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Investigating Risk-On, Risk-Off patterns in global financial markets

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I, Jan Tročil hereby declare that the thesis "Investigating Risk-On, Risk-Off patterns in global financial markets" was written by me, and that all presented results are my own, unless stated otherwise. The literature sources are listed in the List of References.

Prague, September 25th, 2014 Signature……

Jan Tročil

Abstract:

The aim of this thesis is to analyse the increased correlation within four major asset groups (Government Bonds, Equity Indices, Commodities and Currencies) from the beginning of Great Recession till July 2014. The effect of increased correlation is called Risk-On Risk-Off and is connected to problems, where investors struggle to create risk-oriented portfolios and instead minimalize loss. The methods analysing the correlations are Absolute Average Value Index (AAVI) and Heat-map analysis. The AAVI is transforming correlation matrix into a single number and investigating the intensity of correlations. The Heat-map is studying the relationship between any two assets. The results from this study were that the RORO effect was present during Great Recession with intensity never seen before and that in June 2014 the values are close to pre-recession levels.

Table of Content

List of Diagrams

List of Tables

List of Graphs

Abbreviation

AAVI – Absolute Average Value Index

CDS – Collateralized Debt Obligations

EU – European Union

RORO – Risk-On Risk-Off

U.S. – United States

OLS – Ordinary Least Squares

CI – Confidence interval

PI – Prediction interval

ISIS – Islamic state

Introduction

Financial markets are an essential element of today's world economy. They allow buyers and sellers to set the demand and supply for financial assets and thus allocate resources in the most efficient way. Before the year 2007 and the beginning of the financial crisis, markets were the place where it was relatively easy for investors to diversify the risks attached to different assets. Although, when the financial crisis started and the nature of some assets changed, investors had to redefine their strategies to minimalize losses rather than to maximize profit. The financial markets of European Union were hit by the Great Recession crisis in an unprecedented way. In Europe not only investors were strongly influenced by the improperly working financial markets, but also governments of some countries had problems to enter financial markets. Therefore, for the improvement of economic health of European Union it is crucial for financial markets to work properly.

The new factor that appeared in the decision-making process is called Risk-On Risk Off or shortly RORO. RORO is a state on financial markets when investors move from presumably high-risk investments (equities, high yielding currencies, commodities) to safe investments (government bonds). The issue of having financial markets where RORO is present is that from the moment RORO occurs it is difficult for investors to diversify their portfolios. The aim of this thesis is to investigate when the correlation began to exceed acceptable levels and since when it can be seen as RORO environment. Thus, the main questions in this thesis are when the RORO started, is it still present and how does it manifest?

The tools used in the study will work mostly with correlation between various assets traded on financial markets. Two main methods are used. The first one works with absolute average values of correlations in a particular period. By putting all the investigated periods into one graph, the analysis of the intensity of correlations is enabled. The second method is the heat-map analysis. This process explains how the relationships within any two assets were changing in time and allowed observing how separate assets were correlated with other groups. Both off these methods work not only with latest datasets but also with historical data. This research makes the current development on financial markets measurable and gives the European and World financial markets a historical reflection.

1. The Role of Financial Markets

Investing on financial markets has been for a long time a very widespread and popular matter. Long gone are the times when the purchase of shares or bonds was something rare. The present time, with possibilities of communication through the internet or mobile technology, greatly helped extend the possibilities of financial markets. It is a market as any other in the sense of demand and supply. Entrepreneurs, banks, governments, ordinary citizens and others meet with counterparts in order to add value to their assets.

In the beginning it is important to say that investing in financial market is not a game, where everybody can make a profit. Financial market is an invisible market where huge redistribution happens and somebody becomes rich and somebody poor. It is not possible that everybody gets richer at the same time. (Jilek, 2009) It is important to understand why the situation is not optimal. When the RORO patterns are explained, this will be an important point.

1.1. Structure of Financial Markets

Almost every nation has its own financial market. Some have more active with lots of participants and some markets are small. There are many ways to categorize markets. It is possible to use payback time or whether the asset is tangible or not, however the simplest method is by the different financial instruments. To make it easier, there will be only the division based on segments introduced (Rejnus, 2010).

a) Capital Market – Capital markets serve as a place where long-term financial instruments (usually longer than 1 year) are sold and bought. Between the traded instruments belong bonds and stocks. (Jilek, 2009)
    i. A *Bond* is a form of a debt that obliges the receiver to pay back the money with an interest at a specific time. The longer the time period is the higher is the yield. It can be issued either by government or by a company.
    j. *The stock market* works differently. Here the buyers and seller meet to publicly trade shares of companies. The sellers offer parts of companies in order to get additional capital that could be used for further investment. Unlike bonds the participants can buy/sell

whenever they want. We can divide this market into primary and secondary, where primary is when the company first offers theirs share to the public.

b) Money Market – In a Money market financial instruments with short-term maturities are sold. Typically larger amounts are traded, there are fewer participants and the assets are traded at a high speed and low interest rate.

c) Currency market – Currency market is operated by large financial institutions that deal in an interbank market. It is the place where the current values of currencies are determined. Most of the operations are conducted by dealers from trade banks and they buy and sell on their own account.

d) Commodity market – In Commodity market primary goods are traded. The trade can take form in physical or virtual settlement. We differentiate between soft and hard commodities. Soft include agricultural products whereas hard are metals and oil.

As presented, all markets are essential and can be used by the investor to diversify portfolios and make profit. Bearing this in mind, the upcoming analysis contains assets from all of these markets in order to provide a deeper analysis.

1.2. Financial Instruments

It is clear that financial markets are driven by supply and demand and share some similarities with traditional markets. To underline the difference, this section will introduce financial instruments. A financial instrument is any document with value. It can be real or virtual, conducting operations in financial markets. The international accounting association defines financial instrument: *"A financial instrument is any contract that gives rise to a financial asset of one entity and a financial liability or equity instrument of another entity"* (IFRS, 2012, str. 1). For a better understanding financial instruments can be divided into two groups:

a) Derivative Instruments – As there are risks assigned to financial instruments, derivatives allow participants to transfer the risk between each other. The real value is calculated from a derived instrument hence

the name derivative (Heckiner, 2013). For example Credit Default Swaps (CDF) is an example of the instrument.

b) Cash Instruments – The cash instrument value is set directly on the markets. The typical cash instruments are securities, loans and deposits.

1.3. Groups of Risk

Risk is assumed in all activities. But as we are dealing with financial markets we will consider only risks associated with financial instruments. There are many ways to divide risk for further analysis. However most common way is to divide risk into these 5 groups (Jilek, 2009):

a) *Credit risk* – Is the risk of inability of the debtor to uphold the conditions signed in the contract.

b) *Market risk* – It is the unpredictable change in market conditions that affects the contract. It is further divided into: Interest rate risk, Currency risk, Equity Risk and Commodity risk.

c) *Liquidity risk* – Represents the risk of not being able to exchange the assets into money quickly enough to avoid a loss.

d) *Operational risk* – Operational risk has many sub-categories such as Transaction risk, Operational Control risk and System risk. They are caused by political system, inner mistakes and even unexpected external events such as natural disasters.

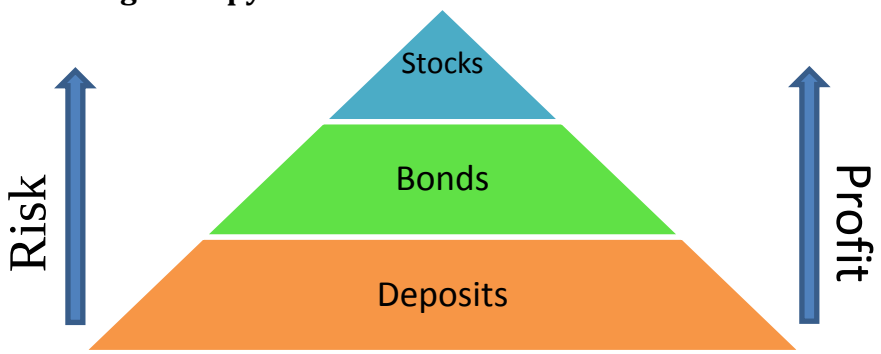
e) *Business risk* – Is connected to the uncertainties associated with doing business. The preferences or tastes of customers might change, government can influence market participants by changing its policy or the competition can bring new risks to business. In many ways it is similar to Operational risk.

1.4. The Difference in Risk

When we assume risk, it is usually about danger or a loss that might occur. However, financial markets view it also as an opportunity, where higher risk also represent higher yield. When we buy an asset with high risk, the probability of loss is greater but the potential profitability increases.

Generally, stocks are considered to be riskier than government bonds, therefore the associated yields are in longer time period higher. The Diagram below shows the risk and profit scenario. As can be seen, deposits have little risk, but lover profits sometimes not even covering for inflation (Barclays, 2010).

Diagram 1.1: Average risk pyramid



Source: (Barclays, 2010), Own creation

The diagram above displays in the idea of bonds being less risky than stocks: Investors cannot assume that this counts for bonds and all stocks. Within bonds alone there are huge differences in yields. During the financial crisis, yields of Greece 10-year bonds rose up to 40%, while the Japanese bonds stayed around 2%. These two countries are considered the two biggest debtors in the world (IMF, 2013). The main reason for this is that although Japan owes in relative and absolute values more than Greece, the investors have more faith in the repayment of the debits.

2. Great Recession

With the growing importance of financial markets, increases the number of investors and the amount of money invested. The past has already confirmed that the problems in the financial markets have an impact on the whole economy. The first serious problems of current crisis[1] began in late 2007, when financial markets worldwide were hit. The hardships in the financial markets become critical due to theirs interconnectedness with the global economy.

[1] Great Recession stands for financial crisis (2007 – mid 2009) and the global recession (2009 - ???). In the thesis when there are words; crisis, pre-crisis, recession, pre-recession, if not described differently they always represent for Great Recession.

2.1. Development of Financial Crisis

The Financial Crisis began as early as in the mid-2007, when the American real estate market began to spread uncertainty. At the beginning of the new millennium, a huge price bubble was created due to the increase of house prices from the beginning of 2000 to the autumn of 2006. This price bubble, however, slowly began to bursts at the end of 2006. It was not only reflected in the price decline of American real estate, but also in a significant decline in the financial products that used to finance the American real estate boom. American financial institutions used to support mortgage loans, specifically the assigned securities, which are further collected into larger portfolios and issued in separate tranches (Collateralized Debt Obligations, abbr. CDOs). The decline in values of real estate is naturally reflected of the decline in the prices of securities. (Baker, 2008)

Investing in CDO and forwarded securities became very popular between American and European banks, investment banks and pension funds. It was estimated that in the fall of 2007 the loss connected to securities linked to the American mortgages amounted to $300 billion. Whereas publicly recognized losses from these financial instrument were roughly at around $40 billion. This lead to the uncertainty in financial markets, in which portfolios was the missing loss. The big international institutions that showed the biggest damage were Citigroup, Merrill Lynch and Morgan Stanley. At the beginning of the year 2008 the investment bank Bear Stearns fell into bankruptcy and was saved by a takeover from JP Morgan (Musilek, 2008).

More negative information about the American financial markets began to appear again at the beginning of September 2008. Markets began to pay more attention to the owners of so-called "toxic" assets (highly risky investment instruments linked to subprime mortgages clients), which were found even in portfolios of the investment bank Lehman Brothers. On Sunday 14th of September, the Federal Reserve decided, in agreement with the Ministry of Finance, not to grant Lehman Brothers an emergency loan, which was a great surprise to most of the market participants. The following day the management of Lehman Brothers could not do anything besides declaring bankruptcy. World financial markets were shocked and immediately began to attack other major American investment banks (particularly Merrill Lynch, Morgan Stanley and Goldman Sachs).

Investment bank Merrill Lynch was taken over by the Bank of America. Investors began to leave the money market sector and speculation began to spread outside the USA, especially to Great Britain, where were under considerable pressure from creditors HBOS

and Lloyds TSB. Investors continued to leave other mayor investment Banks. In particular, Morgan Stanley and Goldman Sachs were still under the strong pressure from investors and had no other choice but to ask the Federal Reserve for a conversion from investment bank to a bank holding company. The Federal Reserve complied promptly these requests on September 21st, causing stricter regulation for the financial institutions, but more importantly it opened up access to much-needed additional liquidity resources. (Musilek, 2008)

The September issues in the world financial markets reached such an enormous scale, that they could be called "global financial crisis". This is evident by significant deterioration of majority of the financial indicators. The global financial system was infected by lack of liquidity, high volatility of financial measurements and by substantial decline of the value of assets. Finally, when the world started to recover from the financial crisis in year 2010, another crisis arrived, as Europe was hit by its debt problems. (Musilek, 2008)

2.2. European Sovereign Debt Crisis

European sovereign debt crisis emerged from the previously described financial crisis. However there were many other factors leading to this situation even before the real estate bubble bursts in U.S. The causes of the crisis lead to the beginning of the monetary union in Europe. After the creation of EURO, many weaker economies could work with low interest money. As EURO was considered a strong currency and the economy was growing, the associated risk of insolvency of countries wasn't seen.

The turning point was when Greek prime minister announced in 2010 that the accounting was manipulated. After this incident, many of the yields of Greek government bonds skyrocketed. However the problems lied not only in Greece but as well in other southern countries like Spain, Portugal and Italy. Also Ireland was hit strongly by investor fear. Most of these countries needed help from international institutions like International Monetary Fund (IMF). (Lane, 2012)

Once again, financial markets were the key to the debt crisis. It was these markets that were borrowing money to countries, and some countries even reached a negative yield on their government bonds. "*Germany sold two-year notes at a negative yield for the second time on record, with the Federal Finance Agency saying the debate over Greece's fiscal sustainability boosted demand for the securities."* (Goodman & Parkin, 2012) In other articles it was discussed that central banks were trying to make investors to borrow money or invest

in their own companies, but as the fear continued to dominate the markets, the companies rather held the cash in their hands. (Phillips & Bartha, 2012)

2.3. Financial Globalisation

Globalisation is used to describe the increasing interconnectivity between countries and cultures. The definition of financial globalisation is: *"Financial globalisation is an aggregate concept that refers to rising global linkages through cross-border financial flows"* (Arestis, Basu, & Mallick, 2005, str. 3). Three kinds of markets are affected by globalisation. The first one is the Labour market, the second one is the Goods market and the third is the Assets and Debt market which is the one we are concerned about (Tobin, 1999).

The latest development of financial globalisation started in mid-80s by increase in cross-border capital flow[2]. This was caused by the liberalisation of capital barriers in many developed and developing countries. Strive for better allocation and the demand for financial capital enabled financial globalisation to happen (Kose, Prasad, Rogoff, & Wei, 2006). The whole process was even more accelerated by the creation of the European Union (EU) and the common currency, the euro which connected till then separate markets of European countries.

