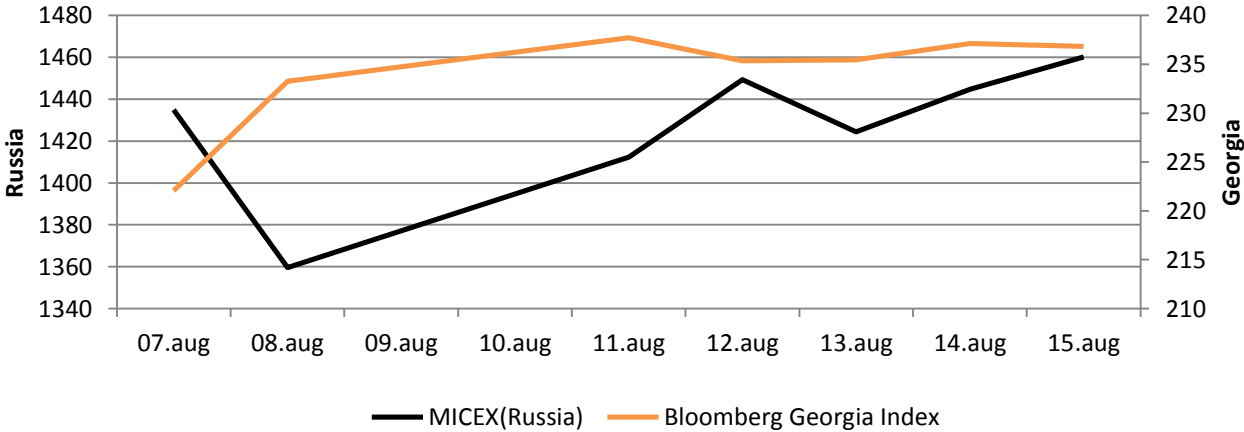
*“buy on the sound of cannons, sell on the sound of trumpets”  
-Nathan Rothschild*

**4.8.14 The South Ossetia War**

*Date: August 2008* *Where: Georgia, South Ossetia*

*Markets that may be affected: Russian and European Markets*

From the 7<sup>th</sup> to the 16<sup>th</sup> of August, an armed conflict took place between Georgia and Russia, South Ossetia and Abkhazia. Georgia was at the time under consideration for NATO membership, and one speculated whether the west would intervene. Through talks led by the European Union, a ceasefire was eventually signed, but Russian troops are still stationed in the breakaway republics of Abkhazia and South Ossetia, which is formally a part of Georgia.



*Chart 4.8.15, Georgian and Russian stock market during the South Ossetia War, 2008*

The Georgian stock market was trading flat before the outbreak of the conflict, and actually rose during the span of the fighting. A weakening currency and the fear of international sanctions caused the Russian stock market to decline, similar to what occurred during the conflict on Crimea in the spring of 2014. Due to its weighing(13,7% of the BRICS index), a 5,2% drop in the Russian stock market would automatically cause the BRICS index to fall by 0,7%, but the actual drop was closer to

3%. Both the Moscow Stock Exchange and the BRICS index are likely to have been affected by the poor economic outlook in the U.S., as the S&P 500 dropped 5,7%. The market did not believe that the Federal Reserve could contain the crisis, and CIO of United Advisors, Darin Pope, was quoted saying that “there is a feeling that no matter what is done, it won’t be enough”(Twin 2008).

#### **4.8.15 Arab Spring**

*Date: 2010 - present*

*Where: the Arab World*

*Markets that may be affected: Emerging Markets, Global Markets*

Main development in a selection of Arabic countries:

- Tunisia: Started on December 18<sup>th</sup> 2010, and ended with overthrowing of the Ben Ali-government. Both the political police and the ruling party, RCD, were decided to be dissolved.
- Libya: After the country’s armed forces were ordered to fight against its own citizens, a military intervention by UN-mandate was put in place, backing an armed revolt that ended with Muammar Gadhafi being overthrown and later executed by rebel forces. Libya had been an important supplier of oil and gas to western countries, which is one of the reasons why Gadhafi’s dictatorship had gone uninterrupted for so many years. Libyan energy exports are still struggling to this day.
- Egypt: From Jan 25<sup>th</sup> to Feb 11<sup>th</sup> 2011, Egypt experienced massive protests to overthrow President Mubarak, and the Muslim Brotherhood and Mohamed Morsi gains control of the country. The military still holds much of the real power in the country, and would eventually remove President Morsi two years later, having the Muslim Brotherhood classified as a terrorist organization.
- Yemen: Started escalating on January 27<sup>th</sup> 2011, and ended on February 27<sup>th</sup> the next year. Presidential elections were held to replace President Saleh, and both the Prime Minister and all MPs from the ruling party resigned.
- Syria: As this is written(March 2014), Syrian Observatory for Human Rights estimate that the death toll of the Syrian civil war has reached 206,065 over the three years the conflict has lasted. President Assad decided to use force to put down the uprisings, and the people decided to fight back. The Free Syrian Army was founded, and defected soldiers joined into battle the armies of the Syrian government. The Syrian government is supported by Russia and Hezbollah, while Qatar, Saudi Arabia, Turkey and the United States are supporting the rebels. Chemical weapons are also reported to have been used, and there were strong international reactions. However, as Putin wants to avoid a western-backed government in Syria, as well as fearing for Russia’s

only naval base in the Mediterranean, Russia has been actively blocking all resolutions in the UN Security Council, preventing UN sanctions and the deployment of UN peacekeepers.

The Arab spring escalated over an extended time period, with events of varying severity building up to regional tensions. With the ongoing tensions in Syria, one can even say that the regional uprising is still ongoing. As this happened parallel to a debt crisis in Europa and an economic recovery in the United States, it is impossible to observe the long term effect the Arab Spring has had on global stock markets.

Even when looking at daily changes in the major stock indices(table A.17), there is no clear pattern related to the major events of the Arab spring. The only significant reaction is on March 15<sup>th</sup>, as the markets reacted to the Nuclear crisis in Japan and the Nikkei 225 dropping more than 10%. Looking at local equity markets, most of them fell by double digits, except Qatar who managed to avoid major protests, while maintaining high economic growth. Egypt went through a tossed government and political uncertainty that may affect the country for several years, and investors reacted by decreasing the value of the Egyptian stock market by 23%. However, the daily reactions was missing the pattern we anticipated in table A.17, as the stock indices were trading fairly flat on the trading days following major events.

#### **4.8.16 Invasion of Iraq**

*Date: March 19<sup>th</sup>-May 1<sup>st</sup>, 2003*

*Where: Iraq*

*Markets that may be affected: US, Global*

Operation Iraqi Freedom was the name used by the United States to describe the invasion of Iraq by troops from the United States, United Kingdom, Australia and Poland. The backdrop for the invasion was to disarm Iraq from WMD(Weapons of Mass Destruction), and to end Saddam Hussein's dictatorial government and support for terrorism. On May 1<sup>st</sup>, the invasion period was declared to be over, and the period of military occupation started.

Regarding the major stock indices, they experienced low average volatilities during the war, and most of the stock indices increased in value over the time of the invasion. On March 24<sup>th</sup>, U.S. and European markets dropped more than 3% on speculations that the invasion may not be as easily won as previously thought, and that it may turn into a long lasting and expensive conflict for the United States and its coalition forces(Twin 2003). Nikkei and BRICS saw a fall of between 1% and 2%. Turkey was an active participant in the war, and their armed forces were active in the northern parts of Iraq, fighting Kurdish rebel forces. The ISE dropped 7,48%, causing the MINT to fall with it, but the average historical volatility still sunk during the span of the invasion. In the weeks leading up to the war, tensions were high and an armed conflict seemed inevitable, causing the historical volatility of the ISE to exceed 100% on March 19<sup>th</sup> and 20<sup>th</sup>(Table A.19).

#### **4.8.17 Reviewing the market reactions to geopolitical events**

Major markets saw minimal reactions due to geopolitical instabilities. Conflicts often escalate over time, and markets have time to prepare for the armed stage of conflicts, causing little or no reaction to the major indices. It is reasonable to assume that the markets of the nation directly affected by the conflict would experience a severe decline in stock market valuations, as the domestic economy and future outlook would have a negative effect from the fighting. If the global energy supply were to be affected, in a scale so large that the growth of the global economy could be hurt, it is reasonable to assume that stock markets around the world would decline, with diminishing GDP growth rates, and a spike in the price of oil.

If a geopolitical event were to occur in a major developed nation or a nation which accounts for a large proportion of world trade, it is natural to expect that global markets will experience a severe drop similar to that of the Eurozone crisis.

### **Other global incidents**

#### **4.8.18 The Chinese Correction of 2007**

*Date: February 27<sup>th</sup>, 2007*

*Where: Shanghai Stock Exchange*

*Markets that may be affected: Chinese Markets, Global Markets*

Rumors started spreading in the financial community that Chinese regulators would start increasing interest rates to curb inflation, as well as put restrictions on leveraged trading, Asian markets saw a sharp drop, and the SSE Composite Index(Shanghai Stock Exchange) dropped 9%, taking other Asian markets down with it.

Before the rumors started spreading, the volatility of the major indices was well below the historical average, going as low as 6% for the S&P 500. As the decline started, global markets followed downwards, with Asian and other emerging markets down around 6% over the following week. Financial restrictions and an increase in interest rates would slow economic growth, hurting the global economy and decreasing commodity prices.

Comparing the market performance for the main trading partners of China, i.e. countries whose economy is largely dependent on the economy of China, table A.22 shows that they declined by approximately the same magnitude as other emerging markets. Thailand even experienced a positive change in stock market valuations, as investors did not see the rumors as a credible threat to the national economy of Thailand. Because of how closely intertwined the global economy has become, as well as Chinas major position within global trade, it is understandable that many of the markets sensitive to either Chinese economic output or the price of commodities experienced similar drops.

Chinas proportion as a trading partner		
	Import	Export
Thailand	14,90 %	11,70 %
Singapore	10,30 %	10,70 %
Taiwan	16,10 %	27,10 %
Hong Kong	46,90 %	54,10 %

Table 4.8.2, China's share of national trade, Source: CIA

#### 4.8.19 The Dubai World debt standstill

Date: November 25<sup>th</sup>, 2009

Where: Dubai, UAB

Markets that may be affected: Emerging Markets, Debt Markets

Similar to many of the developed economies in the world, the real estate market of Dubai saw a sharp decline in the time period following the 2007-2008 financial crises. The investment company Dubai World had already laid off 10,500 employees worldwide, and the government-owned company had built up a debt of \$59 billion, a debt that Dubai's government had stated that needed an extension on all maturities for at least 6 months, leading to an all-out credit rating downgrade (Dubai World 2014).

Financial markets first feared that this may lead to systemic failure, as ripple effects could spread throughout financial markets across the Middle East, hurting the global economy and possibly leading to increased political instability in the region. Several of the stock indices of the Middle East saw the historical volatility spike, and MSCI UAE (United Arab Emirates) decreased almost 11% on November 30<sup>th</sup>. The major stock indices also declined between 2% and 4%, before some of the belief in the solidity in the credit worthiness of the United Arab Emirates reemerged on November 27<sup>th</sup>, as the fear of systemic risk decreased.

Regarding the bond market, neither sovereign government bonds nor U.S. corporate bonds experienced any substantial decline.

#### 4.8.20 The downgrade of U.S. credit rating

Date: August 06<sup>th</sup>, 2011

Where: United States

Markets that may be affected: Global debt- and equity markets

After a troublesome period of negotiations regarding the U.S. budget deficit deal, the financial industry started to speculate whether the U.S. would be able to avoid defaulting on their debts. In the wake of this, Standard & Poor's downgraded the long-term sovereign credit rating from 'AAA' to 'AA+', a drastic move considering that sovereign U.S. debt were considered free of default risk. S&P justified the downgrade by stating that "US policymaking has lost its effectiveness, stability and predictability and weakened political institutions at a time of ongoing fiscal and economic challenges".

Although experts claimed that the downgrade should not have much consequences for the U.S economy (Sweet 2011), the market immediately reacted by sending the

S&P 500 down 6,88% when the markets opened Monday morning. This sent Asian markets further down on Tuesday, as investors feared for the future of the U.S. financial system and a systemic failure that may arise if the dollar loses its position as the reserve currency of the world. Luckily, the S&P 500 rebounded 4,63% on August 7<sup>th</sup>, and by August 15<sup>th</sup>, almost all the losses had been regained on the major stock indices.

Regarding bond indices, Treasury bills remained invulnerable and stable, with an average volatility of 0,0030%. Investment grade corporate bonds traded flat on the day following the S&P's announcement, high yield bonds fell about 2% while government bonds rose by close to 1%. This could indicate how investors were going "risk off", selling riskier assets and seeking the safer government bonds, to await further market reactions as the level of uncertainty increased.

#### **4.8.21 Reviewing the market reaction to other global incidents**

These are the events more likely to hurt major stock- or bond markets, as they have the potential to severely damage vital parts of the modern financial system, as well as causing a greater impact on the global economy. One can see how the increased volatility spreads far easier from the major global markets, and many of the assets that are characterized by a high level of risk experienced a significant decline in value, as investors are looking to reduce their risk exposure. From all three events, we find that the stock market quickly rebounds as the initial uncertainty settles, due to the absence of the clear, long-term effects this would have on the economy.

*Both the Chinese and U.S. economy are vital cornerstones in the globalized economy, and has the potential to severely disrupt the economic growth of multiple nations. However, the economy of U.A.B(United Arab Emirates) is fairly isolated, and mostly based on the export of petroleum and petrochemicals. It is unlikely that a collapse in the economy of Dubai could cause systemic failure in other parts of the global economy, as regulations limits the exposure major financial institutions may have to the region. Still, a collapse in U.A.B. credit could spread to the rest of the region, causing bond yields to rise and economies to shrink. Also, if the daily life of the population were to be affected, demonstrations and unrest may occur, similar to what happened during the Arab spring, which originally were a reaction to the increased prices of wheat stemming from global drought(Hardy 2013).*

#### **4.9 Future crisis' that may occur:**

The main characteristics of a market-altering incident is that it is difficult to anticipate and hard to protect against. The fact that regulators and investors cannot predict the crisis makes countermeasures nearly impossible to implement before it is too late. To illustrate, I have listed some of the possible sources of a future market crash that analysts are watching today. Still, history shows that market moving events are usually under analyzed and not considered in today's market level.

#### **4.9.1 Worsening of Russian-western relations:**

*Likely critical time period: Current, as well as continuous.*

*Market that may be affected: Global markets, especially Eastern European and Energy markets.*

A full-scale war between Russia and NATO is considered extremely unlikely, mostly because of the threat of nuclear war. However, a cold war may lead to satellite conflicts and restrictions on world trade. European sanctions on import of oil and gas from Russia would also lead to an increase in the price of energy commodities, which would slow down economic growth.

#### **4.9.2 A hard landing in China:**

*Likely critical time period: Next 1-3 years*

*Market that may be affected: Global markets, especially Asian markets and commodities.*

China has experienced annual double-digit economic growth over the last decade, and has grown to becoming the second-largest national economy in the world. Analysts are expecting that the real economic data differs significantly from what the Chinese government releases, and that official data is manipulated to give the appearance of stability and growth. The SHIBOR(Shanghai Interbank Offered Rate) has experienced periodically extreme volatility, and several analysts are predicting that the Chinese real estate-market is a massive bubble, waiting to burst(Soares 2014).