But when the financial crisis erupted, foreign capital flows collapsed. According to a report published by McKinsey research centre, cross border capital flows rose since 1970 from $0,5 trillion to $11,8 trillion in 2007. The year 2007 was the turning point and since 2012 capital flows remain around 60 % under the peak. It is important to mention that one of the biggest contributors to growth was the EU, but as the crisis started and worsened, the European banks reduced foreign lending by $3,7 trillion. This was also due to newly introduced regulations regarding required liquidity and capital in order to reduce risk. (Lund, Daruvala, Dobbs, Härle, Kwek, & Falcón, 2013)

Two possible scenarios for future development were introduced. One is to stay on the current track and keep the movement of cross border capital low risk. And the other proposed scenario was to rebuild the global financial markets and even further deepen the interconnectivity between markets. An important factor that would help reset the former

[2] Cross-border capital flows are compound of: "lending, foreign direct investment, and purchases of equities and bonds" (Lund, Daruvala, Dobbs, Härle, Kwek, & Falcón, 2013)

situation would be the invention of a new global regulator that would be supervising the global financial markets. (Lund, Daruvala, Dobbs, Härle, Kwek, & Falcón, 2013)

The idea of financial globalisation is an enormously important part of this thesis as it describes how the capital can be transmitted from one country into another. Thus it gives a small hinge on why there could be correlation between, for example, European government bonds and U.S. companies. Without global interconnection on financial markets the investigation would be only within one country, which would pose a massive limitation.

3. Risk-On Risk-Off

As described in previous section, the world of financial markets consists of multiple different trading places, in which various assets are bought and sold. Yet from the beginning of the crisis, the influence of some macroeconomic events on the development of the world financial markets can be observed. The following part aims to explain the effect on global financial market of a macroeconomic event and specifically the burst of real-estate bubble is, and the evolution of such a situation.

3.1. Risk-On Risk-Off Phenomenon

Since the onset of financial crisis a new phenomenon of increased correlation can be observed. The reason for it is the new market environment, which distinguishes between two regimes; Risk-on Risk-off (RORO). One of the studies, which focuses on proving increased correlation, was set up by HSBC: *"correlations between financial asset returns have intensified since the onset of the credit crisis and nearly all assets are now driven by a single, binary recovery factor. The market either believes that we are on the road to recovery – risk on; or that we are not – risk off"* (HSBC, 2010, str. 2). The RORO phenomenon is a relatively new idea to financial markets, although it was already mentioned in 1990s (Keohane, 2013)

"Risk on" is a state on financial markets during which investors are willing to take a higher risk in comparison to "normal state"[3]. They do so by making high risk investment such as in equities, high yielding currencies, commodities. By accepting higher risk, investors are looking for increased returns and thus are willing to invest into financial instruments

[3] Normal state means in this case market situation where the connections between more assets is not driven by the same factor. The increase in risk can be driven by better macroeconomic conditions and not by the performance

of which the risk and revenues are increased. The "Risk off" regime is the exact opposite. In this case the investors fear high yielding assets and try to find so called "safe havens" such as government bonds (Fengler & Schwender, Basked Volatility and Correlation, 2007).

The issue of having highly correlated financial markets is that from the moment the correlation starts to increase we can observe a move from a diversified market to a simple RORO. This leads to a state in which it is hard for investors to aim for a speculative profit as they behave in a herd-like manner. Therefore, every structured portfolio that is composed of different high and low risk assets, moves simultaneously making it more complicated for investor to diversify their portfolio, increasing the difficulty to lower risk. Pepenbrock and Swender, in their article from 2013, identify six examples why the RORO is dangerous for the investment process (Papenbrock & Schwender, 2013). These three are selected from the list as most relevant for the thesis:

1) *"Due to the extreme market coordination there is a lack of diversification potential so di-versification fails where it is most needed"* (Papenbrock & Schwender, 2013, str. 2).
2) The correlation is influenced by macroeconomic events and thus the differences between assets are low, preventing investors to add value.
3) It is challenging to set the expected returns and risk parameters.

Other points mainly focus on how the situation is for investors. *"It becomes more difficult to have persistent success in investment strategies, and there will be a wider dispersion of potential portfolio outcomes and a higher degree of portfolio concentration"* (Papenbrock & Schwender, 2013, str. 3). It is crucial to understand why the RORO effects are dangerous for financial markets and the above mentioned points summarize the main reasons.

Before the Great Recession of 2007, the increased correlation was only present in market contractions, as is described in the article "*Quoting Multiasset Equity Options in the Presence of Errors from Estimating Correlations"* (Fengler, 2004). The article describes that there was only short-term and small scale trend of correlation until 2004, which was connected to market deterioration.

The worsening of macroeconomic conditions might be also connected to increasing correlation: *"weakening of the "risk on-risk off" paradigm is likely only once macro conditions are improved in a sustainable way, implying the paradigm will continue*

to dominate the market for some considerable time." (HSBC, 2010, str. 13) The main outcome from this study is the idea that once the macroeconomic fundamentals improve to a sustainable value, the correlations should decrease as well. Thus if the later analysis proves low correlation according to the study the markets believe that the economic fundamentals are improving.

3.1.1. Latest Risk-On Risk-Off Development

As the global markets are dynamically changing and could be different every month, there is already some evidence of decreasing correlation. The article "Death of 'risk on, risk off' behaviour" (Parker, 2012) argues that there are still too many risks which can negatively influence the process of recovery. An example used in the article is the Middle East crisis[4]. Now even strengthened with the fear of ISIS, the Islamic organization is operating in the area rich on oil; Nigerian Boko Haram[5] can have an impact on world economies. However, not only the terrorist organizations open many questions about the future, but also the Ukrainian crisis[6].

However some articles such as Stephan Foley's *"Risk on/risk off correlations are fading fast"* (Foley, 2013) from the financial times are already talking about decrease in correlation. In his commentary the author argues that correlations are fading and are not returning to their original levels. He argues that almost all assets are positively correlated. The most surprising for the author is the connection between equity indices and government bonds.

In June 2014 Michael P. Regan presented some new evidence that correlation exists and that there still might be some risks. At the end of the article he explained his view by using the correlation of S&P 500 and US Treasury Long Bond and concluded that; *"Now, the correlation is a positive 60 percent, meaning the two haven't been this much in sync since 2007, according to Bespoke"* (Regan, 2014).

The latest development has shown some signs of revival of financial markets, yet there is evidence of different opinions. Most of the analyses are comparing USD and U.S. equities making it impossible to conclude whether this could be accounted for the global financial markets. In next section the datasets and methods used will be introduced. These will serve

[4] The political turmoil in the Middle East is often called Arab Spring. It started in 2010 and was typical for protest and change of political leaders. Many countries even after the change of leadership struggle because of insecurity.

[5] Boko Haram is a Islamic military organization, controlling north parts of Nigeria.

[6] In 2014 Ukraine became divided into pro-European and pro-Russian groups. These groups are in the middle of 2014 still fighting in eastern parts of Ukraine.

to make conclusion whether there are still some signs of correlation or if it can be concluded that the RORO effect is finally over.

4. Data Analysis

The master thesis compares the correlations of financial markets between various assets before and during the Great Recession. For a better understanding of the evolution of correlation, it is better to work with long-term as well as short-term datasets. As there might be a change in the overall level of correlation the long-term dataset is introduced in order to help to understand how the correlation is evolving in time. This will enable to predict the future values of correlation. On the other hand the short-term index enables to analyse the latest development on financial markets in a more detailed way. More arguments about which data and why was used are given below.

4.1. Frequency

One of the most important issues to consider before deciding what the datasets will look like, is to set the desired frequency of the data. There are crucial differences between various rates. It is important to know whether there even is the possibility to collect data in the specific interval and if any conclusions can even be found in the dataset. It is also essential to be careful whether the dataset is not too large or too small for a more detailed analysis. There are four time-spreads worth considering:

a) Annually
b) Monthly
c) Weekly
d) Daily

Annual data has the advantage that most historical data is available on the internet as yearly averages. Dataset from the beginning of the century can be used to analyse the influence of wars, various crisis, technological invention etc. and compared to the current development. The issue about having yearly data is that it gives not enough information about progress of various assets and thus makes it almost impossible to make any strong conclusions about correlation. Therefore the annual data is not suitable for the analysis.

On the other hand, daily data is the most complex. In comparison to other frequencies, it points out every single movement and therefore allows for clearer description of

the evolution of correlation and the various effects on it. It is also not that difficult to collect the data since many yearly averages are based on daily data. The problem connected to daily data is that it is complicated to work with it, mainly due to the fact different trading hours and different trading places create discrepancy between various assets. Correction of all the datasets would be needed in order to work with the data. This makes the daily data not perfectly suitable for the analysis.

The two frequencies picked for analysis are monthly and weekly. The monthly data carries similar issue as the annual data, thus is not suitable for a detailed analysis of latest development, but as it can be traced back to the middle of 20th century, it enables to analyse the long-term trend in correlation within assets. The weekly data is the most difficult to collect. It can be traced for majority of the data only to the 90's and for the effective exchange rate it had to be calculated from daily data, but by having the dataset with weekly frequencies the analysis of latest development in a more precise way is possible. It enables to purify the effect of different trading hours yet it is still has relatively high frequency making it possible to correlate shorter period. Therefore the monthly data will be used mainly for trend analysis whereas weekly data will serve for a detailed analysis of latest development

4.2. Analysed Groups

Generally, the best method of analysing data would be to have all the data from the same year and use one analysis that would portray the development of the correlations. But as described in previous subchapter, not all the data is available in the desired form. In order to get the most detailed outcomes the thesis will be based on two different analyses. The first one is an index based on absolute average values (AAVI) of correlated matrices and the second is correlation heat-maps. Both of which show similar result, but the index aims to find a historical trend and influences whereas the heat-maps try to analyse the correlation between single assets during a particular period. The index will be further divided into two groups based on the length of the data:

a) Long-term Index: This will be the only index built on monthly data starting from the year 1966. It contains eighteen different variables proportionally chosen from different groups. It aims to find a trend in the correlation development.
b) Short-term Index: Starting from the year 1990 this index uses weekly data. It consists of 23 variables. The purpose of this index is to investigate the intensity

of correlations between assets during the last 20 years and compare it to the pre-crisis and crisis levels in a more detailed way than the long-term index.

c) Correlation Heat-map: For the heat-map analysis data from the year 2004 is collected. The heat-map works with the largest amount of data (53 variables are used). Closely explained are only particular correlations but the historical development is shown by the use of a video.

4.3. Variables Sets

The main objective is to analyse the correlation between various assets on financial markets to get results for as large part of financial markets as possible. As mentioned in previous section, one of the problems in collecting data was its availability. The key for collecting data was to pick the most traded in separate markets. With this serving as a premise four major clusters which are Commodities, Currencies, Government bonds and Equity indices have been created each containing the most traded or important assets. As 5th group serve Corporate bonds and the VIX index. The availability of the data works as a constraint. If one asset from the list was not accessible then it was replaced with the next one in the rank.

In the table below are shown the names of all assets used. The selection for commodities and currencies was straightforward. Since they are daily traded and measured by price and amount, the key was to find the ten most traded in 2013. The ten most traded commodities are listed according to the ranking from top to the bottom. For currencies the selection principle was the same, except that the 9th most traded currency was Hong Kong Dollar. As the measure in which currencies are accounted is the Effective exchange rate[7], the Hong Kong Dollar has not been selected due to its connection to China. Where putting it into analysis could lead into distortions due to unclear amount of goods that end in Hong Kong or are only traded through Hong Kong. Because of the uncertainty of real value of effective exchange rate of Hong Kong dollar, the variable was replaces with New Zealand Dollar.

[7] Effective Exchange Rate is a method how to adjust bilateral exchange rate to trade and other currencies. Bank for International Settlement describes it as follows: *"An effective exchange rate (EER) provides a better indicator of the macroeconomic effect of exchange rates than any single bilateral rate. A nominal effective exchange rate (NEER) in an index of some weighted average of bilateral exchange rates."* (Klau & Fung, 2006)

Table 4.1: Data overview

Commodities	Currencies	Government Bonds	Equity Indices	Others
Crude oil	US Dollar	Japan	FTSE 100	WAAA
Coffee	Euro	USA	DAX	WBAA
Natural gas	Japanese Yen	Canada	CAC 40	VIX
Gold	UK Sterling	Australia	Eurostoxx 50	
Brent oil	SWISS Franc	Germany	Nasdaq	
Silver	Australian dollar	UK	S&P 500	
Sugar	Canadian dollar	France	DJIA	
Corn	Swedish Crown	Italy	Nikkei 225	
Wheat	Corona Norway	Hong Kong	Hang Seng	
Cotton	New Zealand Dollar	India	Bovespa	
Cocoa	Danish Crown	Portugal	SMI	
Platinum		Spain	OMX 30	
		Greece		

Source: Collected data, viz. appendix

For government bonds to be put into indices they have to fulfil two conditions; the countries of origin have to have large economies either in the meaning of total GDP or GDP per capita. The other important feature was whether government bonds are considered to be safe by rating agencies. This would enable to divide measured assets by analysis into safer and riskier, permitting to compare the correlation between market asset classes. As the thesis will be dealing with current recession, the bonds of Greece, Portugal and Spain will be used only in correlation matrix. The behaviour of these bonds could bring interesting features to the development of European sovereign debt crisis.

Setting the formula for selecting Equity indices was more complicate. There is no ranking of which equity index is better or more widely used, as it depends on individual investor. Therefore the key for picking the most important indices is by ranking the stock exchange standing behind the index. By selecting the indices from Stock Exchanges with highest market capitalisation of all listed companies is assured that the stocks of largest companies are added into the analysis. For better understanding of separate indices the appendix describes them.

The last section consists of two groups, the volatility indicator and corporate bonds (VIX). Both of these groups serve as indicators of economic development. The VIX indicator is "*the first index to measure the aggregate volatility of the US equity market"* (Luo & Zhang, 2012, str. 1) and is provided by the Chicago Board Options Exchange (CBOE). When

the market uncertainty increases the VIX index rises as well. The Corporate bond index is created from bonds rated by the Moody's where it measures the performance of company bonds rated either as A or B.

Another important part of the selection process is that to be able to compare the different indices with each other, the thesis always works with proportional amount of data from various major groups. To assure that the datasets are not biased or at least to minimalize this confusion a rule for selecting data is introduced. The rule says that although there might be more variables available in one asset group, the picked number of variables from the four major groups has to be always the same. This means that if for example data for hundred indices was available and at the same time only five currencies, then for the analysis will be only five indices chosen. The reason for it is to make the analysis more straightforward and precise, because an asset group might show higher correlation within each other and therefore increase the value of the index.

4.4. Methods for Analysis

As described in data analysis, there will be two ways how the analysis will be approached. The first one is index of absolute average values and the second one is by using heat-maps. Following pages include the methods and the ways how to calculate them.

4.4.1. Correlation

Correlation is a statistical tool used to measure a dependence of two variables. In finance, it helps to calculate to what extent the two financial instruments are moving together. Correlation values move between -1 and 1, where -1 is a perfect negative correlation and 1 is a perfect positive correlation. 0 stands for uncorrelated variables saying that the movement of one variable has no connection to the movement of the other variable. Perfect positive correlation means that when one variable increases by a certain amount, the other variable increases by the same amount. Negative correlation explains the opposite case where one variable increases and the second decreases. This implies that one of the features of correlation is its ability to express the direction of the relationship. The second feature is its ability to explain the intensity of the correlation (Stock & Watson, 2007).

Correlation has few disadvantages. First, it does not tell us about causation. We cannot imply that one variable is influenced by the other or vice versa. Secondly, we might find

correlation between two variables that do not make sense. Thirdly, basic correlation methods are only good for linear relationship. It might conclude that a strong negative correlation is close to 0. To make sure that a correlation is 0 a scatter plot might help (Stock & Watson, 2007).

The formula for correlation is as follows:

$$rxy = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

Where:

- x_i is each x value
- y_i is each y value
- $\bar{x}$ is the mean of x
- $\bar{y}$ is the mean of y
- n is the total number of all values

4.4.2. Average Absolute Values Indices

The AAVI should mostly serve to analyse the historical trend in correlation. There are two indices in total. Forming AAVI comes from a Heat map. It is transforming a heat-map into one single number by using the average and absolute values. To get a single number, first a correlation matrix is created. The next step is to transform all the values into positive numbers by the absolute value function. The premise is that the correlations are either more positive or more negative during crisis period. The absolute value enables to express the increase in correlation. If it was not for the absolute value, the stronger positive and negative correlations would compensate the increase in correlations and disable the index analysis.

One downside of correlation is that all correlations are equally weighted. Another disadvantage is that by forming absolute values, the ability to show positive and negative correlation is lost, but this is compensated with the ability to show the intensity of correlation

which becomes the main advantage of this graph. This is achieved by the average values formed from the new matrix with absolute values.

The formula for all the indices is:

$$AAVI = \frac{\sum_{i=1}^{n} \left| rxy_{ij} \right|}{\sum_{i=1}^{n} n_{ij}}$$

Where:

- $AAVI$ is the Average Absolute Value Index
- rxy_{iy} is the correlation between two assets
- n_{ij} is the total number of all correlations in one matric

Linear Regression:

Simple linear regression is explaining the influence of one variable on the other one. The linear regression analysis will further help in the investigation of predicted values (Stock & Watson, 2007).

The formula is:

$$Y_i = \beta_0 + \beta_1 X_i + \varepsilon$$

Where

- Yi is the dependent variable
- X_i is the independent variable
- β_0 is the intercept of the regression line
- β_1 is the slope of the regression line

The Ordinary Least Squares Analysis:

OLS analysis is *"The OLS estimator chooses the regression coefficients so that the estimated regression line is as close as possible to the observed data,"* (Stock & Watson, 2007, str. 116). It uses the method minimalizing the mistakes of total squares estimation. The formula for estimating β_1 and $\hat{\beta}_0$ is:

$$\hat{\beta}_1 = \frac{\sum_{i=1}^{n}(Xi - \overline{X})(Yi - \overline{Y})}{\sum_{i=1}^{n}(Xi - \overline{X})^2}$$

$$\hat{\beta}_0 = \overline{Y} - \hat{\beta}_1 \overline{X}$$

Where:

- $\hat{\beta}_1$ is the estimated value of the slope
- $\hat{\beta}_0$ is the estimated value of the intercept
- n is the range of the sample
- $\overline{Y}$ is the average of sample
- $\overline{X}$ is the average of x variable

Confidence Interval:

In the case of the thesis confidence interval will help to analyse the RORO effect and compare the current values with pre-crisis development. A two-sided confidence interval (CI) is constructed from upper and lower bound where these bounds are giving a probability that a certain estimate is within the bound. If the used probability is set at 95 % then the definition is: *"it is an interval that has a 95% probability of containing the true value of β_1: that is, in 95 % possible samples that might be drawn, the confidence interval will contain the true value of β_1 "* (Stock & Watson, 2007, str. 156).

The formula is:

$$CI\beta_1 = \hat{\beta}_1 \pm tSE(\hat{\beta}_1)$$

Where:

- $CI\beta_1$ is the confidence interval of $\hat{\beta}_1$
- t represents the student distribution

- SE is the standard error
- $\hat{\beta}_1$ is the slope estimate

Prediction interval:

The CI analysis can be used to calculate the interval for predicted values (PI). The difference is that whereas confidence interval is trying to forecast the future mean the prediction interval is trying to find the position of future sample. It tells that with 95% probability the future value will lie within the interval (Stock & Watson, 2007, str. 157).

The formula is:

$$PI\beta_1 = \hat{\beta}\Delta x_1 \pm tSE(\hat{\beta}_1) * \Delta x$$

Where:

- Δx is the change of X
- $PI\beta_1$ is the confidence interval of $\hat{\beta}_1$
- t represents the student distribution
- SE is the standard error
- $\hat{\beta}_1$ is the slope estimate

4.4.3. Chow test

The Chow test is testing the similarity between two coefficients of linear regressions. The basic idea is to do the *"testing of whether m additional observations are from the same regression as the first sample of n observations, and the testing of whether subsets of coefficients in the two regressions are identical"* (Chow, 1960, str. 3).

This analysis will help to set the dataset for PI and CI intervals. If the Chow test proves significant the alternative hypothesis of structural break between the pre-recession data before September 2007[8] and recession data from September 2007, then the CI and PI analysis will be based only on pre-recession dataset. This dataset will be comparing pre-recession values to following results.

[8] September 2007 is chosen as the beginning of financial crisis according to the book from George Soros, where he exactly states the beginning of financial crisis on September 2007 (Soros, 2009).

4.4.4. Heat-map

A heat map is a graphical function enabling people to add colours into matrices, to divide different numbers into groups in order to make them more readable. (Wilkinson & Friendly, 2008) In the case of this thesis, the heat map will serve to analyse the correlation between different assets. The formula expressed above is the basic unit of a heat map where by putting data into the formula, the correlation between any two assets for the demanded period can be computed. This will result into X times X metrics with values between -1 and 1. The Correlation Heat map will be used between the years 2005 up to the middle of 2014 to graphically analyse the development and the current situation of correlations between various financial assets.

4.4.5. Method summary

Each of the above described methods for data analysis has its own purpose in the thesis. The first method is the AAVI. By using this graph to analyse the development over time, it is expected to get a general idea of what is influencing the correlations. However this graph is not able to explain what the individual connections between any two assets are. To solve this, individual heat-maps are used to clarify the change in correlation and to closely outline the evolution of correlation between any two assets over time. For outlining the development of heat-maps a video was created and will serve to give insight on how the intensity of correlations was changing. As the last indicator the comparison of the VIX index and S&P 500 index will serve.

All three methods for analysis are important in order to be able to compare the current level of correlation with the economic development of world economies. The AAVI index explains the intensity. The heat-map is added to the AAVI in order to analyse the correlation of assets and to get the idea whether all variables truly arrived to pre-crisis levels of correlation. From these two graphs it should be easy to make a statement about the current position of the world economy. Since there might also be different reasons for decreasing correlation, the comparison of VIX index and S&P 500 index serve as the last measure to deal with other influences. By comparing these two indices with pre-crisis levels the analysis will be finalised.

5. Absolute Average Value Index

As mentioned in previous chapter, the reason to construct the AAVI was to analyse the intensity across assets. It contains two subchapters which are formed from short-term and long-term data. Although these two indices are made with the same procedure, the expected outcomes are different. The short-term index focuses in more detail on the influence of the Great Recession, whereas the long-term analyses trend within assets correlation.

Each of the subchapters contains a table with data description. The table provides information about the dataset used for the analysis. Further information about single variables is given in the Appendix. The first graph in each chapter (graphs 1 and 3) is conducted from three trend lines. The dotted line always shows the trend for the studied period. If there is a sudden change on a market and both data, before and after the change, are taken into account, the outcomes of the analysis have a possibility to suffer from this fact and do not show a reasonable explanation of the case. To analyse the structural break between the trend lines the Chow test was introduced. In order to analyse this potential structural break in dataset, one may use Chow test that divides the dataset into two groups. By dividing it, it can be found whether the recession is influencing the trend line or not and how the new trend evolves and differs from the previous one. Thus the two full lines represent the split on the beginning of Great Recession on September 2007[9].

The graphs 2 and 4 have different value for the analysis. They work with CI and PI. As introduced in chapter four, the CI serves to estimate with certain probability the possible slope of trend lines when there are new values added, whereas the PI estimates with certain probability the boundaries where could future values lie. In the case of this thesis the probability is always 95 %. Both of these graphs have the data points for the studied period, but the intervals and trend line are constructed from data before September 2007.

5.1. Short-term Index

The detailed description of data worked with in short-term analysis is shown in table 5.1 it can be observed that the data frequency is weekly and the rolling window[10] is one years.

[9] September 2007 is chosen as the beginning of financial crisis according to the book from George Soros, where he exactly states the beginning of financial crisis on September 2007 (Soros, 2009).

[10] By rolling window is meant the time period used in correlation. For example, 3 years rolling window represents data from January 1990 till December 1992, meaning that exactly three years are always correlated.

This means that for every single point on the graph that indicates correlation, data for at least one year is used. The maximal value was achieved between 24.6.2011-15.6.2012 and the lowest from 25.9.1992 to 17.9.1993. The Number of points on the graph shows that the weekly rolling window has created a more precise graph.

Table 5.1: Short-term index

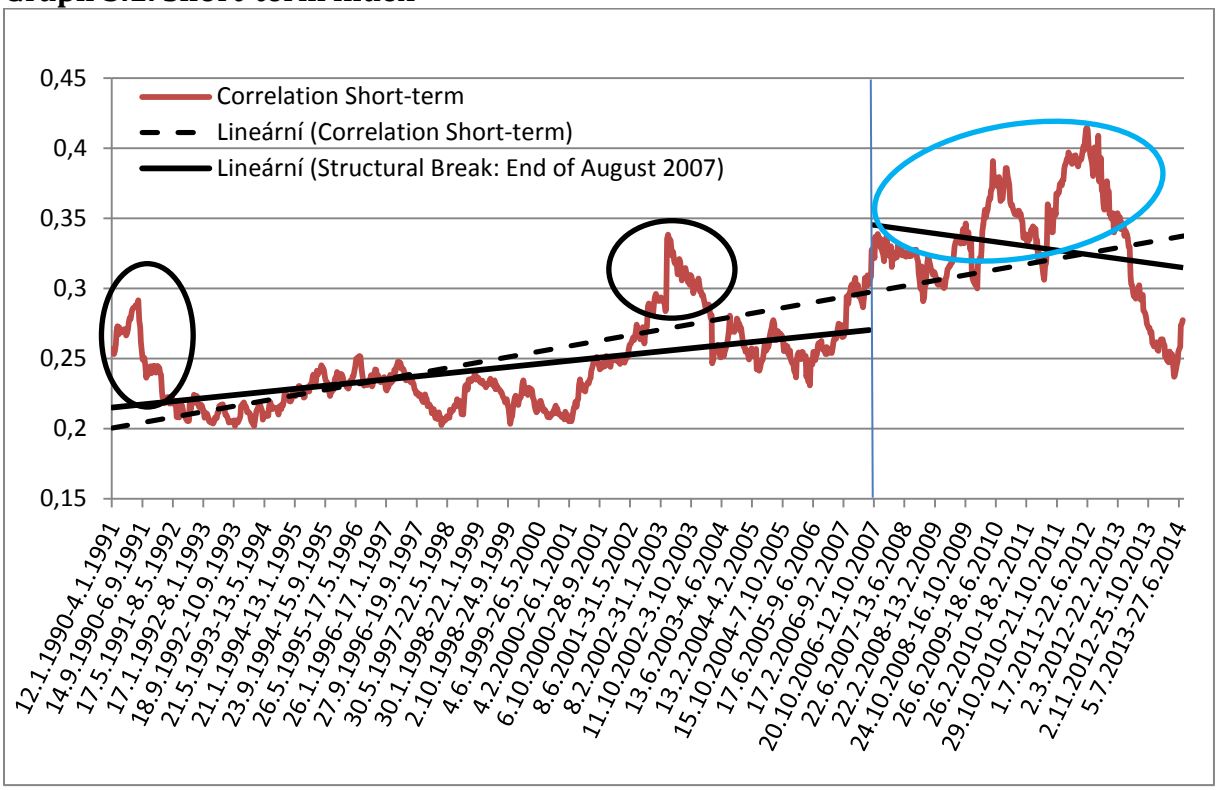
Function	Description
Starting Date	12. January 1990
Closing Date	25. July 2014
Rolling Window Frequency	1 year
Data Frequency	Weekly
Derived in	Excel, Matlab, Gretl
Data collected from	Bloomberg, Bank of England
Min Value	0,2018
Max Value	0,4147
Median Value	0,2529
Standard Deviation	0,05205
Mean	0,2689
Number of points on the graph	1229

Source: Own Calculation, Bloomberg

Graph 5.1 is showing some interesting findings. The first is that the increase in intensity of correlation when the recession started is quite strong, proving the RORO effect to be present. During the pre-recession period there were two smaller peaks, which are highlighted by black circles. The first one on the beginning of 90's was caused by the Kuwait crisis and the American invasion. As Kuwait is an important player on oil market, it was influencing through price many other markets. The second circle was caused by economic slowdown in developed countries.

In the RORO analysis is the plunge in the end of observed period important. The correlation fall down to values it had in 90's. The value achieved between 24.5.2013-16.5.2014 is approximately 0,237 which is a decrease by 43 % in comparison to the maximal value collected during 24.6.2011-15.6.2012. Thus this graph is the first one to indicate, that the RORO effect might be over.

Graph 5.1: Short-term index



Source: Own Calculation, Bloomberg

The table 5.2 on the next page is showing results for Chow test for structural break in dataset. The null hypothesis of the Chow test is: are the coefficients of OLS are the same? Thus, the alternative hypothesis says that there was a structural break and there is a need of dividing the dataset into separate groups.

Running a regression of correlation value dependent on time trend (meaning every week is given a number higher than the previous; starting with number 1 for the second week in January 1990) and consequently testing OLS for Chow test. The start of Great Recession was from September 2007 and therefore that is the break chosen to be analysed.

At this point, one must look at p-value of the Chow test which exhibits value of 0,0000. This is smaller than significant level of 5 %[11], meaning, one may decline the null hypothesis of the same coefficients and accept the alternative that there is a structural break. Therefore, Chow test proved that there was a "big" change on the market and by dividing the period into two of them, we may obtain more suitable results for the purpose of the thesis.

[11] A significance level is the probability that the hypothesis was wrongly rejected. It is often represented as p-value. In the case of this thesis the p-value is set at 5 % level.