#### **4.9.3 General strike in Venezuela:**

*Likely critical time period: During 2014-2015*

*Market that may be affected: Energy Markets, which may slow the global economic growth.*

This is the event listed here that is most likely to occur, but probably will have the smallest long-term impact on the global economy. Venezuela's financial markets are insignificant on a global scale, but the country is the 8th largest oil exporter in the world(CIA 2014a), and geographically close to U.S. markets. The country has been economically mismanaged for several years, and the chance of major upheavals and general strikes has been increasing steadily since the death of President Hugo Chavez in March, 2013. A cut off supply from Venezuelan oil would result in a significant spike in oil prices, which would restrain economic growth globally. However, with extra capacity available in the other OPEC-countries, as well as large shale-oil reserves in the United States, the long-term effect for the global supply of oil is likely to be limited.

#### **4.9.4 Recession and debt crisis in France:**

*Likely critical time period: Next 5 years.*

*Market that may be affected: European markets, all global markets if the Eurozone were to collapse.*

France, the EU's 2nd largest economy, has still managed to stay out of the euro-zone debt crisis, despite a government debt of 93,8% of the national GDP(CIA 2014b). This is fortunate, as a France in need of aid from ECB or IMF could very well be a lethal



blow to the markets faith in the Euro. Social unrest, controversial tax increases and declining productivity is looming in the economic horizon, and a political or financial collapse in France could very well initiate a “Black Swan”-event, leading to the collapse of the Eurozone, and a global recession.

#### **4.9.5 Poor cross-party relations in U.S. politics:**

*Likely critical time period: Varying due to elections. Midterm elections(congress + 1/3 of the senate) in the fall of 2014, and Presidential elections(+1/3 of the senate) in 2016.*

*Market that may be affected: U.S. market, which may quickly spread worldwide.*

The relationship between the two dominant American parties, the Republican and the Democratic Party, has been tense for many years, especially after the rise of the Tea Party over the last couple of years. The level of cooperation across the aisle has been low, and the rhetoric has been aggressive. Negotiations in relations to the heightening of the debt ceiling and the deficit regulation legislation has been so ineffective that the S&P in 2011 downgraded the credit rating to AA+, the first time in history that the US has been graded below AAA. If the political environment in Washington DC does not improve, the US could face increased borrowing costs and further credit rating-downgrades, which again could threaten the dollars position as the reserve currency of the world.

#### **4.9.6 Geopolitical tensions in East Asia:**

*Likely critical time period: Next 3 years.*

*Market that may be affected: East Asian markets, potentially global markets.*

The failed state of North Korea, one of the worst dictatorships throughout the history of the world, is maintaining its aggressive stance towards both its citizens and the outside world. Through either an unlikely revolution by a weakened population, a coup by military leaders, Chinese intervention or a war with South Korea and the United States, the days of the Jong-Il leadership seems to be numbered(Ryall 2014). The Bureau of East Asian and Pacific affairs estimates the size of the North Korean army at about 1,25 million armed men. Combine that with a population of more than 20 million, most of who has been undernourished and brainwashed their entire lives, as well as a China unwilling to allow western influence to establish itself in the north of the Korean peninsula, it is fair to say that major upheavals could rapidly develop into a crisis of global dimensions.

There is also a sovereignty dispute over the Senkaku Islands, a group of small and uninhabited islands in the East China Sea controlled by Japan, and disputed by China and Taiwan. Raised tensions and clashes between the respective countries coast guards has led to strong nationalist movements, especially in China, and analysts fear that an incident may escalate the situation to a level beyond what can be solved by diplomacy.

#### **4.9.7 Economic collapse in Japan:**

*Likely critical time period: In 3-15 years*

*Market that may be affected: Japanese and East Asian markets, may cause a credit crisis similar to that of 2007-2008.*

As stated in the introduction, the outlook for the Japanese economy is uncertain, but they still hold solid credit ratings(S&P: AA-, Fitch: A+ Moody's: Aa3). Similar to U.S. Mortgage securities pre 2007-2008, Japanese sovereign debt is considered extremely low-risk, and the Norwegian Sovereign Wealth Fund is among the institutions that has invested significant amounts in their fixed income-securities. If a scenario were to occur where Japan would either default on their debt or enter a period of hyperinflation, it could lead to a systemic failure similar to what the global economy experienced during the financial crisis of 2007-2008.

#### **4.10 Estimating cross-index relationship for market altering incidents**

After reviewing past incidents and events that may be market altering, the time has now come to estimate the relationship and correlation between the relevant indices, regarding various events with different levels of severities.

When reviewing the historical performance of stock indices, the effect of currency fluctuations has already been included, as all indices has been converted to \$US. When we now wish to estimate future cross-index relationships, a qualitative review of the relevant currency should be included, as there are structural differences that may alter the performance of currency crosses drastically. Using the development of currency crosses during the financial crisis, the Euro rose 14% compared to the \$US, as the credit crisis was caused by a weakening U.S. housing market and domestic economy. As the Lehman Brothers declared bankruptcy, the USD rose 15% compared to the Euro, as investor sought safer holdings in the reserve currency of the world. As for the Eurozone crisis, the Euro declined similarly relative to other major currencies, with a decrease of 15% and 16% against the Canadian and U.S. dollar. Based on this, we may assume that the regional currency of the market experiencing the crisis, may drop 15% against other major currencies, plus an increased demand for \$US if the crisis were to develop into systemic failure.

To better categorize the different events that may cause market alterations, we have separated it into four categories of various severity; Type 1 through 4. For type 3-4, a table listing estimated change in expected index performance in relation to different crisis scenarios has also been listed. Emerging markets have been separated into two categories, where 'EM 1' is major markets on the verge of being considered developed markets(similar to the BRICS), and who plays an important role in the global trade and economy. EM 2 are smaller countries that still has a way to go before being considered developed, and where the potential cross-border spread of domestic problems seems low or unlikely. Note that these are simply qualitative

estimations, meant to give a picture of how such events and crises may alter the values of different financial assets.

*As total return-indices have been used for the bond segments, a flat market development would mean that the total return-index would increase similarly to the monthly yield of the bond. The index performance given in table 4.8.1 and 4.8.2 has therefor included this, and the stated development is relative to what one would expect in a flat market. So if investment grade bonds were supposed to yield 2% over the time span of the crisis, and the total return-index ended up 1%, the relative index performance would therefore equal 1%. The bond indices listed are of a global perspective, and not the same as those listed in chapter 2.5.*

$$(expected\ performance) - (actual\ performance) = (relative\ performance)$$

**4.10.1 Type 1 crisis:** Similar to terrorist attacks and natural disasters, these events hold no direct threat to the macro economy, but may alter other aspects that may lead to long-term effects. If the event were to occur in smaller, developed markets, or in emerging markets, the domestic stock market may react downwards by a magnitude relevant to the severity of the event. This is mostly due to the uncertainty linked to the long-term consequences of the event, as Japan experienced following the earthquake and the following nuclear disaster in 2011. Much of the loss is regained within a few days, as the market regains its confidence.

For major stock markets, the direct consequences for index performance are minimal, but it may decrease index valuation of about -1 to -3% of the domestic stock market, if to occur in a smaller, developed nation.

**4.10.2 Type 2 crisis:** Several events and news are of such a character that it may indicate an oncoming economic crisis, for instance a recession or the collapse of banks or other financial institutions. Examples of such events may be a major financial institution announcing the need for capital or the ECB releasing poor economic data.

Just the incident itself, and the following uncertainty, will cause investors to reduce their risk exposure. This will cause a decline in the high yield bond market, as the investor sentiment shifts towards preferring investment grade-bonds. If this were to happen in a major, developed market, the decline is likely to be in the area between -2 to -4% for the domestic stock index, spreading to other major indices falling between 1 and 3%. If the event were to occur in an emerging market, the decline is likely to be of a much greater magnitude, with a degree of cross-market decline proportional to the size and development of the market of which the event originated.

**4.10.3 Type 3 crisis:** Potentially following a type 2 crisis, as the crisis unfolds, and markets are getting nervous. This may lead to a longer period of volatility, where investors are allocating more of their capital to regions less affected by the ongoing crisis, as well as scaling down their allocation in high risk assets. Investment grade bonds will continue to outperform those of the high yield-segment, and market participants will hold off additional investing in the affected region, as they await

further development of the ongoing crisis. The affected sector/region may be on the brink of systemic failure, facing consequences so severe that financial markets across the world will be deeply affected, and damage financial entities previously considered safe. Government regulators and policymakers are getting increasingly nervous, as they fear an incipient type 4-crisis.

Type 3 crisis								
Country of origin:	Stocks:					Bonds		
	S&P 500	Stoxx 600	Nikkei 225	EM 1	EM 2	Govt.	Invst. Grade	High Yield
U.S.	-12 to -20%	-8 to -20%	-5 to -15%	-4 to -8%	-4 to -8%	1 to 2%	0 to 2%	-10%
Europe	-5 to -15%	-10 to -20%	-5 to -15%	-5 to -15%	-5 to -10%	1 to 2%	0 to -2%	-7 to -10%
Japan	-5 to -10%	-5 to -10%	-20 to -30%	-5 to -15%	-5 to -10%	-1 to -3%	0 to -2%	-6 to -8%
EM 1	-2 to -5%	-2 to -5%	0 to -10%	-10 to -20%	-15 to -25%	+0,5 to 1%	0 to 2%	-
EM 2	-	-	-	-	-1 to -4%	-	-	-

Table 4.10.1, Estimated index decline during a type 3-crisis

For a poor economic development originating in Europe or the United States, the type 3-crisis is likely to develop similarly to what markets experienced in 07-08 and 2010-2012. As the economies of the U.S. and the European Union each makes up a substantial proportion of the global economy(each around 17 trillion \$US), the development of their financial markets is likely to affect global markets substantially. Still, as one could clearly see during the Eurozone crisis(chapter 4.8.2), the main value driver for the S&P 500 is the U.S. economy, and the growth and development of this is more likely to be the focus of attention for U.S. market participants, limiting their correlation with European equity markets.

Regarding Japan, the volatility of the Nikkei 225 experiences a more independent reaction pattern than most major indices, as much of the value drivers are found in the domestic economy(see Table 3.1.2, Correlation between volatilities). Next to this, investors are used to a pessimistic outlook for the Japanese economy, and a poor development here is less likely to cause a widespread sell-off in global stock markets. Investor exposure towards Japan is likely to decrease, including a major decline of the Japanese Yen compared to other major currencies.

When the origin of the issue is located in an emerging market, the investor appetite for emerging market-assets is likely to lessen, as emerging markets are often (incorrectly) viewed as one market sector. The decline of EM 2-markets will probably be of a greater magnitude, due to their riskier nature. As EM 2-countries have generally smaller economies and less developed financial markets, the affect a crisis here may have on other markets is likely to be limited.

For all type 3-scenarios, gold is likely to increase between 2-10% in valuation, depending on the importance of the market where the crisis originated.

**4.10.4 Type 4 crisis:** History shows that at times, the different parties fail to find a solutions to an ongoing crisis, and it will develop into a critical phase, where central

banks and policy makers are left with the responsibility to avoid a total collapse of the economic and financial system. Such an event occurred in September of 2008, as already volatile markets were hit with the bankruptcy of Lehman Brothers. On the day that U.S. stocks hit their low-point, there seemed to be a notion that the path of least resistance were further down(Twin 2009a), and that the market needed some good news. Those news hit the market the following day, as the S&P 500 climbed 6,4% on a report from Citigroup stating that they made a profit over the first two months of the year. It seemed as the market participants felt that stocks had fallen by enough, but they needed a reason to start buying again. Citigroup gave them that reason, and were rewarded with a one-day 38% increase in their stock price(Twin 2009b). Financial news that, isolated, could be considered of low importance, were enough to turn the market sentiment around, as the approximately 50% decline in stock market valuations were considered sufficient.

*A different example of a potential type 4 crisis was one of the possible outcomes of the Eurozone crisis. During 2012, the word “Grexit” was coined, describing the prospect of Greece leaving the Eurozone. Analysts speculated that this may lead to a collapse of the Euro as a currency, and would almost certainly be the end of the Eurozone as we know it today, as several other PIIGS-countries may be forced to exit the Eurozone as well. If ‘Grexit’ were to occur during 2012/2013, this may have led to a systemic crisis similar to what we experienced during the bankruptcy of the Lehman Brothers, and the Type 3-eurozone crisis could escalate into a type 4.*

It is hard to predict the outcome of a type 4 crisis, as the consequences may cause a paradigm shift for the financial industry, or simply lead to a value decrease and a market that restarts their previous methods and ideas from a new market valuation level. Still, estimations have been listed below, to give the reader an idea of how the markets may perform relative to one another.

Type 4 crisis								
Country of origin:	Stocks:					Bonds		
	S&P 500	Stoxx 600	Nikkei 225	EM 1	EM 2	Govt.	Invst. Grade	High Yield
U.S.	-40 to -60%	-40 to -60%	-30 to 50%	-40 to -60%	-30 to 70%	1 to 5%	-2 to -4%	-30 to 40%
Europe	-20 to 40%	-40 to -60%	-30 to 50%	-30 to 50%	-40 to -60%	1 to 5%	0 to -2%	-30 to 40%
Japan	-20 to 40%	-20 to 40%	-40 to -65%	-40 to -65%	-40 to -65%	-3 to -6%	0 to -2%	-30 to 40%
EM 1	-20 to 50%	-20 to 50%	-20 to 40%	-20 to 50%	-30 to 50%	1 to 3%	1 to 3%	-20 to 30%
EM 2	-	-	-	-1 to 3%	-2 to 4%	0 to 2%	0 to 2%	-5 to -10%

Table 4.10.2, Estimated index decline during a type 4-crisis

Similar to a type 3-crisis, the effect on the global economy would be substantial if a type 4-scenario were to occur in either the European Union or the Unit States. Stock valuations would collapse, investors would flee emerging markets and high yield-bonds, and seek safe refuge in safer securities. If ‘ground zero’ of the problem was threatening the Eurozone, the decline in U.S. securities would be limited compared to other indices, due to currency differences and domestic value drivers.

If the Japanese Economy were to collapse as described in section 4.9.7, it is the opinion of the author that the Japanese Yen would experience a fall of a much greater magnitude than what is envisaged for other major currencies. Because of their high debt-ratio, unfortunate demographics and slow economic growth, it is likely that the only option for the Bank of Japan is a zero-interest rate policy with aggressive money printing and quantitative easing. I therefore assume a drop of about 35% of the Yen, compared to other major currencies. Similarly to what happened after the Japanese asset price bubble of 1986, the Nikkei may not rebound as easily from a major downfall, as for example the S&P 500 did after the financial crisis. The long-term structural problems of the Japanese economy, combined with limited options left for policy makers, makes a quick and painless recovery of the Japanese economy highly unlikely. This will also cause a significant decline in the value of Japan's sovereign bonds, which due to their key position in the government bond-segment, will drag down the entire segment by -3 to -6%. High yield-bonds will suffer from investors limiting their risk exposure, causing them to shift their fixed income-allocations towards government- and investment grade bonds.