Table 5.2: Chow test: Short-term

```
Augmented regression for Chow test
OLS, using observations 1991-01-04:2014-07-25 (T = 1230)
Dependent variable: Correlation

                  Coefficient    std. error    t-ratio    p-value
  ------------------------------------------------------------------
  Time_trend       0.000434372   6.42063e-06    67.65    0.0000    ***
  splitdum         0.391106      0.0506490       7.722   2.37e-014 ***
  sd_Time_trend   -0.000490535   4.84288e-05   -10.13    3.26e-023 ***

Mean dependent var    0.268893   S.D. dependent var    0.052052
Sum squared resid     11.08376   S.E. of regression    0.095043
R-squared             0.879868   Adjusted R-squared    0.879672
F(3, 1227)            2995.586   P-value(F)            0.000000
Log-likelihood        1150.918   Akaike criterion     -2295.836
Schwarz criterion    -2280.492   Hannan-Quinn         -2290.063
rho                   0.995693   Durbin-Watson         0.002857

Chow test for structural break at observation 2007-08-31
  F(2, 1227) = 146.043 with p-value 0.0000
```

Source: Own calculation

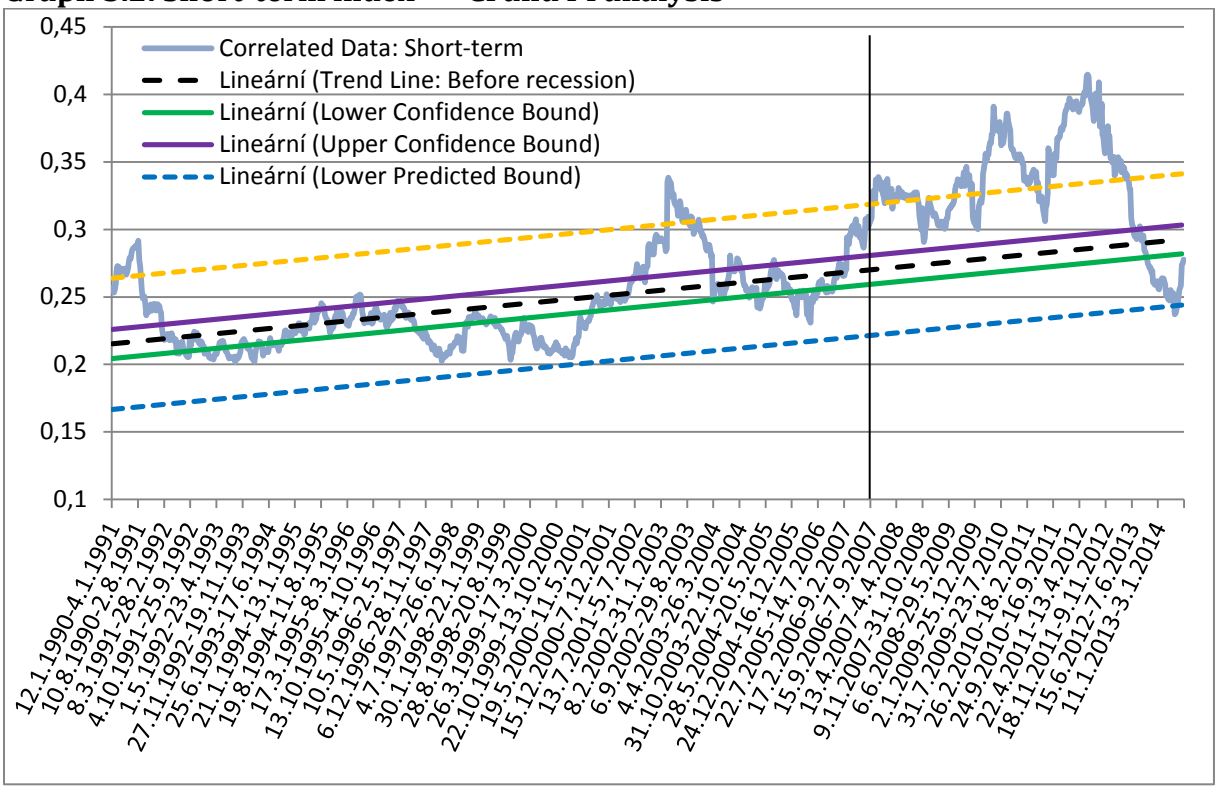
Graph 5.2 tries to explain whether the RORO effect is over or not. The Chow test has proven that the two periods are significantly different, thus all the lines on the graph are calculated only from data before September 2007 and extended to the next period. This should enable to make more precise conclusions about the current state of RORO in comparison to pre-recession development.

It can be seen that also the two peaks from graph 1 are crossing the PI boundaries but the values are returning back within the PI boundaries relatively quickly. Yet for this analysis is the development from September 2007 the most important. The graph shows that he AAVI has risen above the PI boundaries and with only small exceptions it stayed there till the middle of 2013. During that period the AAVI seems to be falling to values similar to pre-recession values.

The latest development leaves the impression that the RORO effect has fallen significantly between the boundaries and although there are still many risks for the world economy[12], the AAVI is recovering to values that are no more representing the RORO effect with a 95 % significance level.

[12] The risk is currently in the Middle East development, the Ukrainian crisis and the relationship with Russia, health problems in Africa or even future bubbles such as the danger of Chinese growth rate. (Parker, 2012)

Graph 5.2: Short-term index => CI and PI analysis



Source: Own Calculation, Bloomberg

5.2. Long-term Index

Long-term index has the advantage in comparison to the short-term index that the data is collected from 1966 allowing the correlation to analyse longer period. The detailed description of data used in long-term analysis is shown in table 5.3. It can be observed that the data frequency is monthly and the rolling window is 3 years. This means that for every single point on the graph that indicates correlation, data for at least three years is used. The long period makes it difficult to exactly state which day was the breaking point in the correlation development. The inability to name the cause of increased correlation is the biggest disadvantage of long-term index.

On the other hand, this index is expected to form a better idea of how the correlation was evolving in long time period. In order to predict what the "normal" value[13] is, it cannot be worked only with mean and median values, because these values assume that the general level of correlations stays on the same level throughout the time. However, a trend might occur in the correlation and therefore the "normal" value might be changing in time. This would mean that it cannot be expect the correlation to return to values seen in previous

[13] "Normal" value in this case stands for trend line.

periods. The lowest value in the studied dataset was achieved by correlating data from June 1971 till June 1974. On the other hand the highest correlation was measured between January 2006 and January 2009.

Table 5.3: Long-term index

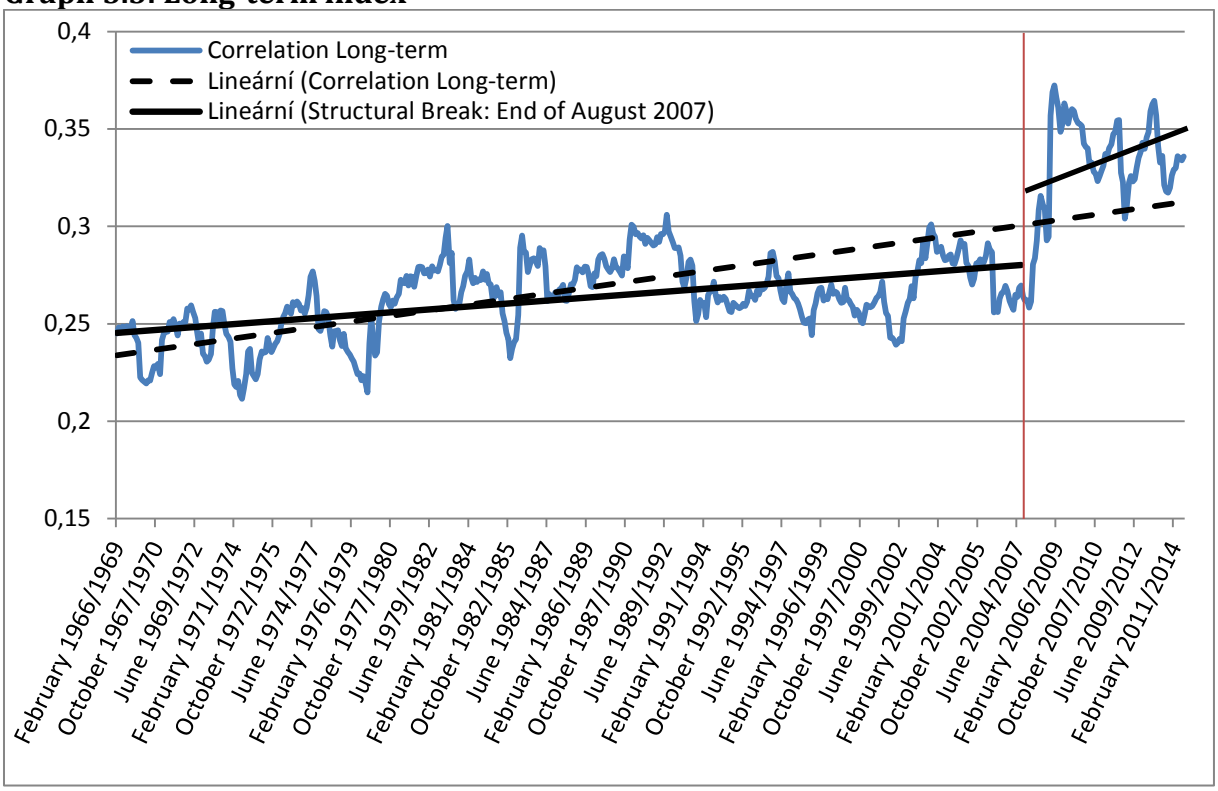
Function	Description
Starting Date	February 1966
Closing Date	July 2014
Rolling Window Frequency	3 year
Data Frequency	Monthly
Derived in	Excel, Matlab, Gretl
Data collected from	Unctad.org; ECB; Federal Reserve Bank of St. Louis; Yahoo Finance; Index Mundi; BIS
Min Value	0,2115
Max Value	0,3723
Median Value	0,2666
Standard Deviation	0,0321
Mean	0,2733
Number of points on the graph	546

Source: Own calculation, Bloomberg

By looking at the graph 5.3 one thing is striking. The surprising is the sharp increase in correlations since September 2007. The correlation between assets skyrocketed and increased by 10 percentage points. During studied period there had never been such a strong correlation for any three consecutive years as during financial crisis. It is also visible on the graph that most of the points behind the red dividing line are higher situated then the dotted line.

The rising dotted line and rising pre-recession line show another important feature of the graph as both trend lines growing in time. These lines give the idea that the overall correlation might be increasing in time. The rise can be caused by new technologies used on markets and thus more precise information about the assets. HSBC explains the increase as follows: *"Correlations between asset classes appear to be on a long-term upward trend, which may reflect the growing internationalisation of financial markets and the improvements in information technology."* (HSBC, 2010, str. 13) . This finding is crucial as it provides guideline for predictions of future correlations development.

Graph 5.3: Long-term index



Source: Own calculation from collected data, viz. Table

The table 5.4 similarly as in previous chapter is analysing the structural break in dataset with Chow test. The null hypothesis is if the coefficients of OLS are the same. The alternative hypothesis is then that there was a structural break in the dataset. The dataset starts from February 1969. This is because the correlation was conducted for 3 years rolling window and by working with the last day of the correlation it allows to easily set the beginning of recession in the analysis on September 2007.

The Chow test similarly as in previous case exhibits the p-value to be significantly lower than 0,05 and thus is rejecting the null hypothesis and accept the alternative of

structural break presence. The Chow test has proven that the trend line before recession is significantly different than the trend line from the crisis period.

Table 5.4: Chow test:

```
Augmented regression for Chow test
OLS, using observations 1969:02-2014:07 (T = 546)
Dependent variable: Correlation

                 Coefficient    std. error    t-ratio    p-value
  ------------------------------------------------------------------
  Time_trend       0.000871105   1.99179e-05   43.73     4.49e-180 ***
  splitdum         0.132073      0.259965       0.5080   0.6116
  sd_Time_trend   -0.000477769   0.000515084   -0.9276   0.3541

Mean dependent var   0.273203   S.D. dependent var   0.032000
Sum squared resid    7.103962   S.E. of regression   0.114380
R-squared            0.828039   Adjusted R-squared   0.827406
F(3, 543)            871.5642   P-value(F)           4.5e-207
Log-likelihood       410.6164   Akaike criterion    -815.2328
Schwarz criterion   -802.3249   Hannan-Quinn        -810.1870
rho                  0.993565   Durbin-Watson        0.004492

Chow test for structural break at observation 2007:08
  F(2, 543) = 23.4142 with p-value 0.0000
```

Source: Own calculation

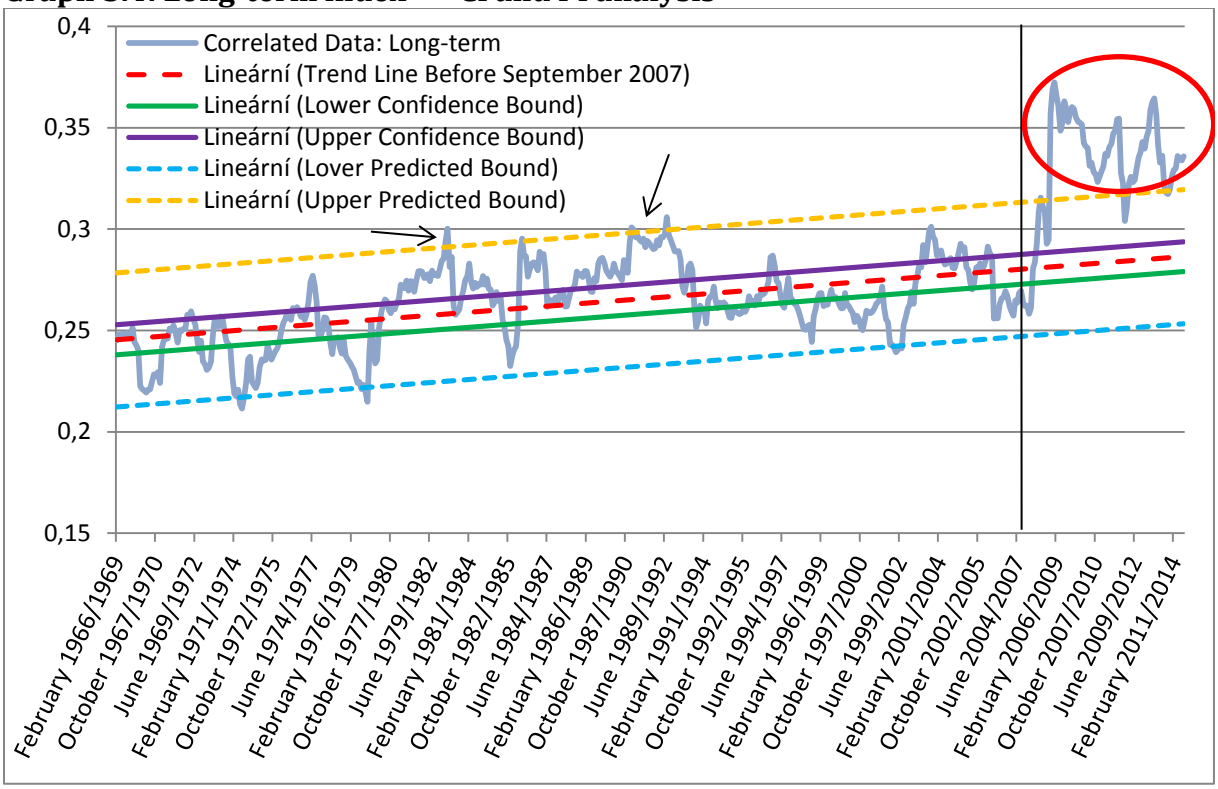
Because the Chow test has proven the two trend lines to be significantly different, the graph 4 was constructed in the same way as graph 5.2: Short-term index => CI and PI analysis. Thus all the presented boundaries are formed from dada before September 2007.

As observed on the graph 5.4, during the pre-crisis period from 1966 up to 2007 there were almost no values that would deviate from the boundaries. The only periods when the AAVI rose above the boundaries are on the beginning of 80s and at the turn of the 90s outlined by two arrows in the graph. The first arrow represents the Israeli bank crisis and the second stays for "Black Monday" and Kuwait invasion where indices of strongest companies started to fall. What is interesting is that the Asian and Russian financial crisis at the end of 90s did not lead to significant increase of correlation. The same goes for the crisis on the beginning of 20th century.

Interesting is that the AAVI has also fallen below the PI boundaries, but as the thesis works with the issue of increased correlation, this will not be analysed. The red circle on graph 5.4 shows that the current recession had a different impact on correlation. The new values deviated significantly from the boundaries, which can be described as the RORO effect. In long term index with three years rolling window the values were the highest in 2009. Then they started to fall, but before falling into the boundaries they again increased to values significantly higher than is represented by the boundaries. The same situation was

repeated once more with only one difference that the values have fallen within the boundaries to again rise to values higher than the previous peak.

Graph 5.4: Long-term index => CI and PI analysis



Source: Own Calculation, Bloomberg

The latest development shows that AAVI is out of the boundaries forming a fourth peak at a yet unknown top. This outcome disables to make the conclusion that the RORO effect is over and that the financial markets are heading out of the recession. But as mentioned before the main disadvantage of long term analysis, is the inability to express the turning point in the development due to three year rolling window. Thus at this stage of analysis it is impossible to make a conclusion about the end of RORO.

6. Heat-map Analysis

Heat maps serve to show the previous graphs in a different way. They do not work with absolute values and therefore enable us to see the positive and negative correlation within assets. On a heat map we can grasp the correlation within two assets in colours which make it in the huge amount much easier to comprehend. Dark blue and dark red stand for negatively resp. positively correlated values. The milder colours represent values of correlation closer to 0. Thus the darker graphs stand for periods of high correlation.

In other words, when on the heat map dark colours prevail the correlation is high. Mild colours show normal values. In order to clearly see the development three groups of graphs are introduced: before crisis, peaks and the latest development.

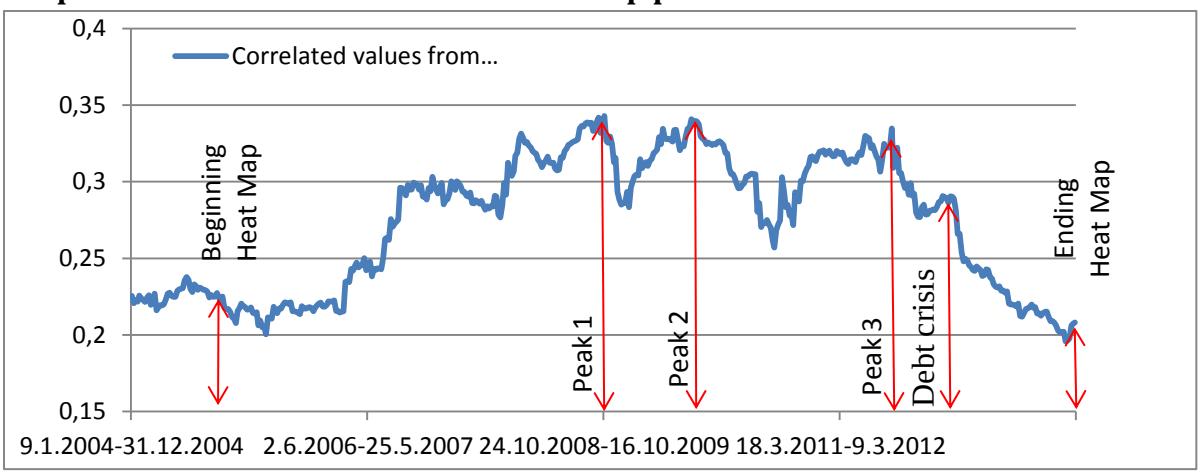
Heat-maps are constructed from 53 assets from the year 2004 making it the largest dataset used in this thesis in the sense of variables. Newly there are also government bonds of risky countries introduced. As previously the rolling window is one year. For this analysis it is not logical to show the maximal or minimal values as well as the mean, because the values are increasing during crisis on both sides.

In general it is expected the colours to change over time. Thus the objective of this analysis is to display the presence of correlation between any two assets on a diagram and show how the correlation is changing by using heat-map. In the AAVI analysis we got one value for all the assets together, so it was impossible to analyse which assets affected the increase.

The periods studied by heat-maps are:

1. Normal state – Before crisis level of correlation
2. First Peak – Peak influenced by development in the USA (Real-estate burst, Bankruptcy of Lehman Brothers
3. Second Peak – Bankruptcy threat for several countries (Greece, Ireland, …)
4. Third Peak – Sovereign debt crisis in Europe
5. Debt Crisis – Crisis on the bond market
6. Last measured state – Current correlation levels

Graph 6.1: Time frame of selected heat-map periods



Source: Own Calculation, Bloomberg

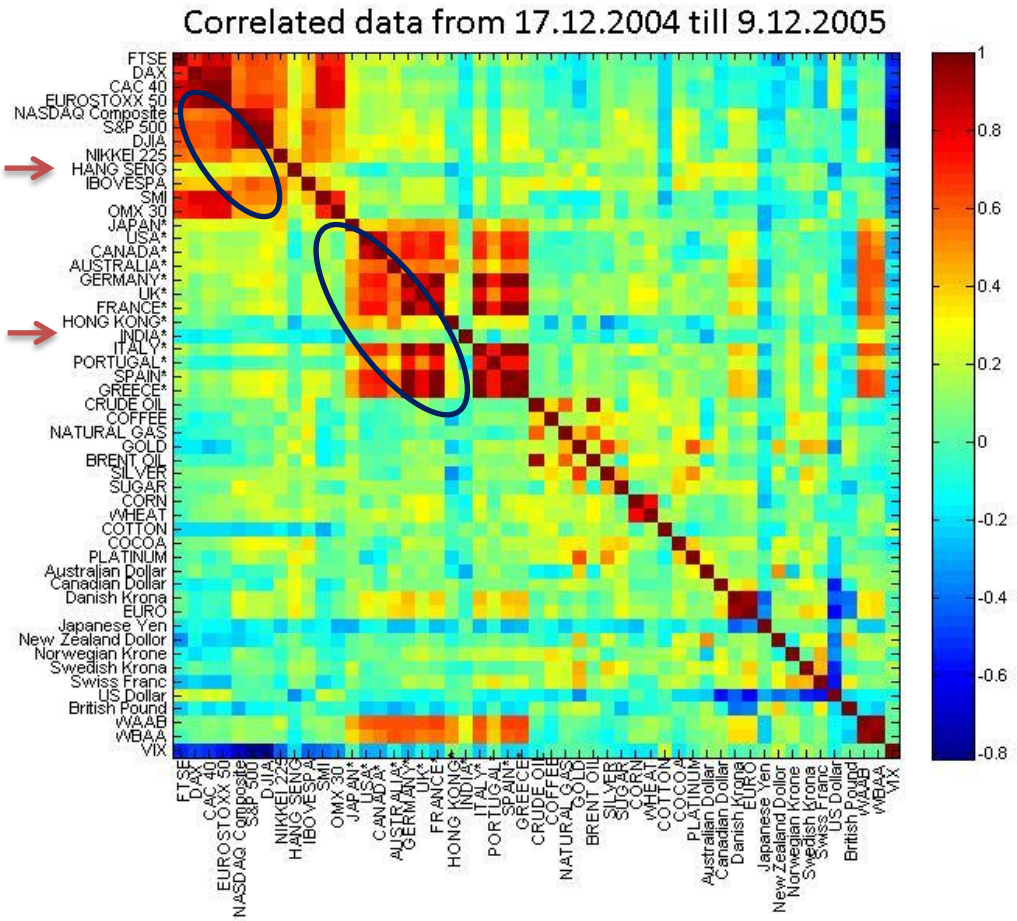
As the heat-map is at some places hard to read, especially the axis are not clearly visible, all the heat-map graphs are copied to the appendix 2, where the names of the axis are larger. Also a video was created in order to show the development of correlations. The video starts in 2004 with yearly rolling windows. It clearly shows the development of correlations by the use of colours. The video is available at: http://youtu.be/apYjuoUwqWk. The issue about the video is, that it does not contain the names of axis and exact time. But the names of axis are the same as all the heat-maps in the thesis. Time window starts from 2005 to 2014 and unfortunately the exact time period can only be compared to the graphs in the thesis. Even without these informations it still gives general idea about the correlations.

6.1. Before Crisis Heat-map

As can be observed on the first heat map before crisis values, "normal" values show that mostly mild colours are prevailing during this period. Only equity indices and government bonds illustrate strong correlation between each other. The connection is not surprising as equity markets and bond markets move together. From government bonds only these from India and Hong Kong show no connection to most of the other assets. During a normal period we can observe that there are many different forces driving the yields on assets. We can get this conclusion from mild colours signalling low links.

Interesting fact arises during normal periods the indicators from developing countries show lower connection to other assets. In our case the Ibovespa and Hang Seng (Brazil and China) equity indices as well as Government bonds from India and Hong Kong show low correlation with other assets even within the group. This demonstrates the presence of different influences on these markets. On the other hand, commodities and currencies display no connection within the group or to other assets.

Diagram 6.1: Correlation during pre-crisis period



Source: Own Calculation, Bloomberg

6.2. The Peak Periods

This subchapter contains four graphs with three peaks and one sovereign debt crisis point. The reason to take all peaks that appeared during financial crisis on the AAVI is because although the index shows some higher correlations it does not explain whether all of the assets or only a few are pushing the numbers up. The objective of this chapter is to analyse which assets were the driving force of increased correlations during various chapters.

First Peak – After the fall of Lehman Brothers the correlations skyrocketed. Equity indices become almost perfectly correlated no matter where they were from. Dark red is dominating this part of the graph. One can see increased correlations between all assets. There are almost no negatively connected assets except for VIX, US dollar and Japanese Yen and some other currencies. The reason behind might be US dollar and Japanese yen are considered to be safe investment during turmoil. The VIX index is the measure of volatility of assets and therefore grows when there are some problems. From the asset groups Equity and

Government bonds had been correlated even before. Yet the correlation was not as strong as is the graph shows. Now commodities are positively correlated to them as well, which is highlighted with the black circle. The red circle than describes the negative correlation within currencies.

Second and Third Peak – The second and third peak are quite similar, therefore they are described in one part. Equity indices and Government bonds still stay highly correlated. Newly they become highly correlated within each other as well as it is shown by increased red colours in the north east area. But already within the bond markets a change is apparent. The government bonds of Italy, Spain, Portugal and Greece do not follow the evolution of other bonds but instead they turn to be negatively correlated to other assets. In the commodity market we can observe that some started to turn back to its normal state of low correlation but others turned to be darker. The same goes for currencies where especially Australian dollar, Canadian dollar and EURO shifted to be more positively correlated with equity and bond market. Also corporate bonds turned out to be more positively correlated to others.

Debt crisis peak – During this period one effect is particularly visible and that is the negative correlation within the so called "PIGS" countries. Although the overall intensity of correlations decreases as shown in the graph 4 the connection with these government bonds has increased. The yield on these bonds turned out to be strongly negatively correlated with other bond and Equity indices. The negatively connection with some commodities and currencies is not so strong. Another interesting factor in this period is the correlation within currencies and commodities. It can be seen that mostly mild colour prevail and the correlation is almost back to pre-crisis state.

Diagram 6.2: First peak
Source: Own Calculation, Bloomberg

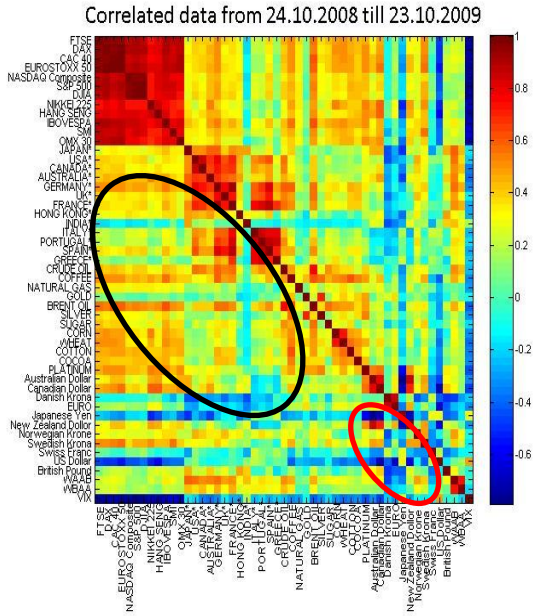


Diagram 6.3: Second peak
Source: Own Calculation, Bloomberg

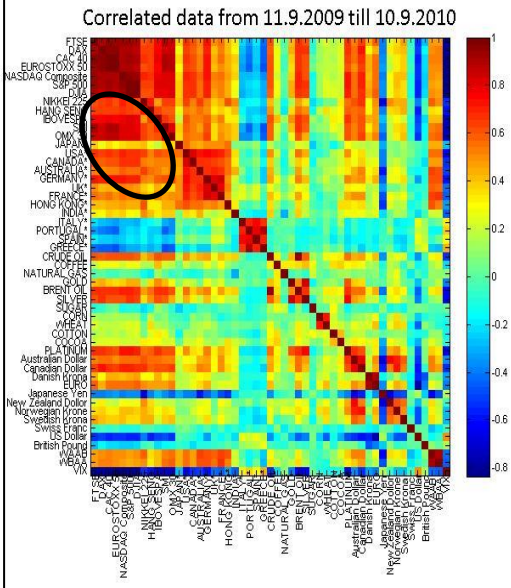


Diagram 6.4: Third peak
Source: Own Calculation, Bloomberg

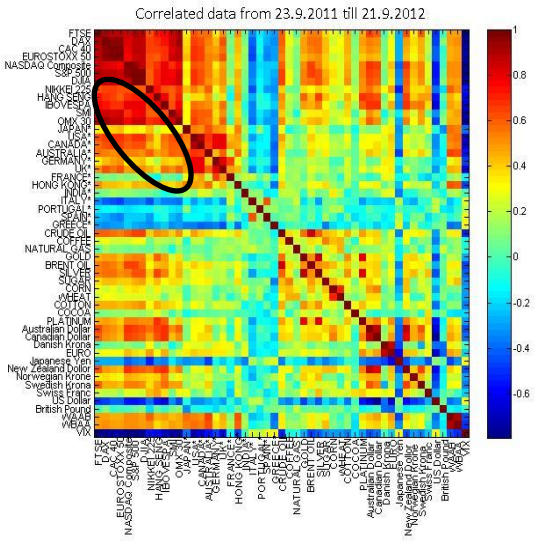
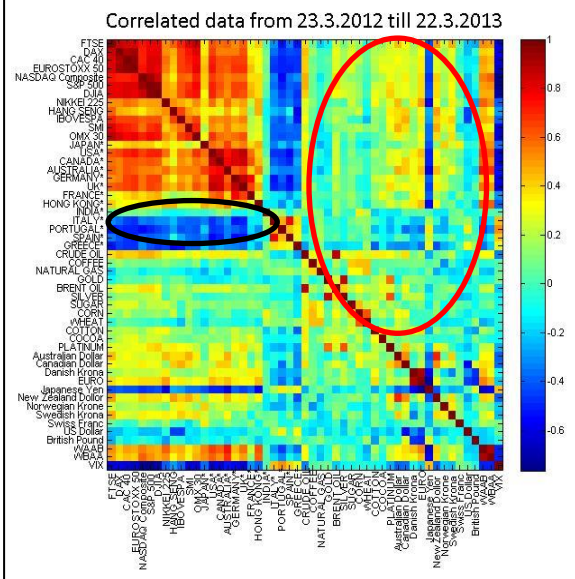