Similarly to for a type 3-crisis, a type 4 occurring in an EM 2-country will have little effect on major financial markets, even when threatening the domestic stability and financial system. Regarding EM 1-countries, a major crisis in countries similar to China and Russia would cause major decline in global markets, especially due to the increased political instability. The scenario regarding the hard landing in China and the potential property bubble comes to relevance here as this would cause declining commodity prices, limit economic growth worldwide and cause panic in financial markets.

Regarding the price of gold, a price increase in the area of 20-30%(in \$US) would seem likely, as investors will flock to safer assets, not threatened by the structural challenges of financial markets.

#### 4.11 Compositions of a portfolio

Simply basing the composition on 11 years of historical data will give an improper view of future performance, and would make the assumption that the events and trends over the last 11 years will be repeated. Some qualitative limitations are therefore needed, to adjust for presumed risk and other factors not captured by the data set. Underneath, tables have been listed setting the upper boundaries for the proportion of the individual markets and asset classes. These boundaries can be used in a Solver-procedure in EXCEL to determine the maximum proportion each variable can take up. The sum of the variables in each table must total to 100%.

##### 4.11.1 Asset classes

Despite the historical position of gold as a means of payment and a valuable commodity, gold has no intrinsic value besides its use in some electronic components. Similar to Bitcoins(digital currency in a peer-to-peer payment system), the underlying value of gold is no more than what the market determines it to be. Both equity- and fixed income-securities has the coupon payments and the book value and cash flow of a company as the underlying value, given in the monetary asset backed by the government of the currency's nation. Of course, it would be unfair to say that gold and bitcoin is the same type of asset, but one should scrutinize how big a proportion of a portfolio that should be allocated to gold. Gold has also experienced a bull market during this millennium, ending in a negative correction throughout the past twelve months. There is great uncertainty regarding how the price of gold will develop over the coming years, and we should limit the proportion of gold in the portfolio to 20%.

As we assume a long-term time horizon, a large proportion of the portfolio should consist of equity investments. However, to reduce the portfolio volatility, the portfolio should also include considerable bond holdings, as they are characterized by considerably less volatility. We will therefore limit each asset class to 60% of the portfolio.

Market	Share		Limit
Equity	$x$	$\leq$	60 %
Bonds	$y$	$\leq$	60 %
Gold	$z$	$\leq$	20 %
	$x+y+z$	$=$	100 %

##### 4.11.2 Categories within fixed-income securities

The four different categories for fixed income-securities are widely different in both credit risk and the associated risk-premium(yield). As the key results from the market data in table 2.5.9 indicated various performance for each of the categories, it is at first glance unclear how the bond categories should be weighted. We will therefore limit the bond categories that are considered investment grade(*Global Government Bonds* and *Investment Grade Corporate Bonds*) to 70% each. It is clear that high yield bonds are more sensitive to macroeconomic downturns, and characterized

by substantial credit risk. We also found in section 4.8 that they are especially vulnerable during times of widespread declines in financial markets. Several institutions exclude high yield bonds completely from their portfolios, but it will here be limited to 30%.

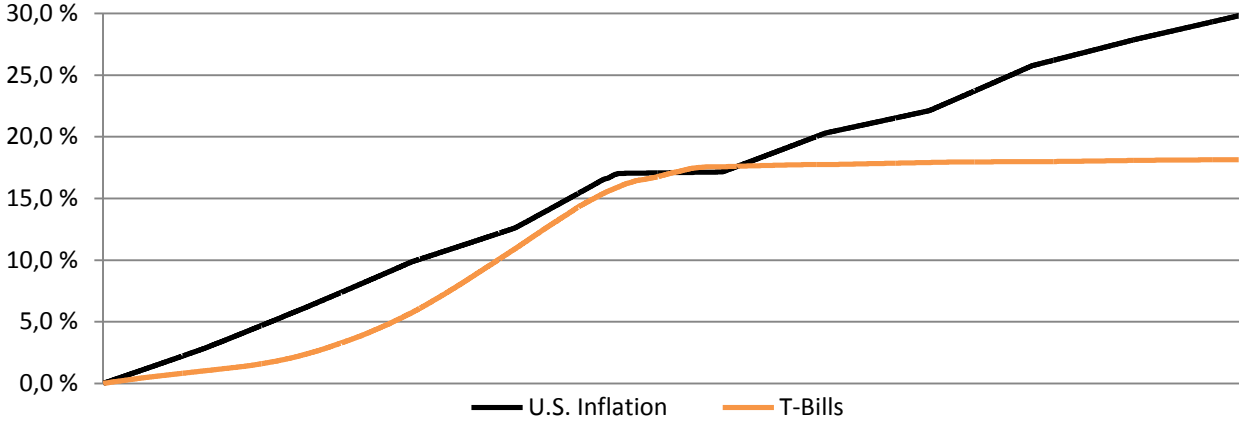


Chart 4.11.1, U.S. Inflation and U.S. Treasury bills, 2003-2013  
 Source: USinflation.org

Due to the low return of Treasury bills, a portfolios holding of the asset will decrease in value due to inflation alone. U.S. Government bonds of varying maturities are included in the Global Government bond index, so the portfolio is still exposed to U.S. sovereign government bonds. But as the short-term Treasury bills have a negative real rate of return, the return of the portfolio would decrease to below the return of the market. During the Weighting-simulations in EXCEL we found that treasury bills were omitted from both the portfolios where the simulation tried to maximize the return and the Sharp ratio, which supports the notion that it is an asset less ideal for a long-term investor. We will therefore omit the risk-free short term treasury bills from the thesis portfolio, after reviewing the return.

One could make the argument that an investor would want to increase its risk-free holdings if a market altering event is expected. However, we have assumed that the incidents and scenarios that may cause a sudden increase in the market volatility are almost impossible to predict, and that if such an incident were well-known to the market participants, the valuation of the market would already adjust to it, causing decreased index values and heightened volatility levels.

Category	Share	Limit
Glob. Govt	$a$	$\leq 70\%$
Invst. Grd.	$b$	$\leq 70\%$
High Yield	$c$	$\leq 30\%$
	$a+b+c$	$= 100\%$

**4.11.3 Geographical diversification**

Developed markets are still the backbone of the portfolios of large institutional investors. Both European and U.S. markets are fairly similar, as they are developed and closely correlated, but faces challenges such as slowing economies and social



inequality. Still, due to their dominant position in global finance, we will limit each of the markets(U.S. and Europe) to 40% each. Regarding Japan, there are so many structural challenges(see the introduction for more information), and it is difficult to remain optimistic regarding the prospects of investing in Japan. Especially considering that the current valuation is still historically high, with a P/E ratio of 19,53. This is why the Nikkei 225 will be limited to 20% of the recommended equity portfolio.

Emerging Markets has experienced periods of high returns, but still holds severe risk due to various factors. One does not want to limit the exposure to emerging markets too much, as these are fast growing markets and may cause an investor having to sell of EM-related asset to reduce the weighting during a bull-marked, missing much of the potential gain. At the same time, due to the different risk factors related to emerging markets, there is a bigger risk of unforeseen incidents causing sudden market fluctuations(such as political unrest, nationalization of assets, etc.). This is especially important for the MINT index, representing markets still in an early stage of development. We will therefor limit the BRICS index to 30%, and the MINT to 20%.

As the Asian index(AC Asia Pacific ex-Japan) consists of a mix of developed and emerging markets, we should apply the same considerations here as above, limiting the index to 25%.

Region	Share		Limit
United States	$m$	$\leq$	40 %
Europe	$n$	$\leq$	40 %
Japan	$o$	$\leq$	20 %
Asia ex Jap.	$p$	$\leq$	20 %
BRICS	$q$	$\leq$	30 %
MINT	$r$	$\leq$	25 %
	$m+n+o+p+q+r$	$=$	100 %

This would result in the following portfolio equation:

$$x(m + n + o + p + q + r) + y(a + b + c) + z = 1$$

When we want to calculate the ideal value of each variable, we have access to the defined dataset for this thesis with index data from the previous 11 years. When utilizing historical data, one could make the mistake that history would repeat itself. This is a dangerous assumption, as other risk factors than market risk are not included, and market trends often fail to repeat itself. Both the price of gold and stock indices of emerging markets have experienced above-average returns over the past eleven years, and it would be unwise to assume that this would reoccur over the following years. If we were to use the return over the past eleven years, and assume that it were to repeat itself, the ideal portfolio would consists of the following:

Equity		Bonds		Gold
60,00 %		20,00 %		20,00 %
of which		of which		
Europe	25,00 %	Inst. Grd	70,00%	
Asia	20,00 %	H.Y.	30,00%	
BRICS	30,00 %			
MINT	25,00 %			
<b>Total return:</b>		330,29 %		
<b>Sharp ratio:</b>		19,46		
<b>Volatility</b>		16,04		

Table 4.11.1, Portfolio weighting when seeking maximized return

This is calculated by using Solver in EXCEL, adding the constraints and calculating the weighting that would maximize the total return. When we take the volatility into account, and using the Sharp ratio(see chapter 2.2) to calculate the risk-adjusted return, we will get the following weighting, when seeking a maximized Sharp ratio:

Equity		Bonds		Gold
25,72 %		60 %		14,28 %
of which		of which		
U.S.	40,00 %	Govt.	0,00 %	
Japan	15,00 %	Inst. Grd	70,00 %	
Asia	20,00 %	H.Y.	30,00 %	
MINT	25,00 %			
<b>Total return:</b>		199,11 %		
<b>Sharp ratio:</b>		22,81		
<b>Volatility</b>		7,93 %		

Table 4.11.2, Portfolio weighting when seeking maximized Sharp ratio

If we assume that each stock index will yield a return equal to the risk-free rate of return plus the corresponding risk premium, each stock index would be an equally good supplement to the portfolio, based on expected return and associated risk. This corresponds to efficient market theory and the Capital Asset Pricing Model. Therefore, the portfolio that is estimated to experience the lowest volatility may be interesting, as it will take the relative relationship between indices into account, and reduce the portfolio volatility. This is calculated in table 4.11.3.

<b>Equity</b>		<b>Bonds</b>		<b>Gold</b>
28,05 %		60,00 %		11,95 %
of which		of which		
US	40,00 %	Govt.	10,39 %	
Europe	25,48 %	Inst. Grd	63,13 %	
Japan	15,79 %	H.Y.	26,48 %	
Asia	14,58 %			
MINT	4,15 %			
<b>Total return:</b>		150,08 %		
<b>Sharp ratio:</b>		18,15		
<b>Volatility</b>		7,31 %		

Table 4.11.3, Portfolio weighting when seeking minimized volatility

As one can see from all three tables above, the weighting equaled the constraints we set for several of the assets and asset classes. When doing the same simulations without any constraints, maximized return could be achieved by investing 100% in MINT equity markets, achieving a 598,99% return with a 21,91% volatility. Similarly, the highest sharp ratio could be achieved with a 95,44% bond weighting, and the rest of the portfolio allocated to gold. The lowest volatility stemmed from a 98,03% bond weighting, with 1,04% in equities and 0,93% in gold. The results are as expected, as equity investments are riskier, but with a higher return. What is more surprising is that the highest Sharp ratio could be achieved by such a high allocation to bonds. The explanation of this lies in the high return and low volatility of the high yield bond index used in this thesis, as the solver model found the ideal bond allocation to be 96,81% in high yield-bonds.

If we were to ideally weight the indices back in 2003, and let them develop over an extended period, some assets will experience higher growth than others, meaning that they will take up a larger part of the portfolio. For example, if the MINT was given a 2,48% weight in 2003, and then let the portfolio sit for 11 years, it would have grown so much that it would have made up 7% of the portfolio by the end of 2013. This can be avoided by rebalancing, setting the asset weighting back to the original weighting. This is now done for our portfolio, to further see the effect of a properly diversified portfolio during market distress. When we wish to rebalance, this is done by setting a base value of 100 for each index every 6 months, and have the portfolio rebalancing itself to the determined weighting. It is here important to remember to incorporate the daily returns and the return over the past six months, so the return of the portfolio will not be returned to 0% every 6 months.

As mentioned earlier, we can assume that the expected return of each stock index matches the perceived risk associated with each index. By assuming this, we calculate the ideal weighting for each stock index, by setting Solver to calculate the weighting that achieves the lowest portfolio volatility, given a 100% equity portfolio. This will then only incorporate each indexes relationship relative to the others, and

avoid emphasizing the actual return of each portfolio over the past decade. The result was the following equity weighting:

	U.S.	Europe	Japan	Asia	BRICS	MINT
<b>% weight</b>	40,00	12,63	20,00	16,81	4,09	6,48

Table 4.11.4, Geographical portfolio weighting

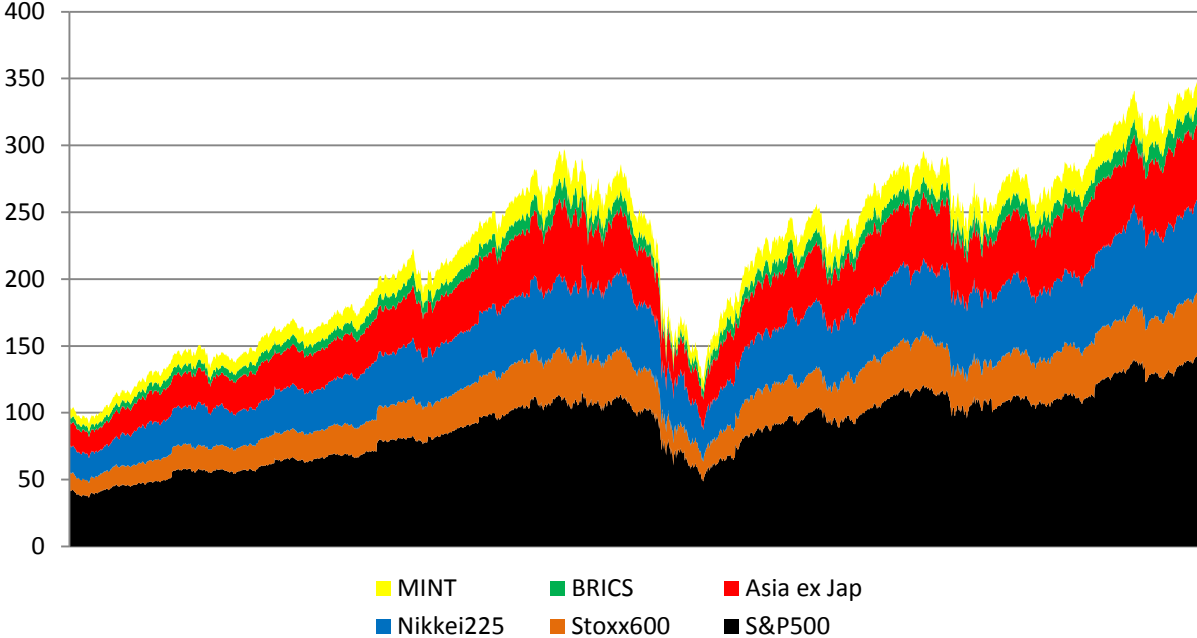


Chart 4.11.2, Cumulative value of a diversified equity portfolio spanning from 2003-2013, with a base-value of 100 in 2003, and semiannual rebalancing.

Then, we test the optimal weighting of the different bond portfolios. One assumption we apply is that global bond markets will develop to closer resemble the bond market of the United States. However, it is natural to assume that the performance of the U.S. bond market somewhat correlates with the U.S. stock market, and we therefore cannot interpret the relationship between U.S. bonds and global equity markets analogously to the relationship between global bonds and global equity markets. This is why we will estimate the optimal bond weighting by using global government bonds and the U.S. corporate bond market, and compare it with the S&P 500. Originally, I wanted to maximize the Sharp ratio, as the relationship between risk and return is much clearer for fixed income-securities. Due to the observations for the Barclays U.S. Corporate High-Yield index, with the high return and the remarkably low volatility, I chose to focus on minimizing the fluctuations, as I believed that the performance data for the index was not representative for the high yield bond segment. In this Solver optimization, we seek the minimum volatility, assuming a portfolio consisting of 50% U.S. stocks and 50% U.S. bonds, allocated to the three mentioned bond indices.

	Glob.Gov	Invst. Grade	High Yield
<b>% weight</b>	17,54	70,00	12,46

Table 4.11.5, Weighting of bond segments

Removing the constraints for investment grade bonds, the ideal weighting would have been 79,29% for investment grade bonds. An explanation for why the combination of investment grade corporate bonds and U.S. stocks were so good at lowering portfolio volatility could be how market participants often switch from one asset to the other based on their appetite for risk and how they expect the markets to perform. As two large, liquid and effective asset markets with thousands of market participants, institutional investors may prefer to alter allocations between the two as their market outlook changes.

Due to the high return the price of gold has experienced over the past decade, it would be unwise to use this price development to calculate a Sharp ratio used to estimate a portfolio weighting suitable for the coming years. At the same time, the volatility- and return-characteristics of equity- and bond indices are so different, that simply seeking the lowest volatility would fail to incorporate several aspects of the portfolio. This has been solved by first calculating the ideal weighting between just stocks and bonds, based on the findings in table 4.11.4 and 4.11.5, and then using this to calculate an asset weighting including the price development of gold.

So the first procedure is to try to maximize the Sharp ratio, based on the variables in table 4.11.4 and 4.11.5, by weighting the different asset classes of stocks and bonds. We found the ideal relationship to be 41,95% stocks and 58,05% bonds. These values were locked proportional to one another, and gold was included in the portfolio, seeking the lowest possible volatility for the portfolio. By doing this, the risk/return characteristics of stocks and bonds could be included, while omitting the substantial price increase gold has experienced so far this millennium. The result was the following weighting of asset classes:

	Equity	Bonds	Gold
% weight	38,36	53,08	8,57

Table 4.11.6, Weighting of asset classes

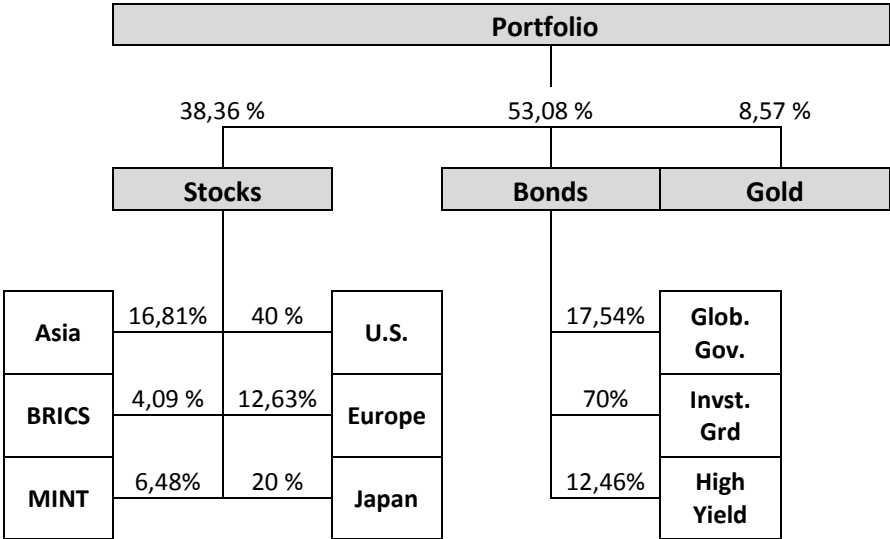


Chart 4.11.3, Composition tree, showing the optimal portfolio weighting

#### 4.12 Portfolio performance and volatility during type 3- and 4-scenarios:

The portfolio with the weighting found in the previous section shall now be tested, both over the historical data, and the estimated index performance for some selected crises, corresponding to those mentioned in chapter 4. The thesis portfolio will also be tested against a reference portfolio, where the reference portfolio of the Norwegian Sovereign Wealth Fund is to be used. The fund applies a hypothetical portfolio consisting of 60% equity and 40% fixed-income securities(NBIM 2014c), to compare their returns to the global markets. The equity allocations are 32,5% in the United States, 43,5% in Europe, 7,3% in Japan, 'Asia ex Japan' is 10%, while the BRICS countries consists of 6,7%. The global bond market will be represented with the BofA ML Global Government Bond Index, and will make up 40% of the index.

*After real-estate was included as a possible investment for the fund, the new reference portfolio consists of 39% fixed income-securities and 1% real estate. However, as real estate is omitted from the thesis portfolio, it will also be omitted from the reference index.*

When trying to predict future price fluctuations of financial securities, "guesstimate"(an educated guess) may be a more appropriate word than estimate, as there are literally millions of factors that may alter the stock market at any given trading day. Still, by using the volatility correlations from table 4.2.2 and the volatility values from tables A.1 to A.4, combined with the qualitative estimations for crisis scenarios, a theoretical development and relationship can be plotted.

#### **Industry insight:**

Everything from astrology to sports results are currently used as pseudoscientific indicators of where the stock market may move in the short-term future. Perhaps the most untraditional approach known to the public is a small one-man hedge fund in the U.S., with an approach made famous during the first season of the TV documentary series 'Wall Street Warriors', where migratory patterns of African elephants were used to indicate whether the future market developments would be that of a 'bear' or a 'bull' market(WSW 2006).

I have applied the middle values for the different scenarios from table 4.10.1 and 4.10.2, except for China(4) where values from the top of the interval has been selected, and Russia(4) where some of the values has been adjusted downwards. As the Asian index in question(MSCI AC Asia Pacific ex Japan) consists of a mix of markets in a various levels of development, ranging from the developed markets of South-Korea to the underdeveloped markets of Vietnam and the Philippines, the index has been given the same scenario values as the BRICS index. Three scenarios from type 3-crisis' and four scenarios from Type 4 has been listed below, and the portfolio performance tested throughout each scenario.

- France(3): A new debt crisis in the Eurozone, as France is hit with a recession and a spike in sovereign debt interest rates(4.9.4).

- China(3): A crash in the Chinese housing market, and a contracting economic growth(4.9.2).
- Japan(3): Unsatisfactory economic development following Abenomics, combined with a declining Yen and increased interest rates on sovereign debt(4.9.7).
- China(4): The China(3) crisis develops, as the government fails to stop the selloff, leading to panic in domestic financial markets, recession, and political instability.
- Japan(4): Could develop rapidly, as the Japan(3) escalades into investors reducing their exposure to Japan, and markets starting to realize that the structural challenges are unsustainable in the long term.
- Russia(4): Tensions between western countries and Russia escalates into a full trade embargo, causing a collapse in the already weakening Russian economy, leading to civil unrest and Putin sending in the armed forces to put down the uprising. Both foreign and domestic tensions cause a tremendous amount of pressure on the current government, leading to global uncertainty regarding what the nuclear state will do next(4.9.1).
- United States(4): An inefficient political system causes global markets to lose faith in the U.S. dollar as a safe-haven, and a collapse in the currency follows. Increased sovereign debt interest rates leads to a massive increase in debt expenses, and the government is required to cut back on government spending, causing a recession(4.9.5).

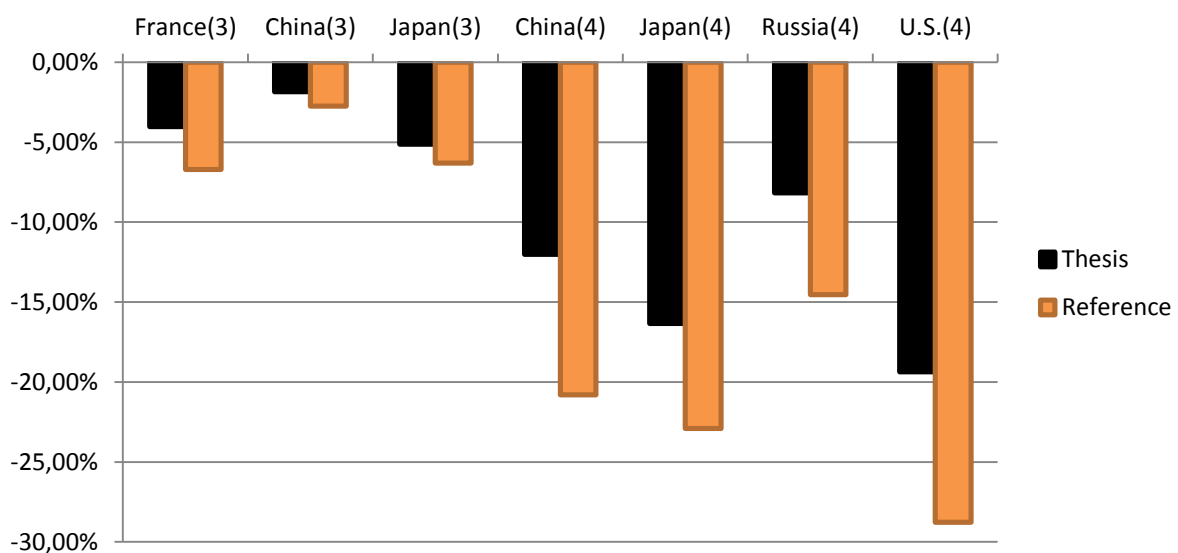


Chart 4.12.1, Estimated portfolio performance for crisis scenarios

For all scenarios, the reference portfolio experiences a greater decline in value, despite omitting MINT-stocks, investment grade bonds and high-yield bonds. This is

likely due to the thesis portfolios considerably higher allocation to bonds and gold, than for the reference portfolio. When reviewing the crisis-specific performance, it is clear that the thesis portfolio is a better suited asset weighting than the reference portfolio. Note that this is based on the estimated portfolio performance founded on qualitative variables and the subjective analysis of the author, and may project unrealistic measurements. One should also see whether the return of the portfolio suffers, due to the reduced risk exposure.

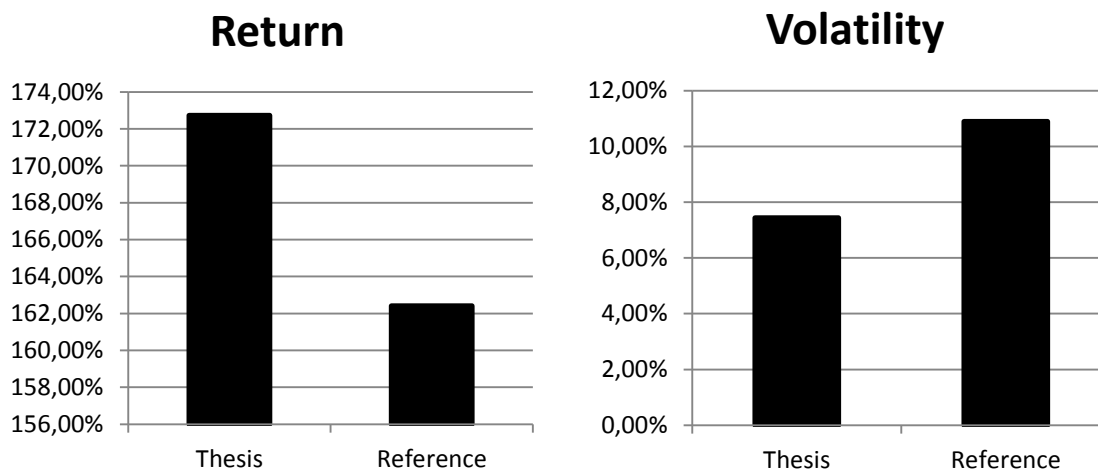


Chart 4.12.2, Historical return and volatility for thesis- and reference portfolios

The portfolio with the weighting calculated in section 4.11 achieves an increased return of almost ten percentage points, while still achieving a lower volatility. One explanation may be the higher allocation to investment grade corporate bonds, and so we tested the portfolio performance when 50% of the government bonds are replaced with investment grade corporate bonds. The return then increased from 162,40% to 167,77%, and the volatility decreased from 10,89% to 10,57%, but this was still far below the volatility adjusted return of the portfolio.

An explanation for the higher return and lower volatility may be how the calculations used to weight the portfolio are done by optimizations based on the same historical data we used to test the performance. Even though the asset allocation has been adjusted, so that previous returns are to be ignored for equity indices and gold, the cross-index volatility relationships has still been included in the calculations, meaning that the portfolio volatility should be expected to be lower than for comparable portfolios.

#### 4.13 Calculating index parameters, and estimating volatility using GARCH(1, 1)

We apply the equation for GARCH(1, 1):

$$\sigma_n^2 = \gamma V_L + \alpha u_{n-1}^2 + \beta \sigma_{n-1}^2$$

$\gamma$ ,  $\alpha$  and  $\beta$  are the weights assigned to the variables, and as the sum of the weights must equal 1, so  $\gamma + \alpha + \beta = 1$ . To simplify, we will set  $\omega = \gamma V_L$ , resulting in the equation



$$\sigma_n^2 = \omega + \alpha u_{n-1}^2 + \beta \sigma_{n-1}^2$$

And to further simplify calculations:

- $\gamma = 1 - \alpha - \beta$
- $V_L = \omega / \gamma$

To increase robustness of the model, we can calculate the long-term variance from the historical data, so that the model only has to determine two parameters. The EXCEL model will have the following columns:

- Column 1:  $S_i$ , the daily value of the index we are examining.
- Column 2:  $u_i$ , the percentage change from  $S_{i-1}$  to  $S_i$ .
- Column 3:  $v_i$ , the estimate of the variance rate, where the GARCH(1, 1) equation is applied, using the variables from column 2 and 3 on day  $i-1$  to find the  $v$  for day  $i$ .
- Column 4: Here, we apply the likelihood measure from section 2.4.3, with the formula  $-\ln(v_i) - \frac{u_i^2}{v_i}$

Parameters			
$\omega$	4,0254E-07	>	0
$\alpha$	0,327703585		
$\beta$	0,641675632		
$\gamma$	0,030620783		
VL	1,31459E-05		
<b>Long-term Volatility</b>			
	0,3626 %		
$\gamma + \alpha + \beta$	1	=	1
$\alpha + \beta$	0,969379217	<	1
<b>Value of function:</b>	32061,03759		

In the output panel, we sum up all the values from column 4 in the cell called *Value of function*. The values in column 3 and 4 are based on current trial estimates of  $\omega$ ,  $\alpha$  and  $\beta$ . By using the Excel Solver Add-In, we can set the *Value of function* as a target cell, and set it to be maximized by altering the cells  $\alpha$  and  $\beta$ . We will then get the *maximum likelihood estimator* of the parameters  $\alpha$  and  $\beta$ , which we will use in the GARCH(1, 1) equations.