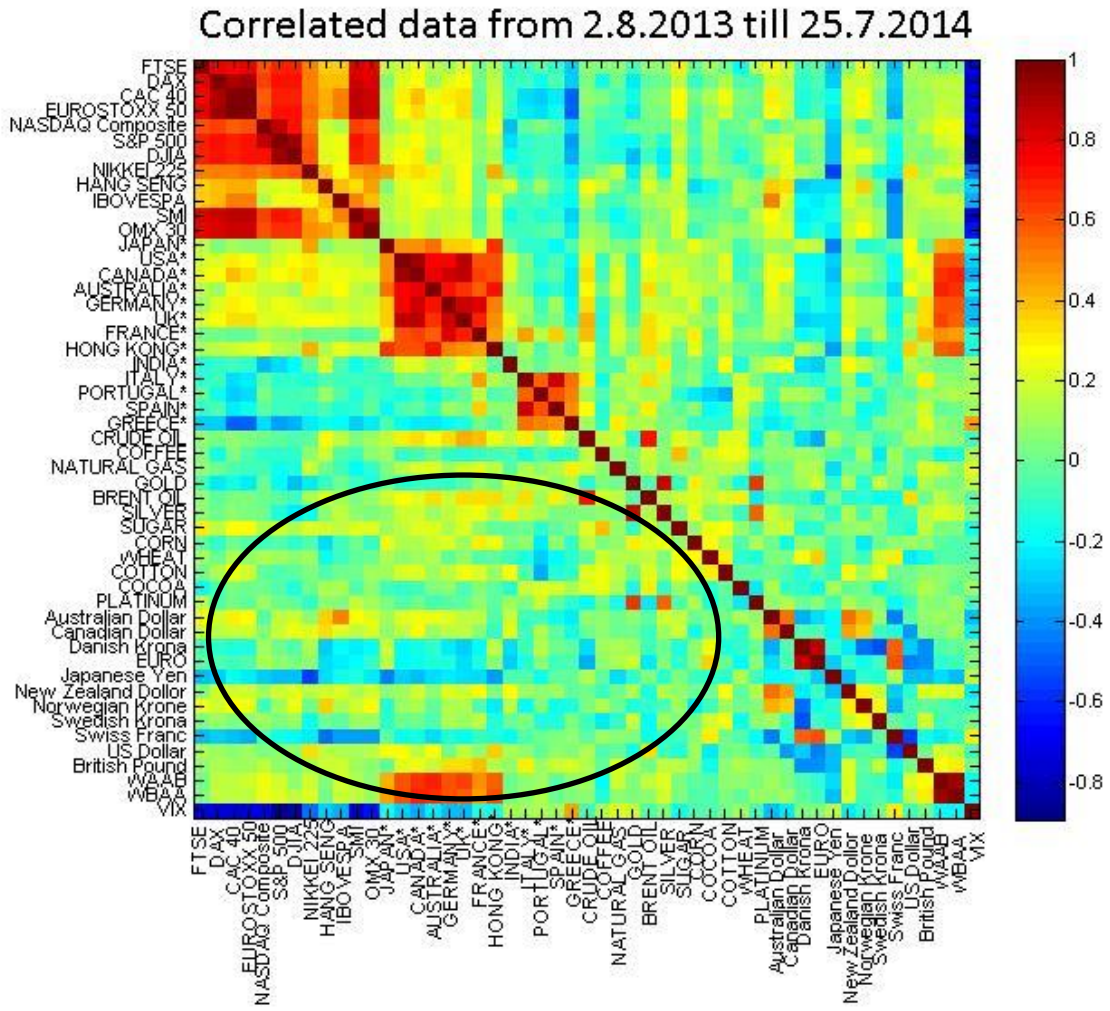
Diagram 6.5: Debt Crisis
Source: Own Calculation, Bloomberg



6.3. Heat-map in 2014

Last heat-map considers the correlation up to the latest followed date. As the graph depicts the colours are much milder than in the previous periods. The commodities and currencies are not at all or slightly correlated between each other. Government bonds and corporate bonds with the exception of "PIGS" show connection, but this situation is similar to the pre-crisis levels. The same goes with equity indices where the indices from developing countries are again not correlated to other indices.

Diagram 6.7: Correlation during current period



Source: Own Calculation, Bloomberg

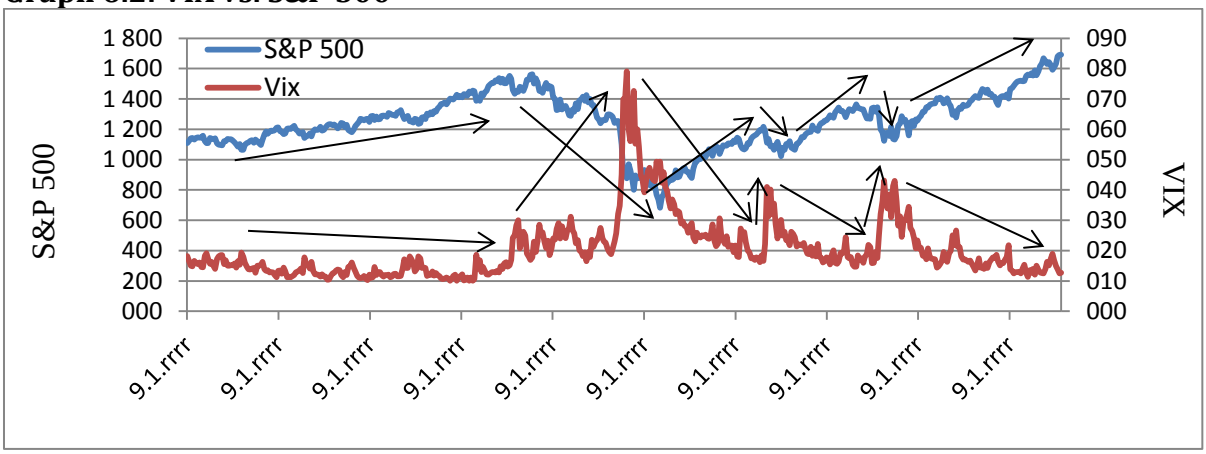
6.4. VIX Index

In this chapter the development of VIX index is analysed. It is interesting because of two reasons. The first one is that as the heat-maps have shown the VIX index was always negatively correlated to Equity indices. That means that either one of them was falling and the other one growing or vice versa. As all the values were slightly opposite to VIX index the next analysis helps us to understand in which phase of economic development we are

That is because as was seen on the heat-maps the correlation within government bonds are dark red meaning they were positively correlated, which also means that they were either falling together or rising together. This allows us to make the premise that when VIX index raises the yields of other assets fall and when the VIX index falls than the yield should grow.

On the graph 5 can be exactly seen what is mentioned in paragraphs above. The VIX index and the S&P 500 index move in the opposite direction. Up to the year 2008 the VIX values were falling and the S&P 500 yields were rising. After that both of the indices took a sharp turn and made it to the maximal resp. minimal value in the followed period. We can see a pattern on the arrows in the graph that. The fall of one index was followed by the surge of the other. The current position is good, because if there is a negative correlation between these two assets and other assets show low connection and at the same time VIX index falls and the S&P 500 index is rises, it means that the current economic situation is the closest to pre-crisis levels than it was during the years since 2007.

Graph 6.2: VIX vs. S&P 500



Source: Own Calculation, Bloomberg

Conclusion

The goal of this thesis was to analyse the Risk-On Risk-Off (RORO) effect, its current and past development and explain its impact on financial markets. For the purpose of the analysis, the first chapter was introducing the financial markets, what they serve for and why they are important. This was followed by a part describing current economic crisis, how it started and what was changed on the financial markets. The third section describes what RORO effect means and how it is influencing financial markets and global economy. Starting from the fourth section, the thesis was orienting more on the analysis of RORO. The fourth section also contain arguments for data and methods selection.

The first method analysing the RORO effect was the Absolute Average Value Index. The short-term index showed that the correlation intensity has increased since 2007, but that during the year 2013 started to fall to normal values. Normal values refer to market environment where RORO is not present anymore. This was proven by the use of PI boundaries which are saying that with a probability of 95% the RORO effect is over. Long-term index was analysing the correlation from a different perspective and has shown that since the year 1966 to the year 2007 the correlations were increasing. This means that expected average value is higher at the beginning of 21st century than it was 50 years ago. The heat maps have supported the outcome with another method by showing how correlations were increasing within any two assets since 2007 and returning to pre-crisis values in middle of 2013.

For the reasons named above and described throughout the thesis, it can be concluded that since the second half of 2007 investors had to face increased correlation within assets. Therefore, facing a new problem with making portfolios as the correlations increased to levels unseen in the last 50 years. The EU was one of the most strongly hit regions. The European debt crisis led some countries to have negative correlation to other assets. The increased RORO effect and fewer government bonds that could have been considered as “safe havens” led to the situation, where in order to lower the volatility of portfolio, investors were willing to borrow money for a negative interest rate. However, final results of the analysis are suggesting the end of RORO on financial markets. The latest development of RORO allows concluding that with probability of 95 %, the problems on financial markets for investors are over.

Appendix 1: DATA Analysis

Equity Indices	Explanation	Source	DATA	Min	Max	Median	Mean	Standard deviation
FTSE 100	Index of 100 companies traded on London Stock Exchange with the highest market capitalisation	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	1 990	6 930	5 078	4 758	1 375
			Correlation	3 531	6 866	5 711	5 595	751
DAX	Index of 30 German companies listed on Frankfurt Stock Exchange with the highest market capitalisation	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	1 335	10 009	4 779	4 658	2 205
			Correlation	3 647	10 009	6 232	6 307	1 535
CAC 40	Index of 40 French companies listed on Euronext with the highest market capitalisation	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	2 534	6 168	3 928	4 126	791
Eurostoxx 50	Index of 50 largest Eurozone stocks	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	1 817	4 557	2 896	3 062	615
Nasdaq	Index of all companies traded on Nasdaq stock exchange	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	1 294	4 486	2 392	2 543	651
S&P 500	Index of 500 companies most widely traded companies in the US	Yahoo.finance	Long-term	64	1 973	340	581	527
		Bloomberg	Short-term	300	1 985	1 108	1 014	408
			Correlation	683	1 985	1 280	1 305	243
DJIA	Index of 30 largest and most influential companies in the US	Yahoo.finance	Long-term	608	16 827	2 662	5 031	4 687
		Bloomberg	Short-term	2 398	17 100	9 903	8 861	3 732
			Correlation	6 627	17 100	11 502	11 879	2 070
NYSE Composite	Index of companies listed on the New York Stock Exchange	Yahoo.finance	Long-term	354	10 979	1 980	3 386	3 080
			Short-term	x	x	x	x	x
			Correlation	x	x	x	x	x
Nikkei 225	Index of 225 Japanese companies listed on Tokyo stock exchange with the highest market capitalisation	Yahoo.finance	Long-term	1 277	38 916	10 586	11 990	7 813
		Bloomberg	Short-term	7 173	38 275	15 204	15 359	5 293
			Correlation	7 173	18 239	11 363	12 188	2 881
Hang Seng	Index of 48 companies listed on Hong Kong stock exchange with the highest market capitalisation	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	11 277	30 468	20 377	19 414	4 033

Bovespa	Index of 50 companies listed on Sao Paulo stock exchange with the highest market capitalisation	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	18 285	72 767	53 178	49 233	14 955
SMI	Index of 20 companies listed on Swiss stock exchange with the highest market capitalisation	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	4 312	9 531	6 589	6 928	1 178
OMX 30	Index of 30 companies listed on Stockholm stock exchange with the highest market capitalisation	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	568	1 404	1 010	998	198
Commodities	**Explanation**	**Source**	**DATA**	**Min**	**Max**	**Median**	**Mean**	**Standard deviation**
Crude oil	West Texas Intermediate crude oil futures known for light grade and traded on Chicago Mercantile Exchange.	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	10,8	145,3	29,8	46,2	31,6
			Correlation	32,5	145,3	78,0	77,9	22,7
Coffee	Futures contract price of Arabica coffee traded on Intercontinental exchange (ICE)	UNCTAD	Long-term	33,1	315,0	99,3	99,8	48,9
		Bloomberg	Short-term	42,6	299,4	110,8	116,8	50,1
			Correlation	65,0	299,4	127,0	139,9	49,1
Natural gas	Futures contract price of natural gas traded on New York Mercantile Exchange (NYMEX)	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	1,9	14,3	5,0	5,7	2,4
Gold	Futures contract price of gold traded on New York Mercantile Exchange (NYMEX) in the commodity division (COMEX)	data.okfn	Long-term	34,9	1 780,6	356,8	431,2	386,5
		Bloomberg	Short-term	253,9	1 874,4	387,3	625,4	439,0
			Correlation	377,1	1 874,4	941,1	1 004,6	438,9
Brent oil	Futures contract price of brent oil traded on New York Mercantile Exchange (NYMEX) and Intercontinental exchange (ICE)	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	28,8	144,5	77,8	82,1	27,3
Silver	Futures contract price of silver traded on New York Mercantile Exchange (NYMEX) in the commodity division (COMEX)	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	3,5	48,6	5,4	10,5	9,0
			Correlation	5,6	48,6	16,4	18,0	9,3
Sugar	Futures contract price of sugar traded on Intercontinental exchange (ICE)	UNCTAD	Long-term	1,3	56,1	9,4	11,0	7,1
		Bloomberg	Short-term	4,7	34,0	10,8	12,3	5,7
			Correlation	5,5	34,0	15,7	16,1	6,5