Output Panel for the Barclays U.S. Corporate High-Yield

The output panels showing the parameters for all the relevant indices are pasted into appendix B at the back of the thesis. We find that all stock indices have fairly similar  $\alpha$  and  $\beta$  values, and that all indices were stable GARCH(1, 1) processes, as the sum of  $\alpha$  and  $\beta$  were smaller than 1.

I realized that it may be a good idea to test the parameter values from Appendix B, as the legitimacy of the  $\alpha$  and  $\beta$ -values for each index are hard to interpret by themselves. I therefore plotted the historical volatility of the S&P 500 following the height of the financial crisis, together with the estimated volatility values for the same index found by the GARCH(1, 1) equation and the parameters we found earlier.

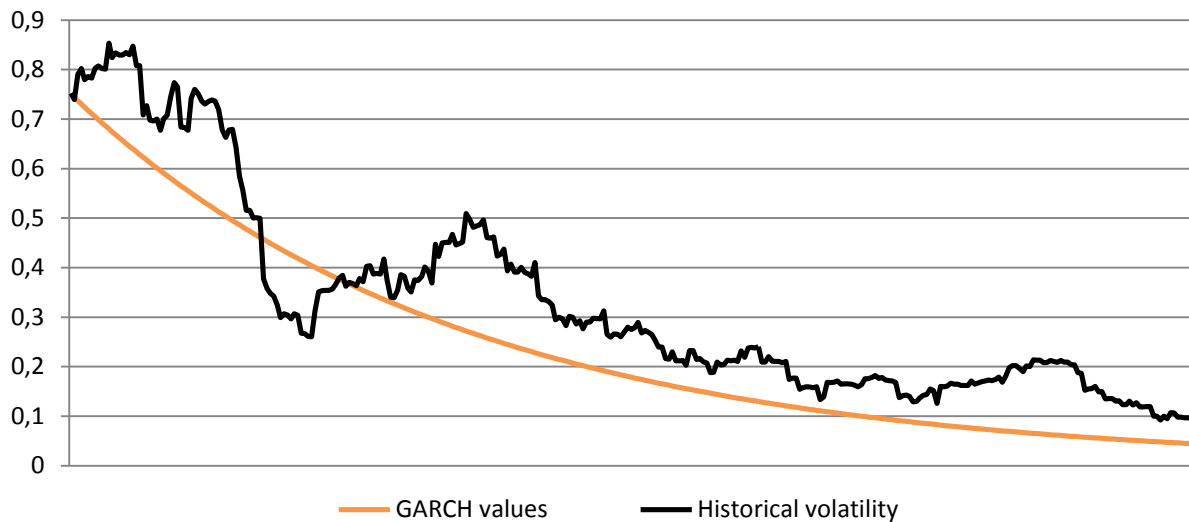


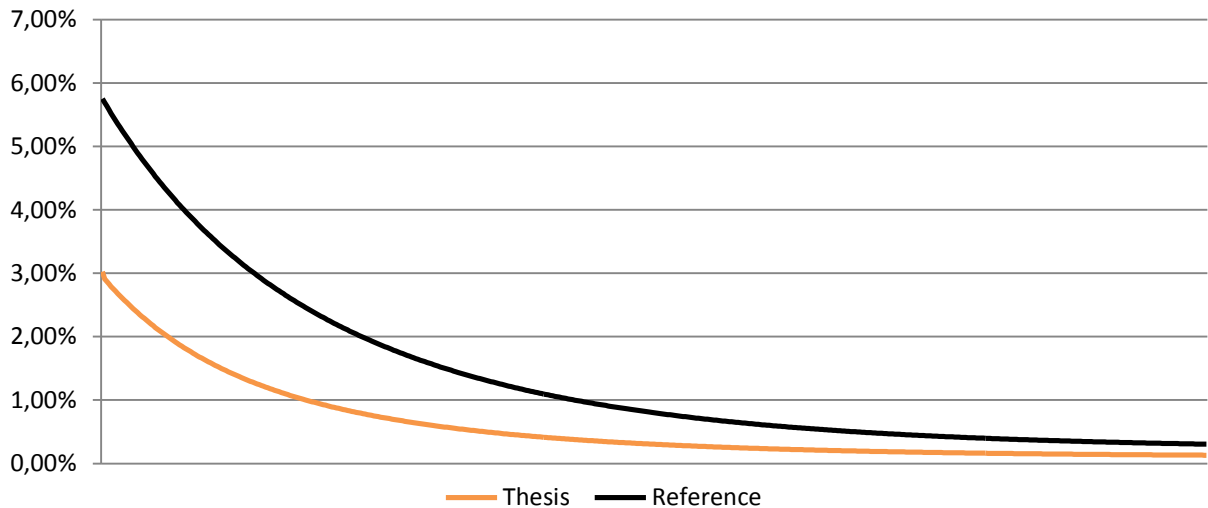
Chart 4.13.1, GARCH values and historical volatility of the S&P 500 from the height of the financial crisis, and the next 300 trading days

One can see that the GARCH values give a fairly good approximation of the historical volatility of the S&P 500 following the height of the financial crisis, giving us no indication that the GARCH(1, 1) parameters are incorrect.

Using the GARCH(1, 1) equation, and the parameters in appendix B, one may calculate the long-term development of the portfolio volatility. Due to how the financial crisis of 07-08 affected all global markets, and led to increased volatilities worldwide as it had the potential to affect economies in all corners of the world, the volatility values from tables A.3 and A.4 will be used as volatility values for day  $t_0$ . The square of the volatility at day  $t_0$  will equal  $\sigma_n^2$ , and can be inserted into the estimation-formula we found in chapter 2.4:

$$E[\sigma_{n+t}^2] = V_L + (\alpha + \beta)^t(\sigma_n^2 - V_L)$$

To account for how some assets increased in valuation while others declined, I will use the negative values of the volatilities of those assets that increased in value during the financial crisis. Due to the stochastic movement of asset prices, it is impossible to calculate the portfolio volatility on the background of daily changes for each individual asset, and I will rather find an approximation of how the overall portfolio may develop during the crisis, including both the magnitude and direction of price movements for each asset. So the chart below does not show the actual volatility values, as this would require knowing the daily changes of each asset, but it indicates how the value of the portfolio may fluctuate during the crisis and its aftermath.



*Chart 4.13.2, 30 day variance of thesis- and reference portfolio following volatilities similar to that of the financial crisis, and the next 500 trading days.*

It showed that the thesis portfolio would experience less value fluctuations, and would faster return to levels similar to the historical average. This is likely due to a higher allocation to assets that may move independently against, or even opposite of, global equity markets. It supported the notion that a higher allocation towards bonds and gold will reduce the portfolios sensitivity to global equity markets. I also tried including more investment grade-bonds in the reference portfolio, but found minimal change in the GARCH-values, likely due to the high correlation between investment grade corporate bonds and sovereign government bonds.

## **Chapter 5: Discussing the results and potential shortcomings, as well as potential sources of error**

Regarding the portfolio composition, it may seem odd that such a high proportion of the portfolio should be allocated to fixed income-securities, especially considering the low interest level we are currently experiencing. As stated in Chapter 1, the current bond market seems to yield a real rate of return that can be considered unsustainable for an investor, when considering the prospect of declining bond prices as interest rates increases towards historical averages. However, corporate bonds traditionally experiences higher yield than sovereign bonds, and a higher allocation to this and high yield-bonds may increase the return to sustainable levels. On May 17, Ben Bernanke (currently 60 years old) was quoted saying that he did not believe that interest rates would reach the historical average of 4% in his lifetime (Spicer 2014). Even though Bernanke currently holds no position where he can make policy altering decisions, he has worked with Chair Yellen for several years, and probably has more insight into the plans and processes of the FOMC, than most people in the world. He indicated that interest rates will remain relatively low for years to come, which would improve the short-term outlook for the bond market. Stock markets may be due for a correction, and a more positive outlook for the bond market would allow a larger proportion of the portfolio to be allocated to fixed income-securities.

If interest rates were to increase over the following years, continuous investments into fixed-income securities will yield a higher and higher return, so the overall return of the portfolio would in the long-term gain from higher interest rates, even though current bond-holdings may see periodic declines in value. We can therefore justify how increased bond holdings are a recommended investment decision, despite the current low-level interest regime.

When looking at potential sources for error, the relative fluctuations between indices should be interpreted with a high level of uncertainty, as the dataset may not be interpreted analogously from one index to another. There are millions of value drivers every day in the stock market, and smaller events and rumors may alter market to a degree that is hard to omit from the dataset. As the portfolio is denoted in \$US, currency changes may cause an increased volatility for non-U.S. assets, which may alter the perceived market risk, especially when investors are seeking safer assets during times of turmoil. This is in reality currency risk, and not market risk, but as the portfolio value would be given in \$US, it is still necessary to include.

As the index data has been limited to a given time span, the start- and end-date is an important factor for the overall performance of each index. At the beginning of 2003, markets were still recovering from the internet bubble, and a 4 year bull market followed. Same for the end of the dataset, as the S&P 500 has been through a 5-year bull market, ending 2013 up 29,6%. On the other hand, the MINT index dropped

11,8% last year, and if the relevant dataset ended on December 31<sup>st</sup>, 2012, the performance of the different indices would look very different.

As aforementioned in section 4.5, the varying opening hours of different markets may also affect the degree that markets interact, especially as the different regions are often watching the development of the markets in other regions. This, combined with domestic value drivers spanning from key economic data to news and rumors regarding individual companies, causes a high degree of uncertainty when analyzing cross-market relationships.

Regarding the compositions of the indices, some sub-indices may not be representative for the entire asset segment. This was a major concern for the high yield-bond segment, as the Barclays U.S. Corporate High-Yield Index may not have been representative for the entire junk bond-segment. The high return and low volatility for the index seemed unlikely to be representative for the entire segment, and constraints were added to limit the percentage of portfolio allocation devoted to high yield-bonds.

Gold as an asset may be unsuited for a portfolio, especially considering its lack of intrinsic value. Gold is currently regarded as a safe haven, and has a tradition of being a low-risk asset used for personal savings, especially in countries with underdeveloped financial systems, where citizens struggle to trust banks. Gold has no periodical yield, unlike bonds(coupon rate) and stocks(dividends), and actually has prices more volatile than the stock market. In addition, it gives no protection against inflation. There is currently no reason to expect that gold's position as a popular investment asset is threatened in any way, but an investor might still want to pay attention to future developments.

## Chapter 6: Conclusion

Volatility is still viewed as the most important variable in measuring market risk, and its position is likely to be uncontested for years to come. Even though it is clear that the measurement is mathematically insufficient to give a comprehensive view of the exposure to market risk, its solid position in modern day finance makes it an important variable for any investor or fund manager. Private portfolios and institutional investors less affected by regulations and the satisfaction of customers (closed end funds etc.) may profit from this, as increased volatility may lead to self-reinforcing declines in market valuations. When applying periodically portfolio rebalancing, one will still see the importance of a low-volatility portfolio, as the reallocation of assets to increase risk exposure may yield a substantial profit as the market rebounds after times of economic uncertainty.

A closer look at index performance and correlation, using daily data for different financial indices from all over the world, was done to get a clearer understanding of the relationship between geographical regions and asset classes. To make the data range as appropriate as possible, we limited the data to the years 2003-2013, so to focus on the modern day era of internet based trading and information flow.

A qualitative analysis of the historical return led to a volatility-focused optimization, as both the price of gold and the value of emerging market-equities has experienced a substantial return over the past decade, well above their historical averages. The same review had to be done regarding the risk associated with the different markets, as several regions are exposed to risk factors other than market risk. Good examples of such risk factors that accounts for a substantial proportion of the risk exposure in less developed markets, are political uncertainty and geopolitical tensions that may alter the stability of a nation's economy.

Naturally, one would rather be able to avoid volatility all together, rather than focusing on reducing it. Chapter 3 therefore focused on whether one may be able to foresee changes in volatility, based on a variety of economic data and financial ratios. This is assumed to be unlikely, as such an indicator would automatically adjust the behavior of the market participants. Through qualitative and graphical analysis, the conclusion was that there was no direct indicator found in the data that could be utilized to predict an alteration in volatility levels. However, some signs were found that could indicate that the market is currently overvalued, and that a downward correction may be due. Especially the price of commodities, compared to the price of equities, are showing trends similar to what markets experienced before the Internet bubble of 2000-2001.

When analyzing the regional differences and the effect of diversification, a special focus was directed towards negative and potentially market altering events, where we found that the magnitude of the reaction of the market largely depended on the ability to absorb the consequences of the event for the domestic economy. This led to larger economies with well-developed financial markets, such as the United States,

experiencing little or no decline in stock index valuations when incidents with potentially serious consequences were to happen. On the other hand, developing economies are more prone to external factors, as their economies and political stability are often more sensitive. These occurrences could also spread on a global scale as potential consequences for macroeconomic factors could also lead to increased uncertainty in other markets not directly affected by the event in question. Market uncertainty was more prone to spread to neighboring countries, if the market altering event had the potential to severely affect the economies of those nations. Similarly, problems originating in major, global economies, have the potential to spread worldwide, due to the implication it could have on the global economic growth. For the crises in question, there was also a reoccurring trend that financial markets often regained much the losses within days, as the increased uncertainty caused market participants to unload risk, and then regain faith in the market as more information regarding the incident became available.

Throughout the thesis, the different segments within asset classes were compared, both the long-term trends and the price movements during periods of increased uncertainty. When comparing blue-chip stocks with stocks of the Small-Cap segment, we found a relatively linear relationship, as the indices experienced a 0,985 Correlation Coefficient, and similar patterns throughout both bull- and bear-markets. The S&P 600 Small-Cap experienced similar reactions as the DJIA, but with a higher magnitude, as the smaller companies are considered riskier than those of the Dow Jones Industrial Average.

The same relationship did not occur for the different bond segments that we compared, as their performance differed widely, depending on the market trend and the markets willingness to take on risk. Sovereign Government bonds and Investment Grade Corporate Bonds experienced similar reaction patterns, where corporate bonds returned a higher yield overall, but government bonds performed substantially better during periods of declining financial markets and investor uncertainty. High yield-bonds returned far better than the other two segments of fixed income-assets, but were considered highly sensitive to risk-averse markets. Especially during what we defined as “type 3” and “type 4” crises scenarios, high yield-bonds experienced movements similar to the opposite of the VIX index, as the implied volatility increased with the uncertainty of the market participants, causing them to reduce their risk exposure by reducing their holdings in high yield-bonds.

Calculations and estimations were done, based on a quantitative view of the future, with a qualitative analysis of the years to come, and an ideal portfolio weighting was calculated with the aim of minimizing the volatility while still achieving above-market returns. The calculations indicated that a large proportion of the portfolio should be allocated to investment grade corporate bonds, well above what was expected when we compared it to Norway’s Sovereign Wealth Fund. An equity allocation of less than 40% may seem substantially smaller than what is normal, especially when considering the Yale-model from section 1.4, but the simulations still

found a superior portfolio performance when using the weighting found in the optimizations in chapter 4. This could be an indication that the fund, as well as other major, institutional investors, should restructure their mandate, and that by including riskier assets such as high yield-bonds and gold, as well as equity investments in less developed nations, may achieve higher return, while a higher bond allocation will prevent an increased risk exposure.