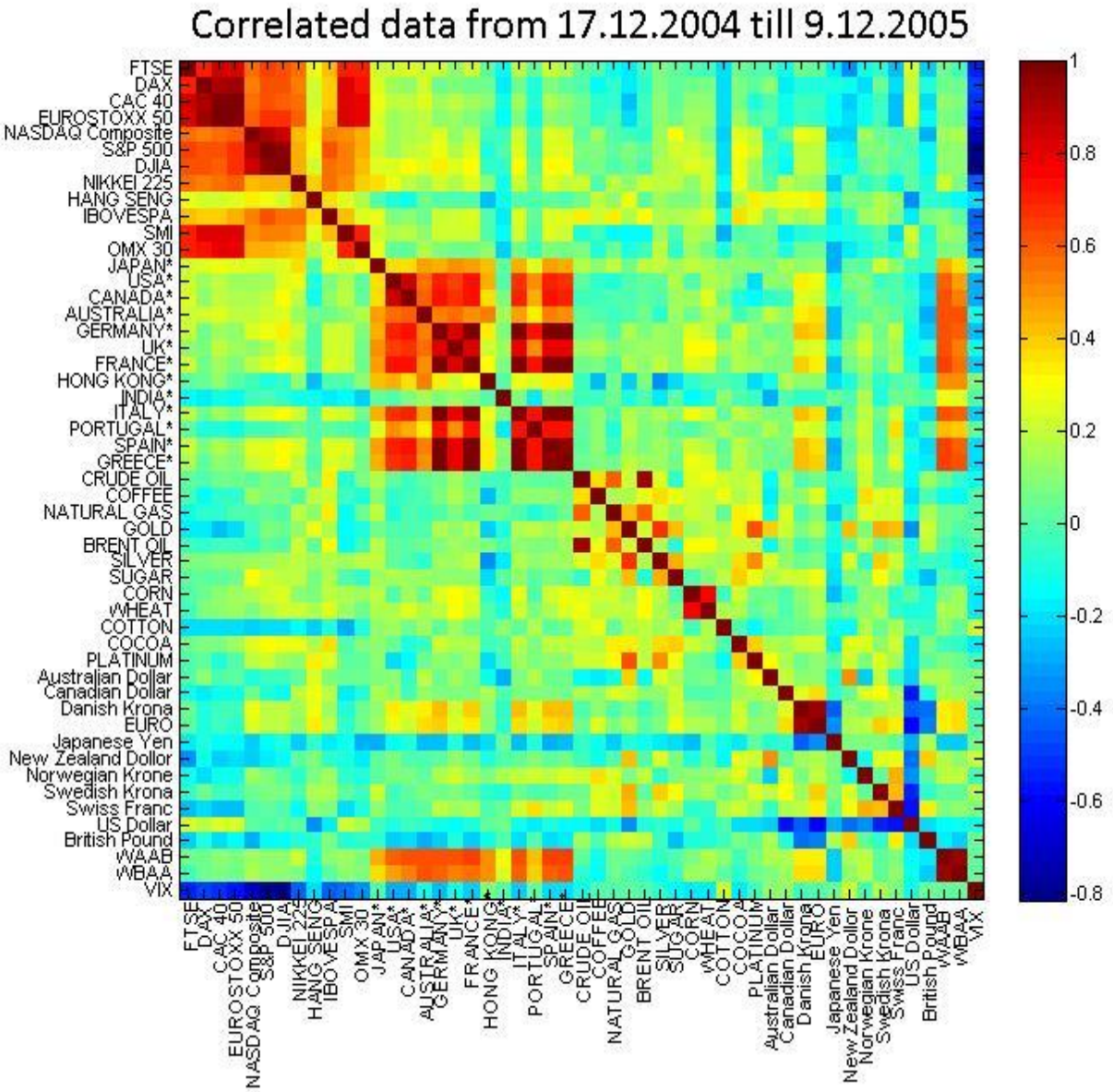
Corn	Futures contract price of corn traded on Chicago board of trade (CBOT)	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	189,8	824,5	399,6	438,7	176,1
Wheat	Futures contract price of wheat traded on Chicago board of trade (CBOT)	UNCTAD	Long-term	51,8	454,0	150,1	159,6	73,9
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	284,0	1 160,0	582,4	577,8	186,6
Cotton	Futures contract price of cotton traded on Intercontinental exchange (ICE)	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	39,3	215,2	68,2	73,7	29,7
Cocoa	Futures contract price of cocoa traded on Intercontinental exchange (ICE)	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	1 312,0	3 698,0	2 304,0	2 273,6	617,8
Platinum	Futures contract price of platinum traded on New York Mercantile Exchange (NYMEX)	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	776,5	2 166,5	1 401,3	1 341,4	332,4
Government Bonds	**Explanation**	**Source**	**DATA**	**Min**	**Max**	**Median**	**Mean**	**Standard deviation**
Japan	Yields on 10 year Japanese government bonds	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	0,4	8,2	1,6	2,4	1,8
			Correlation	0,5	2,0	1,3	1,3	0,4
USA	Yields on 10 year US government bonds	FED	Long-term	1,5	15,3	6,5	6,7	2,8
		Bloomberg	Short-term	1,5	9,0	4,9	5,0	1,8
			Correlation	1,5	5,2	3,6	3,4	1,0
Canada	Yields on 10 year Canadian government bonds	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	1,6	11,8	5,1	5,4	2,3
			Correlation	1,6	5,0	3,5	3,4	0,9
Australia	Yields on 10 year Australian government bonds	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	2,8	6,7	5,3	5,0	0,9
Germany	Yields on 10 year German government bonds	ECB	Long-term	1,2	10,8	6,5	6,2	2,2
		Bloomberg	Short-term	1,1	9,1	4,4	4,8	2,0
			Correlation	1,1	4,7	3,3	3,0	1,0
Portugal	Yields on 10 year Portugese government bonds	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	3,2	14,7	4,5	5,6	2,5

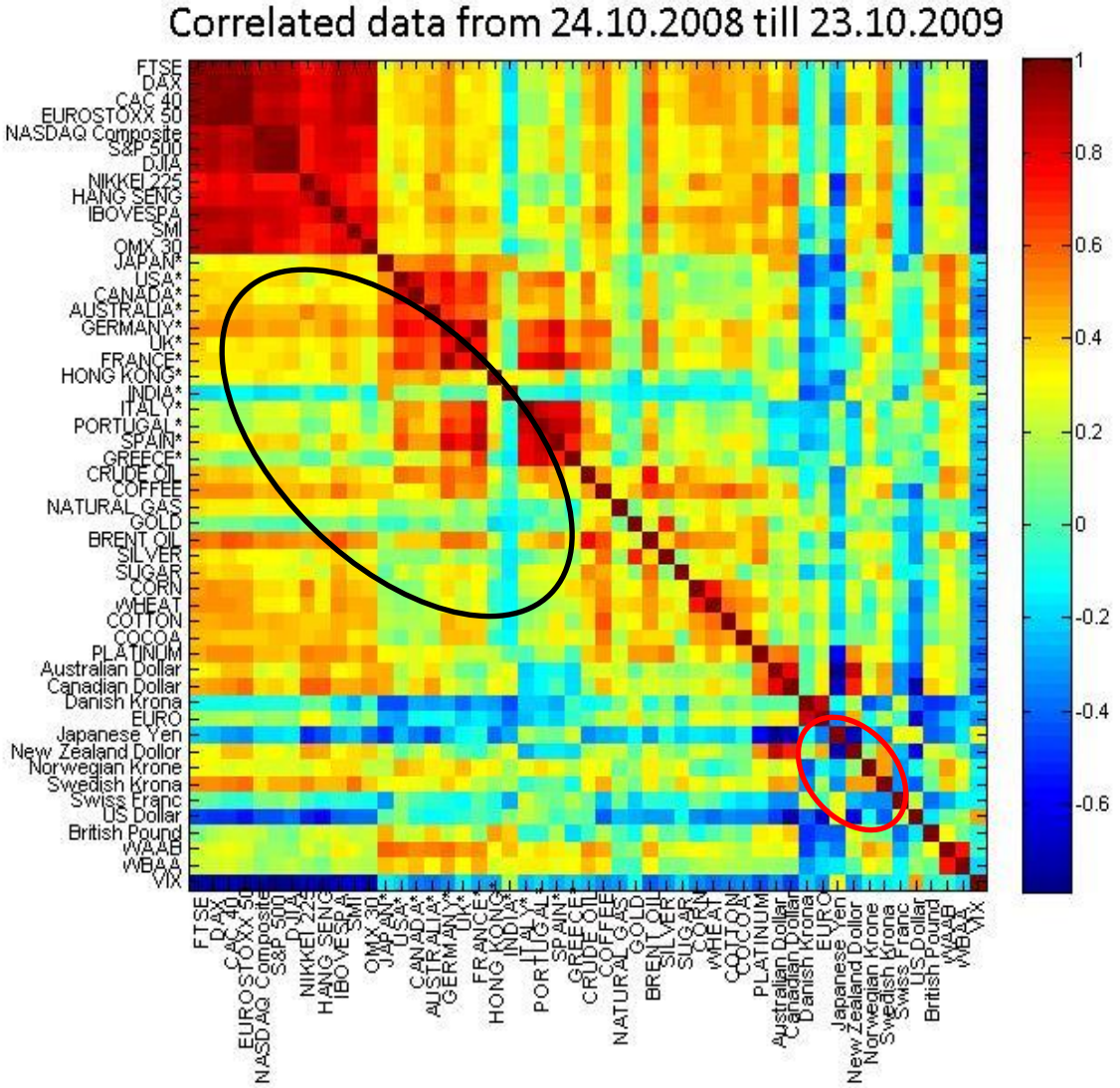
UK	Yields on 10 year UK government bonds	ECB	Long-term	1,6	16,3	8,1	8,2	3,5
		Bloomberg	Short-term	1,5	12,8	4,9	5,6	2,4
			Correlation	1,5	5,5	3,9	3,7	1,1
France	Yields on 10 year French government bonds	ECB	Long-term	1,7	17,3	7,9	7,7	3,6
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	1,6	4,8	3,5	3,4	0,8
Italy	Yields on 10 year Italian government bonds	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	2,7	7,3	4,3	4,4	0,7
Spain	Yields on 10 year Spanish government bonds	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	2,5	7,3	4,2	4,3	0,8
Greece	Yields on 10 year Greece government bonds	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	3,3	37,1	5,2	8,7	7,2
Hong Kong	Yields on 10 year Hong Kong government bonds	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	0,5	4,9	2,7	2,9	1,2
India	Yields on 10 year Indian government bonds	x	Long-term	x	x	x	x	x
		Bloomberg	Short-term	x	x	x	x	x
			Correlation	5,1	9,5	7,9	7,6	0,9
Currencies	**Explanation**	**Source**	**DATA**	**Min**	**Max**	**Median**	**Mean**	**Standard deviation**
Australian dollar	Effective exchange rate of Australian dollar	x	Long-term	x	x	x	x	x
		Bank of England, own calculation	Short-term	x	x	x	x	x
			Correlation	74,5	116,7	97,2	96,6	9,1
Canadian dollar	Effective exchange rate of Canadian dollar	x	Long-term	x	x	x	x	x
		Bank of England, own calculation	Short-term	x	x	x	x	x
			Correlation	83,4	122,0	107,0	104,5	8,6
Danish Krona	Effective exchange rate of Danish Krona	x	Long-term	x	x	x	x	x
		Bank of England, own calculation	Short-term	x	x	x	x	x
			Correlation	103,7	114,9	107,6	108,2	2,2
Euro	Effective exchange rate of EURO	BIS	Long-term	73,0	111,3	93,2	91,8	7,9
		Bank of	Short-term	73,8	106,2	94,2	93,3	7,0

		England, own calculation	Correlation	86,1	106,2	94,7	95,4	4,6
Japan. Yen	Effective exchange rate of Japanese Yen	BIS	Long-term	50,5	143,2	89,9	88,4	20,4
		Bank of England, own calculation	Short-term	92,8	186,8	135,4	137,0	19,6
			Correlation	113,5	186,8	138,1	145,1	20,1
New Zealand Dollar	Effective exchange rate of New Zealand dollar	x	Long-term	x	x	x	x	x
		Bank of England, own calculation	Short-term	x	x	x	x	x
			Correlation	79,5	127,7	107,7	107,4	20,1
Norweg. Krone	Effective exchange rate of Norwegian Krone	x	Long-term	x	x	x	x	x
		Bank of England, own calculation	Short-term	x	x	x	x	x
			Correlation	88,2	110,8	102,9	102,4	8,7
Swerige Krona	Effective exchange rate of Swerige Krona	x	Long-term	x	x	x	x	x
			Short-term	66,4	90,6	82,3	81,7	4,2
			Correlation	66,4	90,6	82,3	81,7	4,2
SWISS Franc	Effective exchange rate of Swiss Franc	x	Long-term	x	x	x	x	x
		Bank of England, own calculation	Short-term	91,9	165,8	111,2	114,2	14,3
			Correlation	106,7	165,8	118,7	124,9	4,1
US Dollar	Effective exchange rate of US dollar	BIS	Long-term	93,0	148,6	109,3	113,8	16,0
		Bank of England, own calculation	Short-term	75,8	124,6	96,1	96,6	11,0
			Correlation	75,8	100,5	86,5	87,1	15,0
UK Sterling	Effective exchange rate of Sterling	BIS	Long-term	92,9	153,6	120,2	119,6	12,4
		Bank of England, own calculation	Short-term	74,3	106,3	95,8	92,4	8,5
			Correlation	74,3	106,3	85,8	90,1	9,8
Others	**Explanation**	**Source**	**DATA**	**Min**	**Max**	**Median**	**Mean**	**Standard deviation**
AAA	Average seasonally adjusted yields of all companies graded by Moody's Aaa	Federal Reserve Bank of St. Louis	Long-term	3,4	15,5	7,5	7,8	2,4
WAAA			Short-term	3,3	9,6	6,4	6,4	1,5
			Correlation	3,3	6,5	5,3	5,0	0,7
BAA	Average seasonally adjusted yields of all companies graded by Moody's Baa	Federal Reserve Bank of St. Louis	Long-term	x	x	x	x	x
WBAA			Short-term	4,5	10,8	7,4	7,3	1,4
			Correlation	4,5	9,5	6,2	6,1	0,9
VIX	Volatility index of S&P 500 created by Chicago board of trade (CBOT)	Federal Reserve Bank of St. Louis	Long-term	4,5	17,2	8,3	8,8	2,7
			Short-term	9,5	79,1	18,0	19,8	8,1
			Correlation	10,0	79,1	16,7	19,7	9,9

Appendix 2: Heat-map graph

In appendix two graphs from chapter 6 six are shown. There is nothing new added to these graphs in comparison to the previous ones, the difference is in the size, as the graphs were hardly readable in chapter 6.




Correlated data from 24.10.2008 till 23.10.2009
FTSE
DAX
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EUROSTOXX 50
NASDAQ Composite
S&P 500
DJIA
NIKKEI 225
HANG SENG
IBOVESPA
SMI
OMX 30
JAPAN*
USA*
CANADA*
AUSTRALIA*
GERMANY*
UK*
FRANCE*
HONG KONG*
INDIA*
ITALY*
PORTUGAL*
SPAIN*
GREECE*
CRUDE OIL
COFFEE
NATURAL GAS
GOLD
BRENT OIL
SILVER
SUGAR
CORN
WHEAT
COTTON
COCOA
PLATINUM
Australian Dollar
Canadian Dollar
Danish Krona
EURO
Japanese Yen
New Zealand Dollor
Norwegian Krone
Swedish Krona
Swiss Franc
US Dollar
British Pound
WAAB
WBAA
VIX
1
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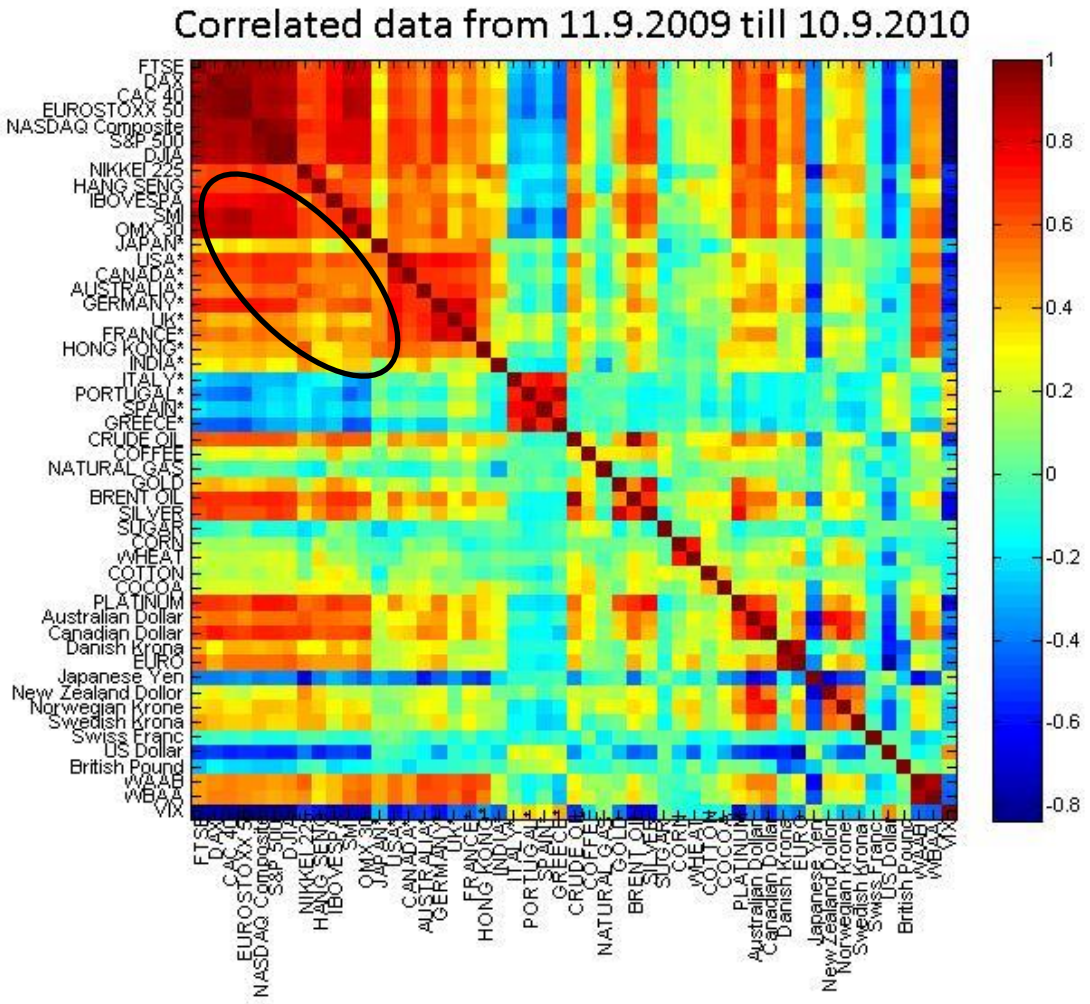
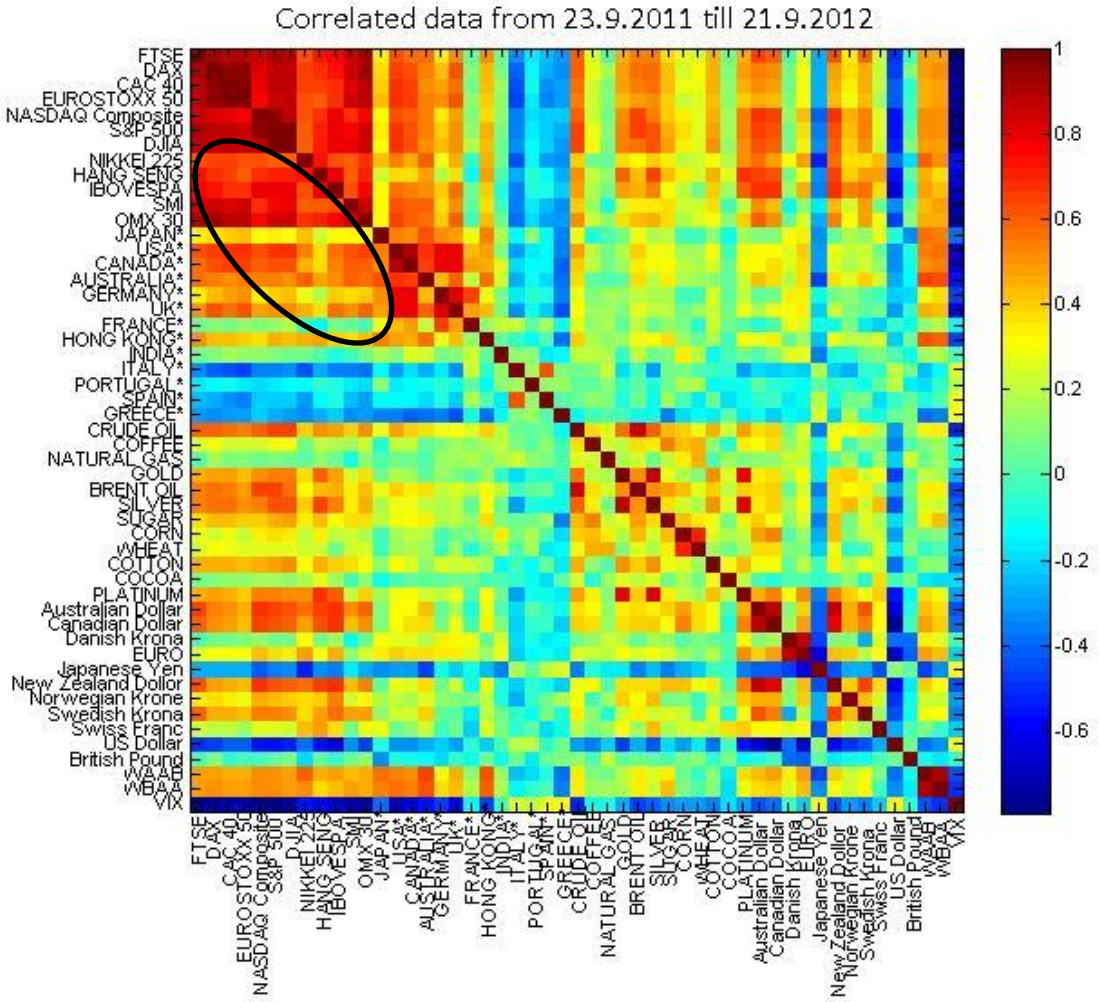
0.6
0.4
0.2
0
-0.2
-0.4
-0.6


Correlated data from 11.9.2009 till 10.9.2010
FTSE
DAX
CAC 40
EUROSTOXX 50
NASDAQ Composite
S&P 500
DJIA
NIKKEI 225
HANG SENG
IBOVESPA
SMI
OMX 30
JAPAN*
USA*
CANADA*
AUSTRALIA*
GERMANY*
UK*
FRANCE*
HONG KONG*
INDIA*
ITALY*
PORTUGAL*
SPAIN*
GREECE*
CRUDE OIL
COFFEE
NATURAL GAS
GOLD
BRENT OIL
SILVER
SUGAR
CORN
WHEAT
COTTON
COCOA
PLATINUM
Australian Dollar
Canadian Dollar
Danish Krona
EURO
Japanese Yen
New Zealand Dollor
Norwegian Krone
Swedish Krona
Swiss Franc
US Dollar
British Pound
WAAA
WBAA
VIX
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8


Correlated data from 23.9.2011 till 21.9.2012
FTSE
DAX
CAC 40
EUROSTOXX 50
NASDAQ Composite
S&P 500
DJIA
NIKKEI 225
HANG SENG
IBOVESPA
SMI
OMX 30
JAPAN*
USA*
CANADA*
AUSTRALIA*
GERMANY*
UK*
FRANCE*
HONG KONG*
INDIA*
ITALY*
PORTUGAL*
SPAIN*
GREECE*
CRUDE OIL
COFFEE
NATURAL GAS
GOLD
BRENT OIL
SILVER
SUGAR
CORN
WHEAT
COTTON
COCOA
PLATINUM
Australian Dollar
Canadian Dollar
Danish Krona
EURO
Japanese Yen
New Zealand Dollor
Norwegian Krone
Swedish Krona
Swiss Franc
US Dollar
British Pound
WAAA
WBAA
VIX
1
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0.6
0.4
0.2
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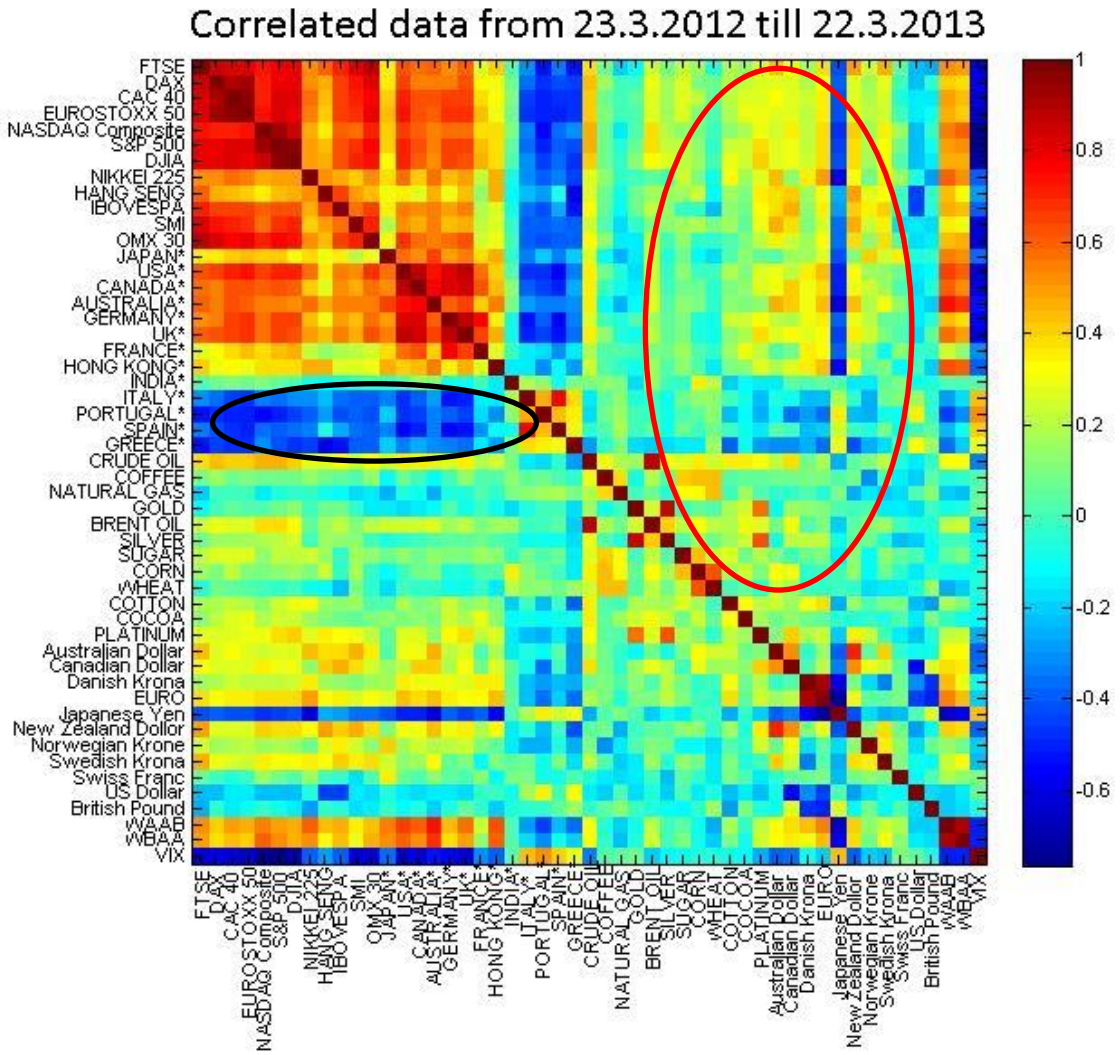
-0.4
-0.6


Correlated data from 23.3.2012 till 22.3.2013
FTSE
DAX
CAC 40
EUROSTOXX 50
NASDAQ Composite
S&P 500
DJIA
NIKKEI 225
HANG SENG
IBOVESPA
SMI
OMX 30
JAPAN*
USA*
CANADA*
AUSTRALIA*
GERMANY*
UK*
FRANCE*
HONG KONG*
INDIA*
ITALY*
PORTUGAL*
SPAIN*
GREECE*
CRUDE OIL
COFFEE
NATURAL GAS
GOLD
BRENT OIL
SILVER
SUGAR
CORN
WHEAT
COTTON
COCOA
PLATINUM
Australian Dollar
Canadian Dollar
Danish Krona
EURO
Japanese Yen
New Zealand Dollor
Norwegian Krone
Swedish Krona
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US Dollar
British Pound
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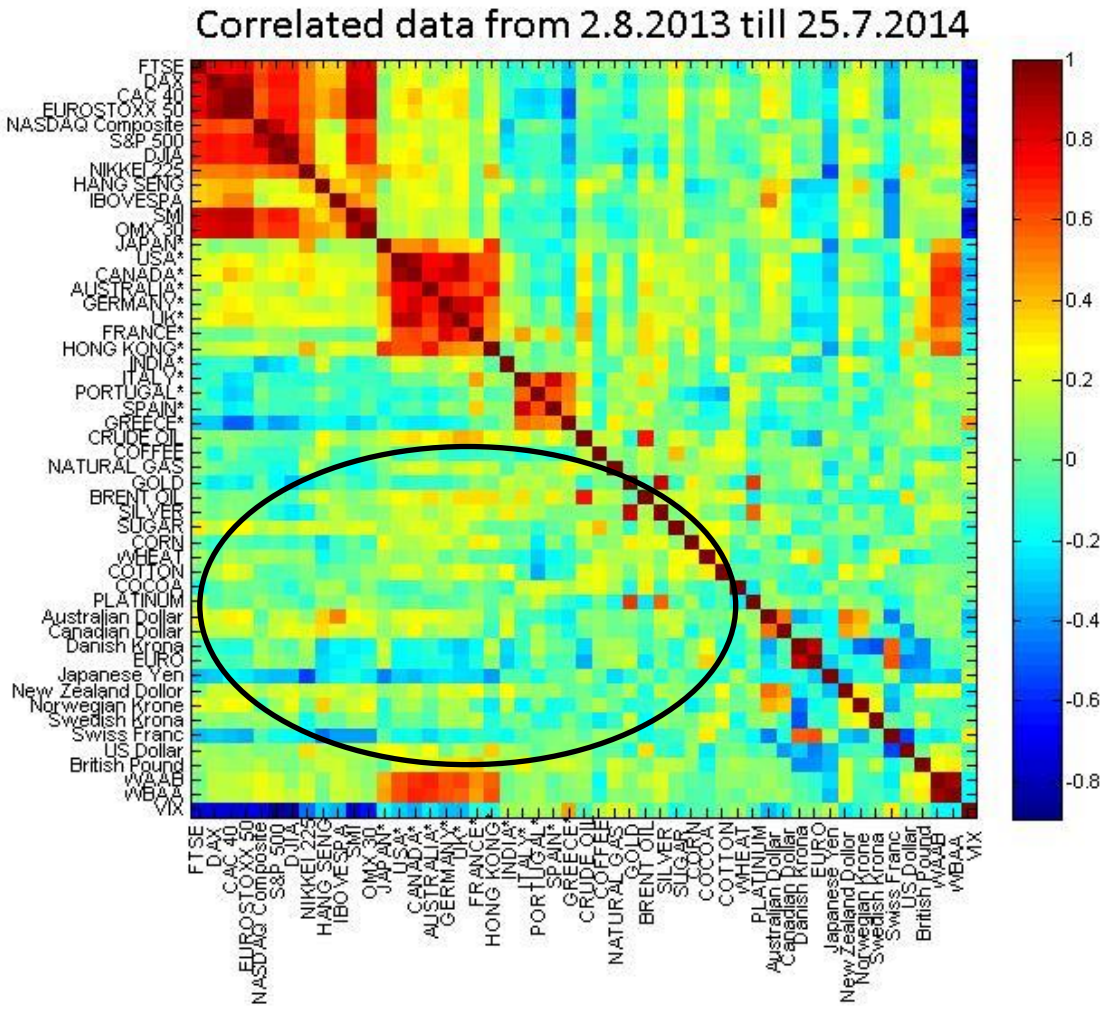
Correlated data from 2.8.2013 till 25.7.2014
FTSE
DAX
CAC 40
EUROSTOXX 50
NASDAQ Composite
S&P 500
DJIA
NIKKEI 225
HANG SENG
IBOVESPA
SMI
OMX 30
JAPAN*
USA*
CANADA*
AUSTRALIA*
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COTTON
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PLATINUM
Australian Dollar
Canadian Dollar
Danish Krona
EURO
Japanese Yen
New Zealand Dollor
Norwegian Krone
Swedish Krona
Swiss Franc
US Dollar
British Pound
WAAA
WBAA
VIX
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-0.2
-0.4
-0.6
-0.8

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