## Afterword

Both U.S. and European markets ended the thesis' work period of 4 months with a similar growth of about 7%, which may seem surprising as the economies of the Eurozone are still retrieving lost growth from the Eurozone crisis, while the general consensus seems to be that U.S. stocks are overvalued (Faber 2014) (Sjolin 2014). Both developed and emerging markets are still watching the situation in China, as there is still considerable uncertainty related to the real estate-market and the "soft landing" of the economy. A lack of transparency causes unpredictability, and global markets are currently considering the development as a potential source for a future Type 3- or Type 4-event (Chiang 2014).

One of the most important events, attracting the attention of global financial markets, was the conflict on Crimea, and the following unrest in Eastern Ukraine. After the Ukrainian Revolution in February, pro-Russian forces began to establish themselves on the Crimean peninsula, which has a large ethnic Russian majority. Crimea declared their independence from Ukraine, and declared itself as a part of the Russian Federation on March 18<sup>th</sup>, a decision not recognized by the UN or the EU. The MICEX fell 10,79% on March 3<sup>rd</sup>, as tensions grew and investors started fearing international sanctions (Egan 2014). Similar to previous events reviewed in this thesis, and consistent with previous findings, it rose by 5,2% the following day, as investors regarded the fall of the previous day as an overreaction after Putin calmed markets by stating that war was the last resort (Warden 2014). Major stock markets fell around 1% following the escalation of the conflict around March 3<sup>rd</sup>, and even though the conflict had little direct effect on the global economy, the uncertainty related to the potential global conflict limited the growth of global stock markets (Yousuf 2014). Especially the uncertainty regarding the energy supply for the European Union, and the fear that Putin would use Russia's gas-exports as a means of coercion, caused market participants to closely follow the development in Eastern Ukraine (Mazneva & Bierman 2014).

Another major, political event of the spring occurred in South East-Asia, as Thailand's armed forces launched a coup d'état on 22<sup>nd</sup> of May, and a military junta dissolved the government and overtook executive and legislative powers. The domestic stock market experienced declining valuations and a period of increased volatility, but this had limited to no effect on the market of neighboring countries (He 2014), corresponding to previous findings in this thesis.

Bond indices experienced low volatilities and steady returns, as the past months were relatively eventless when considering the macroeconomic outlook of developed markets. Russian Government bonds declined, but the overall sovereign bond-segment remained stable. Markets are currently focusing on the ongoing tapering from the Federal Reserve, and analysts fear that the tapering in the fall of 2014 could lead to markets performing more in line with the economic fundamentals, causing a decline in valuations (Lyster 2014).

## References

The references are listed alphabetically, in correspondence with the reference given in the thesis. This means that when referring to 'Options, Futures and Other Derivatives' by John C. Hull, it will be listed under "H" for Hull, as this is the reference used in the text.

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## Appendix A - Tables for price movements during crisis' and fluctuations

Data observations have been skewed to account for time differences, so that the market reaction from the first day the market is open after the incident occurred, is used. For example, if an incident happened Tuesday afternoon in Europe, Index data for Wednesday morning in Asia is applied. If an incident occurred over the weekend, all indices use the data for Monday.

### The Financial Crisis of 2007-2008

To refine the time period in question, we define the financial crisis to start on August 9<sup>th</sup>, 2007, and use the data set until March 9<sup>th</sup>, 2009. Underneath, I have listed how the value of the index changed during the time period, as well as the correlation between the indices and the S&P 500. I have also calculated a  $\beta$ , where data observations has been listed for all indices for days corresponding to trading days in the United States with market drops of more than 3%, or following a significant event or announcement.

*Note that Asian data observations used to compare US data from day "i" are from day "i+1", due to opening hours of the markets.*

There has been to template for all tables, as each crisis has required different variables to be analyzed. The nature and dynamic of each event has varied greatly, and a quantitative analysis is needed to consider what data to include for each crisis.

	S&P 500	STOXX 600	Nikkei 225	Asia ex Jap	BRICS	MINT	World	DJIA	S&P 600
	<i>Aug 9th, 2007: BNP Paribas suspends mortgage debt funds:</i>								
Index:	2264,5	172,9	186,1	854,2	590,1	545,1	4754,5	21759,02	461,67
	<i>March 9th, 2009: Global stock markets reach their lowest level in over a decade:</i>								
Index:	1095,0	70,8	94,5	389,8	297,7	225,1	2196,9	11239,3	209,3
$\Delta$	-51,6 %	-59,1 %	-49,2 %	-54,4 %	-49,5 %	-58,7 %	-53,8 %	-48,35 %	-54,66 %
Corr	-	99,0 %	97,9 %	97,4 %	94,4 %	96,8 %	99,6 %	99,75 %	97,91 %
$\beta$		0,78	0,67	0,74	0,98	0,78	0,83	0,88	1,02

Table A.1, stock indices during the financial crisis of 2007-2008.

	S&P 500	Gold	US Treas	GlobGov	Invst.Grd.	High Yield
	<i>Aug 9th, 2007: BNP Paribas suspends mortgage debt funds:</i>					
Index:	2264,5	664,6	1661,2	219,9	198,0	787,4
	<i>March 9th, 2009: Global stock markets reach their lowest level in over a decade:</i>					
Index:	1095,0	918,6	1709,6	243,5	203,2	555,9
$\Delta$	-51,64 %	38,2 %	2,91 %	10,73 %	2,63 %	-29,40 %
Corr	-	-17,2 %	-78,29 %	-48,08 %	17,46 %	94,67 %
$\beta$	-	-0,10	0,00	-0,09	-0,07	0,19

Table A.2, asset classes during the financial crisis of 2007-2008.

Avg. Volatility	S&P 500	STOXX 600	Nikkei 225	Asia ex Jap	BRICS	MINT	World	DJIA	S&P 600
2003-2013	16,37 %	19,99 %	21,72 %	18,02 %	21,05 %	19,17 %	14,21 %	15,16 %	21,08 %
During crisis	30,45 %	31,94 %	32,04 %	33,34 %	38,51 %	29,63 %	23,92 %	27,99 %	34,09 %

Table A.3, stock index volatility during the financial crisis

Avg. Volatility	S&P 500	Gold	US Treas	GlobGov	Invst.Grđ.	High Yield
2003-2013	16,37 %	18,15 %	0,06 %	6,49 %	5,41 %	3,79 %
During crisis	30,45 %	26,37 %	0,01 %	8,19 %	7,62 %	7,75 %

Table A.4, bond index volatility during the financial crisis

### Eurozone debt crisis

Similar to the financial crisis of 07-08, this crisis developed over several months, so it is hard to determine the real cross-market effect. I chose to follow a similar procedure as the financial crisis, making a table showing key data for each index compared to STOXX 600. The observations are based on daily data for days when the STOXX 600 saw severe declines(>2%).

In addition to the main indices used in this index, I have compared the Euro Stoxx 50(large-cap Eurozone) index with the FTSE 100(London) and the SMI(Switzerland), to compare how neighboring countries with closely intertwined economies react to uncertain markets. I have done this as a separate comparison, as the STOXX 600 includes both the Eurozone, and developed European markets such as the FTSE 100 and the SMI.

*In the aftermath of the earthquake and tsunami in Japan in March 2011, global markets experienced large volatilities on March 15th. These have been left out of this dataset, to avoid statistical noise caused by the catastrophe. I have also applied Asian market data for day "i+1", similar to the procedure for the financial crisis.*

	$\Delta$	Corr. with STOXX 600	Volatility Correlation	$\beta$	Avg. Volat.	Vol. during crisis
<b>STOXX 600</b>	6,35 %	-	-	-	19,99 %	25,55 %
<b>S&amp;P 500</b>	21,36 %	71,59 %	84,70 %	0,52	16,37 %	18,31 %
<b>Nikkei 225</b>	8,46 %	76,14 %	23,36 %	0,39	21,72 %	20,16 %
<b>Asia ex Jap</b>	8,44 %	96,08 %	91,17 %	0,28	18,02 %	19,81 %
<b>BRICS</b>	-2,23 %	86,22 %	93,42 %	0,63	21,05 %	25,58 %
<b>MINT</b>	18,03 %	83,71 %	86,02 %	0,57	19,17 %	18,91 %

Table A.5, Global equities during the Eurozone crisis

	$\Delta$	Corr. with Eur.Stx.50	Volatility Correlation	$\beta$	Avg. Volat.	Vol. during crisis
<b>Euro Stoxx 50</b>	-6,82 %	-	-	-	28,30 %	31,60 %
<b>FTSE 100</b>	13,11 %	90,91 %	93,72 %	0,71	19,70 %	23,18 %
<b>Switzerland</b>	16,01 %	92,00 %	92,46 %	0,04	17,75 %	20,09 %

Table A.6, European equities during the Eurozone crisis

<b>Bond Indices during the Eurozone crisis</b>					
	<b>Glob Gov</b>	<b>US. Invst.</b>	<b>US. HY.</b>	<b>EUR. Invst.</b>	<b>Eur. HY.</b>
Performance 2003-2013					
Avg. Volatility	6,49 %	5,41 %	3,79 %	7,96 %	10,78 %
Ann. Return	5,09 %	6,48 %	11,75%	12,43 %	13,42 %
Performance during Eurozone crisis, 2012-2012					
Avg. Volatility	4,95 %	4,46 %	2,40 %	4,51 %	9,63 %
Δ index	13,61 %	17,29 %	21,16%	15,83 %	13,46 %

Table A.7, bond indices during the Eurozone crisis

### The Japan Earthquake

- The earthquake struck on 11:46 local time, off the coast off Japan. As this catastrophe developed over the following days, it became clear just how serious the consequences of the quake were.

Daily changes	Nikkei 225	Stoxx 600	S&P500	Asia ex Jap	BRICS	MINT	Thailand	Australia	Gold
11.3.2011	-0,25 %	-0,60 %	0,74 %	-1,24 %	-0,26 %	-0,29 %	-1,79 %	-0,58 %	0,16 %
14.3.2011	-6,17 %	-0,09 %	-0,60 %	0,48 %	0,72 %	0,98 %	2,31 %	-0,17 %	1,22 %
15.3.2011	-10,14 %	-2,34 %	-1,13 %	-3,04 %	-1,83 %	-1,38 %	-2,54 %	-3,72 %	-2,14 %
16.3.2011	6,30 %	-1,88 %	-1,97 %	0,76 %	-0,20 %	-0,91 %	0,65 %	-0,07 %	0,24 %
17.3.2011	0,37 %	2,57 %	1,33 %	-0,98 %	-0,70 %	-0,80 %	-0,37 %	-0,26 %	0,23 %
18.3.2011	-0,30 %	1,04 %	0,43 %	1,11 %	0,41 %	0,16 %	0,24 %	2,73 %	1,10 %
Δ 01.4.2011	-7,57 %	3,47 %	2,97 %	5,23 %	6,43 %	5,84 %	5,55 %	7,33 %	1,22 %
Δ 02.5.2011	-0,90 %	11,22 %	5,31 %	9,38 %	5,61 %	9,17 %	10,62 %	13,40 %	9,10 %
Volatility on march 10th									
	15,59 %	12,11 %	15,15 %	16,79 %	15,54 %	13,49 %	22,28 %	14,25 %	10,73 %
Volatility on march 11th									
	15,29 %	11,84 %	15,41 %	16,16 %	14,51 %	12,41 %	19,75 %	14,30 %	10,66 %
Average volatility the following week, march 14-18th									
	43,01 %	15,42 %	16,58 %	17,97 %	14,34 %	13,54 %	20,44 %	17,55 %	13,32 %
Average Volatility, from 2003-2013									
	21,72 %	19,99 %	16,37 %	18,02 %	21,05 %	19,17 %	24,42 %	22,36 %	18,15 %

Table A.8, Stock indices following the Japanese earthquake

Underneath is a timeline related to the opening hours of the stock market, were times are given in UTC.

- Friday March 11<sup>th</sup>: At 02:46, the Japanese stock market has been open for almost three hours, as the earthquake occurs. First reports of a tsunami hitting the Japanese coast come in at 06:26, after the closing of the Tokyo Stock Exchange.
- The weekend of 12-13<sup>th</sup> of March: Global stock markets are closed, but explosions and radiation leaks from the Fukushima Nuclear power plant are being reported.



- At 5:40 on Monday, Local media reports that the cooling system of the second reactor has malfunctioned. On 21:20, shortly after the U.S. stock market has closed, explosions are reported at Fukushima.
- At Tuesday on 02:41, Radiation levels near Tokyo are measured at levels more than 40 times higher than normal.

### Other incidents

Hurricane Katrina and Rita, August-September 2005								
Volatility:	S&P 500	Stoxx 600	Nikkei 225	Asia ex Jap	BRICS	MINT	Inst. Grade	High Yield
Avg(03-13)	16,37 %	19,99 %	21,72 %	18,02 %	21,05 %	19,17 %	5,41 %	3,79 %
Aug. 23rd	8,60 %	11,23 %	16,98 %	10,53 %	17,71 %	12,82 %	4,90 %	1,90 %
Aug.23-31th	8,79 %	11,69 %	17,67 %	11,29 %	16,69 %	16,09 %	4,69 %	1,85 %
Sep. 1-30th	9,03 %	11,90 %	17,64 %	11,12 %	12,98 %	18,11 %	4,33 %	1,97 %
Change of indices during the catastrophe time span								
Aug. 29th	0,61 %	-0,23 %	-1,86 %	-1,78 %	0,06 %	-2,67 %	0,13 %	0,13 %
Aug.23-31th	0,29 %	0,03 %	-1,42 %	-1,84 %	1,96 %	-0,18 %	1,03 %	0,06 %
Sep. 1-30th	0,71 %	0,33 %	5,77 %	4,11 %	10,98 %	7,52 %	-2,02 %	-1,13 %

Table A.9, Indices during Hurricane Katrina and Rita

BP Oil Spill, April-July 2010								
Volatility:	S&P 500	Stoxx 600	Nikkei 225	Asia ex Jap	BRICS	MINT	Inst. Grade	High Yield
Avg(03-13)	16,37 %	19,99 %	21,72 %	18,02 %	21,05 %	19,17 %	5,41 %	3,79 %
Apr. 20th	9,74 %	15,99 %	13,30 %	13,97 %	15,18 %	14,83 %	4,74 %	1,87 %
Apr. 21-27th	11,24 %	18,60 %	15,45 %	14,36 %	15,77 %	15,28 %	4,69 %	1,92 %
Apr. 28-May 7th	17,12 %	25,94 %	20,62 %	17,23 %	18,73 %	20,02 %	5,85 %	4,31 %
Change of indices during the catastrophe time span								
Apr. 21st	-0,10 %	-1,07 %	1,64 %	0,62 %	-0,15 %	0,04 %	0,45 %	0,19 %
Apr. 21-30th	-1,56 %	-3,57 %	-1,12 %	-1,03 %	-0,84 %	-0,12 %	0,35 %	0,39 %
May 3-7th	-7,55 %	-12,20 %	-2,68 %	-7,06 %	-8,65 %	-10,15 %	-0,06%	-2,85%

Table A.10, Indices during the Deepwater Horizon Oil Spill

### Terrorist Attacks

Underneath, key data has been listed for the terrorist attacks. In addition, a variety of indices that is exposed to risk related to terrorism is included, including two stock indices from the Middle East:

- MSCI GCC: An MSCI Index for the Gulf Cooperation Council
- MSCI J, E & M: An MSCI Index for Jordan, Egypt and Morocco.

Istanbul Bombings, November 15th and 20th, 2003								
	S&P	Stoxx	Nikkei	Asia	BRICS	MINT	Turkey	FTSE
Volatility:	500	600	225	ex Jap				100
Avg(03-13)	16,37 %	19,99 %	21,72 %	18,02 %	21,05 %	19,17 %	35,97 %	19,70 %
Nov. 14th	11,31 %	10,74 %	34,42 %	13,54 %	20,65 %	15,37 %	52,27 %	9,51 %
Nov. 17-19th	11,27 %	12,24 %	38,27 %	15,07 %	21,25 %	16,24 %	51,89 %	10,51 %
Nov. 20-25th	11,30 %	11,84 %	38,37 %	14,20 %	19,64 %	17,01 %	60,06 %	10,34 %
Change of indices during the bombing time span								
Nov. 17th	-0,64 %	-1,68 %	1,74 %	0,49 %	-1,43 %	-1,07 %	-2,28 %	-1,07 %
Nov. 20th	-0,01	-0,25 %	-0,11 %	-0,11 %	-0,35 %	-1,28 %	-9,74 %	-0,18 %
Nov. 21st	0,00	0,39 %	-0,38 %	-0,85 %	0,85 %	0,70 %	*	0,30 %
ΔNov 14-20th	-1,57 %	-1,49 %	-3,49 %	-2,67 %	-3,18 %	-3,37 %	-10,84 %	-0,96 %
ΔNov14-Dec1st	1,94 %	2,39 %	1,17 %	0,04 %	5,22 %	-0,31 %	1,01 %	2,62 %

Table A.11, Istanbul Bombings

\* ISE closed due to the terrorist attack

Madrid Bombing, March 11th, 2004							
	S&P	Stoxx	Nikkei	Asia	BRICS	MINT	Spain
Volatility:	500	600	225	ex Jap			
Avg(03-13)	16,37 %	19,99 %	21,72 %	18,02 %	21,05 %	19,17 %	24,70 %
March 10th	9,96 %	14,49 %	19,77 %	13,25 %	17,84 %	14,28 %	18,15 %
March 11-15th	11,11 %	16,75 %	20,27 %	13,06 %	20,11 %	15,45 %	20,90 %
Change of indices during the bombing time span							
March 11th	-1,50 %	-2,49 %	-1,41 %	-1,09 %	-2,81 %	-2,66 %	-2,00 %
March 12th	1,24 %	-0,20 %	1,69 %	-0,08 %	0,97 %	0,59 %	-1,58 %
ΔMar 10-19th	-1,21 %	-2,36 %	3,81 %	0,16 %	-1,21 %	-0,46 %	-4,18 %

Table A.12, Madrid Bombing

London Bombing, July 7th, 2005							
	S&P	Stoxx	Nikkei	Asia	BRICS	MINT	FTSE
Volatility:	500	600	225	ex Jap			100
Avg(03-13)	16,37 %	19,99 %	21,72 %	18,02 %	21,05 %	19,17 %	19,70 %
July 6th	8,40 %	8,28 %	11,30 %	7,45 %	10,27 %	9,90 %	7,67 %
July 7-15	8,82 %	11,14 %	10,07 %	8,69 %	11,40 %	10,20 %	12,05 %
Change of indices during the bombing time span							
July 7th	0,25 %	-1,64 %	-0,35 %	-0,12 %	-1,12 %	-0,42 %	-2,32 %
July 8th	1,16 %	1,21 %	1,19 %	1,73 %	0,59 %	0,75 %	1,13 %
ΔJuly 6-15th	2,78 %	1,50 %	1,64 %	3,70 %	1,76 %	2,19 %	-0,19 %

Table A.13, London Bombing

Bomb at Times Square, May 1st, 2010								
	S&P	Stoxx	Nikkei	Asia	BRICS	MINT	Inst.	High
Volatility:	500	600	225	ex Jap			Grade	Yield
Avg(03-13)	16,37 %	19,99 %	21,72 %	18,02 %	21,05 %	19,17 %	5,41 %	3,79 %
Apr. 30th	14,86 %	21,77 %	20,23 %	15,10 %	16,30 %	16,96 %	5,08 %	2,12 %
May 3rd	15,49 %	21,80 %	20,21 %	15,73 %	16,86 %	17,00 %	5,22 %	2,10 %
May 3-7th	18,32 %	25,89 %	20,81 %	17,26 %	18,84 %	20,09 %	5,98 %	4,26 %
Change of indices during the bombing time span								
May 3rd	1,30 %	-0,59 %	-0,53 %	-1,29 %	-1,34 %	-0,23 %	-0,26 %	0,04 %
May 3-7th	-7,55 %	-12,20 %	-2,68 %	-7,06 %	-8,65 %	-10,15 %	-0,06 %	-2,85 %

Table A.14, Bomb at Times Square

Boston Marathon Bombings, April 25th, 2013								
	S&P	Stoxx	Nikkei	Asia	BRICS	MINT	Inst.	High
Volatility:	500	600	225	ex Jap			Grade	Yield
Avg(03-13)	16,37 %	19,99 %	21,72 %	18,02 %	21,05 %	19,17 %	5,41 %	3,79%
Apr. 24th	14,33 %	16,95 %	22,14 %	11,50 %	14,91 %	11,26 %	3,42 %	1,47%
Apr. 25th	14,37 %	16,64 %	22,09 %	11,66 %	15,39 %	10,53 %	3,43 %	1,50%
Apr. 25-May 3rd	14,62 %	16,42 %	19,93 %	11,83 %	15,73 %	10,61 %	3,71 %	1,62%
Change of indices during the bombing time span								
Apr. 25th	0,41 %	0,88 %	0,48 %	0,81 %	1,08 %	0,64 %	-0,07 %	0,18%
Apr. 25-May 3rd	1,88 %	2,58 %	-1,12 %	0,99 %	1,75 %	-0,06 %	-0,09 %	1,19%

Table A.15, Boston Marathon Bombings

	VIX	Crude WTI	Gold	GCC	MSCI J,E & M
$\sigma$	6,60 %	2,35 %	1,24 %	1,34 %	1,25 %
Istanbul Bombings					
Nov. 17th	*	-2,03 %	-0,91 %	*	*
Nov. 20th	*	-0,15 %	-0,56 %	*	*
Nov. 21st	*	-2,46 %	0,46 %	*	*
Madrid Bombing					
Mar. 11th	10,18 %	1,78 %	-0,38 %	*	*
Mar. 12th	-12,18 %	-1,64 %	-0,63 %	*	*
London Bombing					
Jul. 7th	1,78 %	-0,90 %	0,49 %	-0,28 %	-1,43 %
Jul. 8th	-8,69 %	-1,83 %	-0,83 %	-0,01 %	0,08 %
Mumbai Attacks					
Nov. 25th	-6,05 %	-6,85 %	-1,71 %	0,48 %	3,70 %
Nov. 26th	-10,34 %	8,97 %	0,44 %	-0,30 %	1,19 %
Nov. 27th	0,33 %	0,00 %	0,08 %	1,66 %	1,15 %
Nov. 28th	0,33 %	-8,97 %	-0,26 %	-0,11 %	-1,04 %
** Dec. 1st	21,46 %	-0,99 %	-4,92 %	6,05 %	0,90 %
Bomb at Times Square					
** May 3rd	-8,81 %	0,05 %	0,00 %	0,52 %	-1,39 %

Boston Marathon Bombings					
Apr. 15th	35,91 %	-2,87 %	-10,16 %	-0,87 %	0,53 %
Apr. 16th	-21,28 %	0,01 %	2,28 %	-0,40 %	0,19 %

Table A.16, Indices during terrorist attacks

\* Before Index start date

\*\* Market closed throughout the weekend, causing new information to reach the market, which may remove some of the uncertainty linked to the attack.

### Arab Spring

Crude Oil and Stock Indices in the Middle East										
	Crude WTI	MSCI J,E&M	Turkey	Israel	Egypt	Lebanon	UAE	Qatar	Tunisia	Kuwait
$\sigma$	2,35 %	1,25 %	2,50 %	1,19 %	1,81 %	1,52 %	1,96 %	1,54 %	1,00 %	1,39 %
Average Volatility	33,59%	17,99 %	35,97%	17,77%	26,05%	20,01%	25,88%	19,36%	14,36%	18,38%
Ann. Return	11,05%*	4,65 %	17,45%	10,07%	26,55 %	10,37 %	-3,42 %	6,29 %	9,68 %	1,72 %
Volatility Dec. 17th	16,54%	12,48%	37,23%	18,26%	15,38%	11,40%	13,81%	19,09%	10,01%	16,62%
December 18th, 2010, major protests in Tunisia(data from Dec 20th)										
Volatility	16,40%	12,44%	37,01%	18,68%	15,38%	9,97%	13,94%	19,83%	9,92%	16,74%
$\Delta$	0,89 %	-0,07 %	-0,84 %	-1,00 %	0,10 %	-0,03 %	0,44 %	-1,23 %	-0,60 %	-0,46 %
January 14th, 2011, the resignation of the Tunisian president										
Volatility	19,96%	9,35%	23,54%	11,71%	10,71%	26,41%	10,21%	11,86%	29,31%	10,09%
$\Delta$	0,15 %	-0,13 %	-1,58 %	-0,01 %	0,00 %	1,50 %	0,00 %	-0,03 %	3,28 %	0,05 %
February 3rd, 2011, major protests in Yemen										
Volatility	28,42%	30,57%	33,19%	18,55%	44,82%	33,52%	30,09%	12,69%	31,59%	15,64%
$\Delta$	-0,35 %	-0,44 %	-3,72 %	-1,19 %	0,00 %	-1,05 %	0,49 %	0,28 %	1,76 %	-0,29 %
February 14th, 2011, President Mubarak of Egypt resigns(data from Feb. 15th)										
Volatility	27,10%	29,35%	33,66%	18,88%	44,30%	21,96%	30,25%	12,80%	30,33%	17,94%
$\Delta$	-0,58 %	0,12 %	1,05 %	0,73 %	0,00 %	0,00 %	-0,54 %	0,49 %	0,31 %	-0,16 %
*March 15th, 2011, Unrest in Syria, Saudi troops is sent in against protesters in Bahrain										
Volatility	39,18%	5,61%	33,59%	16,09%	1,30%	15,11%	36,79%	31,14%	24,70%	32,86%
$\Delta$	-4,04 %	-0,22 %	-0,70 %	-0,87 %	0,06 %	-0,28 %	-1,47 %	-1,54 %	-0,51 %	-1,80 %
March 19th, 2011, NATO offensive begins in Libya(data for Mar. 21st)										
Volatility	40,05%	5,61%	33,68%	16,02%	1,29%	15,72%	38,76%	31,55%	26,01%	35,42%
$\Delta$	1,24 %	0,03 %	0,81 %	0,73 %	-0,07 %	-0,92 %	2,56 %	2,01 %	-0,08 %	-0,15 %
Index change and average volatility during the first 6 months of 2011 (MSCI Global gained 4,97%, with an average volatility of 11,68%)										
Volatility	13,40%	10,69%	24,40%	18,40%	14,73%	9,44%	14,12%	14,74%	14,16%	12,79%
$\Delta$	4,23 %	-16,22 %	-9,72 %	-7,82 %	-23,19 %	-7,70 %	-4,23 %	1,36 %	-10,00 %	-9,93 %

Table A.17, Middle East indices during the Arab Spring

\* During the aftermath of the earthquake and the radiation crisis in Japan

Volatility:	S&P 500	Stoxx 600	Nikkei 225	Asia ex Jap	BRICS	MINT
$\sigma$	1,25 %	1,46 %	1,50 %	1,33 %	1,57 %	1,38 %
Volatility December 17th						
$\Delta$	0,08 %	-0,76 %	0,17 %	0,25 %	0,25 %	0,07 %
Index change on December 18th						
$\Delta$	0,26 %	0,33 %	-0,31 %	-0,30 %	-0,52 %	-0,07 %
Index change on January 14th						
$\Delta$	0,74 %	0,11 %	-0,86 %	-0,25 %	-0,53 %	-0,07 %
Index change on February 3rd						
$\Delta$	0,25 %	-1,15 %	-0,49 %	0,34 %	-0,08 %	-0,81 %
Index change on February 15th						
$\Delta$	-0,31 %	0,51 %	-0,31 %	-0,22 %	-0,15 %	-0,07 %
Index change on March 15th						
$\Delta$	-1,13 %	-2,34 %	-10,14 %	-3,04 %	-1,83 %	-1,38 %
Index change on March 19th						
$\Delta$	1,49 %	2,08 %	0,01 %	1,36 %	1,05 %	1,04 %

Table A.18, Global stock indices during the Arab Spring

### Invasion of Iraq

- March 20<sup>th</sup>: The deadline set for Saddam Hussein and his sons to leave Iraq expires. President Bush announces that Operation Iraqi Freedom has started, and Tomahawk Missiles are being fired against Baghdad.
- March 24<sup>th</sup>: Analysts are speculating that the war will not be as easily won as previously thought, and selling pressure hits the stock market.(Twin 2003)
- April 3<sup>rd</sup>: Coalition forces capture Baghdad International Airport
- April 6<sup>th</sup>: Basra becomes the first major city to be captured and controlled by coalition forces.
- April 9<sup>th</sup>: Baghdad is captured by coalition forces.
- May 1<sup>st</sup>: President Bush announces that the war has been won, and the end of major combat situations in Iraq

Crude Oil and Stock Indices in the Middle East					
	Turkey	Israel	Egypt	Lebanon	Crude WTI
$\sigma$	2,50 %	1,19 %	1,81 %	1,52 %	2,35 %
Average Volatility	35,97 %	17,77 %	52,48 %	20,01 %	33,59 %
Ann. Return	17,45 %	10,07 %	26,55 %	10,37 %	-
Historical Volatility					
March 19th	112,18 %	21,99 %	27,92 %	19,20 %	52,34 %
March 20th	112,30 %	21,26 %	36,48 %	19,20 %	53,18 %
March 20-April 30	76,17 %	19,30 %	33,81 %	21,30 %	49,83 %
May 1-May 15	32,88 %	13,85 %	28,97 %	23,54 %	45,86 %

Index movements					
March 20th	-2,90 %	-0,09 %	6,06 %	*	-4,27 %
March 24th	-7,48 %	-0,17 %	3,08 %	*	5,93 %
April 3rd	4,40 %	1,48 %	1,04 %	-1,64 %	1,39 %
April 6th	4,00 %	1,51 %	3,09 %	*	-2,30 %
April 9th	3,75 %	0,93 %	-2,39 %	1,70 %	2,99 %
May 1st	0,61 %	0,28 %	0,00 %	*	0,77 %
Mar 1-20th	-8,97 %	6,06 %	-6,08 %	0,01 %	-20,21 %
Mar 20-May 1	32,45 %	16,64 %	22,28 %	-4,76 %	-9,08 %

Table A.19, Middle East Indices during the invasion of Iraq

	S&P 500	Stoxx 600	Nikkei 225	Asia ex Jap	BRICS	MINT
Historical Volatility						
March 19th	24,54 %	30,52 %	20,47 %	20,19 %	11,72 %	20,14 %
March 20th	24,35 %	29,91 %	21,24 %	21,20 %	11,83 %	20,14 %
March 20-April 30	21,36 %	24,05 %	22,16 %	19,11 %	13,20 %	17,95 %
May 1-May 15	16,10 %	17,12 %	23,02 %	15,20 %	13,50 %	14,49 %
Index movements						
March 20th	0,19 %	-0,21 %	1,31 %	1,82 %	0,46 %	0,58 %
March 24th	-3,59 %	-3,11 %	-1,87 %	-0,43 %	-1,13 %	-1,58 %
April 3rd	-0,50 %	0,53 %	-1,02 %	0,34 %	0,06 %	0,71 %
April 6th**	0,13 %	2,71 %	1,92 %	1,80 %	1,47 %	3,18 %
April 9th	-1,40 %	0,13 %	-1,29 %	-1,37 %	-0,53 %	0,32 %
May 1st	-0,05 %	0,54 %	1,18 %	0,30 %	-0,21 %	0,36 %
Mar 1-20th	5,01 %	0,55 %	-5,31 %	-1,03 %	-0,71 %	-0,42 %
Mar 20-May 1	4,81 %	11,32 %	-2,04 %	3,08 %	5,86 %	16,97 %

Table A.20, Global stock indices during the invasion of Iraq

## The Chinese correction of 2007

	S&P 500	Stoxx 600	Nikkei 225	Asia ex Jap	BRICS	MINT
Data from 2003-2013						
Avg. Volatility	16,37 %	19,99 %	21,72 %	18,02 %	21,05 %	19,17 %
Ann. Return	9,18 %	10,82 %	8,81 %	14,24 %	17,73 %	19,34 %
Before crisis-data						
Volatility Feb. 26th	6,20 %	10,32 %	11,55 %	9,02 %	11,15 %	13,94 %

After crisis-data						
Volatility Feb. 27th	14,02 %	13,95 %	11,77 %	10,27 %	18,05 %	21,47 %
Δ Feb. 27th	-3,53 %	-2,52 %	-2,68 %	-1,24 %	-4,05 %	-4,60 %
Δ Feb. 28th	0,58 %	-1,75 %	-0,13 %	-2,93 %	-2,09 %	-0,45 %
Volatility Feb.27-Mar. 7th	14,73 %	15,32 %	15,03 %	15,73 %	22,81 %	22,63 %
Index change Feb.27-Mar. 7th	-0,44 %	-2,97 %	-5,75 %	-5,45 %	-6,00 %	-1,97 %

Table A.21, Global stock indices during the Chinese correction

	China	Thailand	Singapore	Taiwan	Hong Kong
Data from 2003-2013					
Avg. Volatility	25,27 %	24,42 %	18,81 %	21,64 %	18,52 %
Ann. Return	17,87 %	19,35 %	14,51 %	9,58 %	13,35 %
Before crisis-data					
Volatility Feb. 26th	15,53 %	27,65 %	17,30 %	10,61 %	14,46 %
After crisis-data					
Volatility Feb. 27th	18,05 %	25,16 %	18,81 %	10,07 %	15,96 %
Δ Feb. 27th	-2,48 %	-1,93 %	-1,96 %	0,02 %	-1,87 %
Δ Feb. 28th	-3,24 %	-0,59 %	-4,43 %	0,00 %	-3,13 %
Volatility Feb.27-Mar. 7th	24,29 %	24,28 %	23,08 %	15,60 %	19,41 %
Index change Feb.27-Mar. 7th	-8,11 %	1,76 %	-5,48 %	-6,15 %	-6,02 %

Table A.22, East Asian stock indices during the Chinese correction

### The Dubai World debt standstill

- November 25<sup>th</sup>: the Dubai government announces that all holders of Dubai World-debt will be asked to standstill, and extend maturities.
- November 30<sup>th</sup>: the Dubai Finance Department Director General makes a public statement, saying that the debts of Dubai World are not guaranteed by the government.
- December 3<sup>rd</sup>: Rating downgrades by S&P hits 4 Dubai banks and 6 Dubai World subsidiaries.(Al-Jazeera, 2009)

Stock Indices in the Middle East										
	MSCI GCC	MSCI J,E&M	Turkey	Israel	Egypt	Lebanon	UAE	Qatar	Tunisia	Kuwait
$\sigma$	1,34 %	1,25 %	2,50 %	1,19 %	1,81 %	1,52 %	1,96 %	1,54 %	1,00 %	1,39 %
Average Vol.	16,65 %	17,99 %	35,97 %	17,77 %	26,05 %	20,01 %	25,88 %	19,36 %	14,36 %	18,38 %
Ann. Return	0,48 %	4,65 %	17,45 %	10,07 %	26,55 %	10,37 %	-3,42 %	6,29 %	9,68 %	1,72 %
November 24th										
Vol.	11,32 %	17,66 %	32,37 %	18,34 %	25,88 %	24,84 %	28,14 %	15,51 %	13,91 %	33,02 %
November 25th										
Vol.	11,96 %	18,32 %	32,09 %	18,02 %	26,68 %	25,00 %	28,22 %	15,60 %	13,92 %	33,40 %
$\Delta$ index	0,77 %	0,96 %	0,52 %	0,42 %	1,21 %	-0,79 %	0,13 %	0,37 %	0,65 %	0,73 %
November 26th										
Vol.	10,93 %	18,19 %	30,97 %	18,09 %	26,66 %	25,11 %	27,70 %	15,60 %	13,84 %	33,05 %
$\Delta$ index	-0,02 %	-0,05 %	-2,59 %	-2,17 %	*	-1,11 %	*	*	-0,23 %	0,05 %
<i>(November 27th, markets closed in the Middle East)</i>										
November 30th										
Vol.	10,80 %	24,98 %	28,15 %	18,17 %	38,62 %	25,75 %	43,09 %	13,60 %	13,02 %	32,61 %
$\Delta$ index	-1,03 %	-5,39 %	-0,34 %	0,81 %	-8,69 %	-1,89 %	-10,67 %	*	0,03 %	0,04 %
December 3rd										
Vol.	10,41 %	27,59 %	35,87 %	15,80 %	43,59 %	19,34 %	47,72 %	38,32 %	11,44 %	32,99 %
$\Delta$ index	0,42 %	1,45 %	4,60 %	1,19 %	2,57 %	0,44 %	0,00 %	1,26 %	0,35 %	1,59 %

Table A.23, Stock indices in the Middle East during Dubai World Debt standstill

	S&P 500	Stoxx 600	Nikkei 225	Asia ex Jap	BRICS	MINT	Glob. Gov	Invst. Grade	High Yield
November 24th									
Vol.	20,41 %	28,01 %	18,16 %	20,61 %	27,45 %	22,21 %	4,48 %	5,75 %	2,16 %
November 25th									
Vol.	20,34 %	28,10 %	18,42 %	20,23 %	25,68 %	19,40 %	4,74 %	5,29 %	2,17 %
$\Delta$ index	0,46 %	1,16 %	1,39 %	1,06 %	0,64 %	0,95 %	0,59 %	0,17 %	0,08 %
November 26th									
Vol.	18,77 %	30,01 %	18,61 %	18,93 %	23,34 %	20,45 %	4,75 %	5,24 %	1,74 %
$\Delta$ index	0,00 %	-3,78 %	0,65 %	-1,46 %	-2,59 %	-3,34 %	0,28 %	0,02 %	0,00 %
November 27th									
Vol.	18,65 %	29,27 %	20,68 %	22,11 %	23,25 %	20,14 %	4,68 %	4,66 %	1,52 %
$\Delta$ index	-1,71 %	1,09 %	-3,43 %	-3,57 %	-1,14 %	0,67 %	0,04 %	0,22 %	0,02 %
November 30th									
Vol.	15,22 %	28,22 %	22,63 %	23,69 %	23,14 %	19,68 %	4,65 %	3,94 %	1,79 %
$\Delta$ index	0,39 %	-1,19 %	3,51 %	2,61 %	1,29 %	0,69 %	-0,64 %	-0,01 %	-0,20 %
December 3rd									
Vol.	16,02 %	27,35 %	23,96 %	22,73 %	22,47 %	19,95 %	5,03 %	3,68 %	1,76 %
$\Delta$ index	-0,84 %	-0,10 %	2,78 %	0,71 %	0,33 %	1,21 %	-0,47 %	-0,14 %	0,27 %

Table A.24, Major stock indices during Dubai World Debt standstill



## The Downgrade of U.S. Credit Rating

Equity Indices following the downgrade						
	S&P 500	Stoxx 600	Nikkei 225	Asia ex Jap	BRICS	MINT
August 5th						
Vol.	22,31 %	28,08 %	21,66 %	25,18 %	21,45 %	17,26 %
August 6th						
Vol.	31,25 %	30,53 %	21,07 %	26,78 %	27,79 %	22,15 %
Δ	-6,88 %	-4,26 %	-1,15 %	-3,40 %	-5,69 %	-4,47 %
August 7th						
Δ	4,63 %	1,63 %	-1,20 %	-2,50 %	-2,09 %	-1,67 %
August 5-15th						
Avg. Vol.	33,06 %	32,78 %	22,46 %	27,28 %	26,46 %	21,20 %
Δ Index	0,51 %	1,40 %	-0,01 %	-1,31 %	-1,19 %	-0,86 %

Table A.25, Major stock indices during downgrade of U.S. credit

Bond Indices following the downgrade				
	U.S. Treas.	Glob. Gov.	Invst. Grade	High Yield
August 5th				
Vol.	0,00 %	6,20 %	6,99 %	4,21 %
August 6th				
Vol.	0,00 %	6,76 %	6,57 %	7,84 %
Δ	0,00 %	0,93 %	0,03 %	-2,00 %
August 7th				
Δ	0,00 %	0,24 %	0,51 %	-0,87 %
August 5-15th				
Avg. Vol.	0,00 %	6,45 %	8,30 %	6,92 %
Δ Index	0,00 %	2,03 %	-0,89 %	-2,45 %

Table A.26, Major bond indices during downgrade of U.S. credit

## Appendix B

### Parameter estimations for the GARCH(1, 1)-model

Parameters S&P 500	
$\omega$	1,37359E-06
$\alpha$	0,092949551
$\beta$	0,898202926
$\gamma$	0,008847523
$V_L$	0,000155252
<b>Long-term Volatility:</b> 1,2460 %	
$\gamma+\alpha+\beta$	1
$\alpha+\beta$	0,9912
<b>Max. Value of function:</b> 23848,20925	

Parameters STOXX Europe 600	
$\omega$	1,59154E-06
$\alpha$	0,097389277
$\beta$	0,895137953
$\gamma$	0,00747277
$V_L$	0,000212978
<b>Long-term Volatility:</b> 1,4594 %	
$\gamma+\alpha+\beta$	1
$\alpha+\beta$	0,9925
<b>Max. Value of function:</b> 22600,63152	

Parameters Nikkei 225	
$\omega$	5,38437E-06
$\alpha$	0,095215962
$\beta$	0,880681243
$\gamma$	0,024102794
$V_L$	0,000223392
<b>Long-term Volatility:</b> 1,4946 %	
$\gamma+\alpha+\beta$	1
$\alpha+\beta$	0,9759
<b>Max. Value of function:</b> 21892,81	

Parameters Asia Pacific ex Japan	
$\omega$	2,56235E-06
$\alpha$	0,105333972
$\beta$	0,880129525
$\gamma$	0,014536503
$V_L$	0,00017627
<b>Long-term Volatility:</b> 1,3277 %	
$\gamma+\alpha+\beta$	1
$\alpha+\beta$	0,9855
<b>Max. Value of function:</b> 23115,04	

Parameters BRICS	
$\omega$	3,82837E-06
$\alpha$	0,103756367
$\beta$	0,880716074
$\gamma$	0,015527559
$V_L$	0,000246553
<b>Long-term Volatility:</b> 1,5702 %	
$\gamma+\alpha+\beta$	1
$\alpha+\beta$	0,9845
<b>Max. Value of function:</b> 22175,40	

Parameters MINT	
$\omega$	3,5831E-06
$\alpha$	0,129992205
$\beta$	0,851084291
$\gamma$	0,018923503
$V_L$	0,000189348
<b>Long-term Volatility:</b> 1,3760 %	
$\gamma+\alpha+\beta$	1
$\alpha+\beta$	0,9811
<b>Max. Value of function:</b> 22592,72	

Parameters MSCI World	
$\omega$	8,20673E-07
$\alpha$	0,081992319
$\beta$	0,910815958
$\gamma$	0,007191723
$V_L$	0,000114114
<b>Long-term Volatility:</b> 1,0682 %	
$\gamma+\alpha+\beta$	1
$\alpha+\beta$	0,9928
<b>Max. Value of function:</b> 24568,31	

Parameters US Treasury Bills	
$\omega$	3,52488E-12
$\alpha$	0,292079593
$\beta$	0,70747339
$\gamma$	0,000447017
$V_L$	7,88533E-09
<b>Long-term Volatility:</b> 0,0089 %	
$\gamma+\alpha+\beta$	1
$\alpha+\beta$	0,9996
<b>Max. Value of function:</b> 57431,98	

Parameters DJ Corp. Bonds Index	
$\omega$	1,25867E-07
$\alpha$	0,057111036
$\beta$	0,933614633
$\gamma$	0,009274331
$V_L$	1,35715E-05
<b>Long-term Volatility:</b> 0,3684 %	
$\gamma+\alpha+\beta$	1
$\alpha+\beta$	0,9907
<b>Max. Value of function:</b> 29728,91	

Parameters Glob. Gov. Bonds	
$\omega$	2,24782E-07
$\alpha$	0,048138391
$\beta$	0,939791062
$\gamma$	0,012070547
$V_L$	1,86223E-05
<b>Long-term Volatility:</b> 0,4315 %	
$\gamma+\alpha+\beta$	1
$\alpha+\beta$	0,9879
<b>Max. Value of function:</b> 28580,75	

Parameters Corp. High-Yield Index	
$\omega$	4,02536E-07
$\alpha$	0,327703585
$\beta$	0,641675632
$\gamma$	0,030620783
$V_L$	1,31459E-05
<b>Long-term Volatility:</b> 0,3626 %	
$\gamma+\alpha+\beta$	1
$\alpha+\beta$	0,9694
<b>Max. Value of function:</b> 32061,04	

Parameters Gold Bullion	
$\omega$	1,90107E-06
$\alpha$	0,042002405
$\beta$	0,945494188
$\gamma$	0,012503407
$V_L$	0,000152045
<b>Long-term Volatility:</b> 1,2331 %	
$\gamma+\alpha+\beta$	1
$\alpha+\beta$	0,987496593
<b>Max. Value of function:</b> 22783,41	

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