Bachelor Thesis
Analysis on international financial markets and diversification opportunities
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Abstract

This paper aims to explain the development between the financial markets: US, UK and Japan within a 12-year timeframe from 2001-2012. The relationships between the markets are analyzed based on the major index representing each market. Simple linear regression will be used to show the relation and causality between the paired variables. Furthermore, correlation matrices will show how close the markets move together. The paper will focus on the downturns and upturns in the period and search for possible development in the correlation between the markets. Additionally, each market will be analyzed in periods with high and low volatility. Analyzing the relationship between the markets will provide an answer to, whether international diversification opportunities exist between the markets. Another aim of the paper is to look at the correlation between gold and the markets and show how gold can be used to diversify a portfolio. Furthermore, in the last section, inflation is accounted for, to analyze how the correlation will change when the data have been corrected for inflation.

The research shows that the US and UK markets are becoming increasingly more correlated as times progresses. The combination of these two markets would provide little diversification to a portfolio. To increase diversification gold and the Japanese market proved as the better choice as correlations are significantly lower than between the UK and US market. When the markets experiences times with low volatility, the relationship and correlation decreased and the return becomes positive. This is seen in contrast to the opposite, where high volatility markets increase the correlation and the return becomes negative. When the UK and US markets are paired with the Japanese market the analysis shows that not much correlation exists. This combination will provide international diversification to a portfolio, and will help to lower risk. Furthermore, gold shows to have less correlation with the Japanese market after a time of crisis, however, the overall correlation remains low, which makes it suitable for diversification.

Taking inflation into consideration and using the real interest rate instead of the nominal interest rate of the indices, a whole new picture of the correlation between the indices appears. The indices become more correlated and using any of the indices, as diversification will not make any sense.
Introduction

Former papers have shown different results of the correlation between markets. Allen’s (2011) conclusion was, that having stocks for more than one country is not beneficial, while Wang and Wang (2007), Fisher (2012) and Yavas (2009) stated that it would be good to have stocks from more than one country in a portfolio. The paper will analyze the correlation between three major financial markets, the S&P 500, FTSE 100 and Nikkei 225. This is interesting when it concerns risk management, as investment managers seeks to eliminate as much risk in a portfolio as possible. The question is whether international diversification is possible, or the international markets have become increasingly more correlated. The financial markets have changed rapidly during the last decade where the possibility for global capital has become more accessible. The investors have become more international interested, which became clear after the financial crisis where debt packages were sold to the international market and the global economy experienced a global meltdown.

This paper will show how correlation between markets may have changed over time. Four periods are of specific interest to the research; the Dotcom crisis 2000-2002, the period in-between where the markets experienced a period of high profitability 2003-2007, the global financial crisis in 2007-2008 and the period after the crisis, where the markets have recovered, even though many macroeconomic problems still exists. The two crises will show whether there has been a change in correlation of the markets when there is a crisis. The knowledge about how markets might correlate in different times will be very useful for decision makers in financial institutes, as it will provide a tool, which could help to allocate capital. The volatility index shows the stability of the market. Therefore, periods with high and low volatility will be analyzed to search for a significant change in correlation between the indices in these periods.

Another aspect of this paper is to take gold into the consideration concerning diversification. The question is whether gold is correlated with some of the indices, or if gold is negatively correlated. If gold moves differently from the three markets, it can be used in risk management to increase the diversification in a portfolio.

Furthermore, the inflation will be added to the calculation as the inflation rates vary across the three countries. The inflation might influence the correlation as it could affect the prices of the indices.
It is interesting to notice that access to foreign investment opportunities and lower barriers in form of transaction costs, have increased the volume of trades by foreigners in the US. In the 1990’s there was a rapid change in the volume of foreign trades in U.S. stocks. Especially in the mid 90’s where foreign trade was close to 320 billion dollars and in late 90’s it was 1,560 billion dollars (Madura 263-270). Not only have barriers for international trade been reduced, but it is also possible for foreign companies to list on different stock exchanges, which makes it possible for investors to buy foreign stocks on their own stock exchange.

**Problem statement**

The goal with this paper is to provide a pension fund with a useful report, which looks at the possibility for diversification between markets.

In this research the stock market correlation between the American (S&P500), Japanese (Nikkei 225) and the British (FTSE 100) indices will be analyzed. The study will be conducted to see if diversification can be done across markets. Furthermore, the paper will investigate how the correlation will be influenced in high and low volatility markets. First the study will be handled with nominal values and afterwards inflation will be taken into consideration.

Finally the report will look at gold and the markets to see if there is a negative correlation amongst these. If this is the case, gold can also be used to diversify a portfolio.
Methodology:

Theory of science can be made in two different methods, the deductive and the inductive procedure. Rationalist looks at science in the deductive way, which looks at science on behalf of logic and reason. From the theory they have made from their logic, they gather data and analysis it. If the analysis confirms the theory the scientist have made, it will be accepted and vice versa if the data disprove the theory. The deductive model is also called the top down model. This paper are using the inductive method, which is just opposite of the deductive method. The first step in the inductive method is to gather data and analyze them. From the analysis a pattern should occur and from this pattern, a theory can be made. Karl Popper has recognized this model as using data from the past as the inductive method cannot be used to predict future events. (Holm, 2011) This is important for this report, because it uses the historical index prices, to see if diversification of a portfolio is still possible and how correlated the three chosen markets have become. The paper cannot conclude if it will be possible in the future, but only look at the past years, and find a pattern to build a theory upon.

The paper uses the index prices from the chosen indices. From these prices the nominal rate of return is found and the paper uses single linear regression to find the relationship and causality between the indices. The single linear regressions look like

- \( \text{spx}\_\text{return} = x\*\text{ukx}\_\text{return} + c + \varepsilon \)
- \( \text{spx}\_\text{return} = x\*\text{nky}\_\text{return} + c + \varepsilon \)
- \( \text{ukx}\_\text{return} = x\*\text{nky}\_\text{return} + c + \varepsilon \)

\( \text{spx}\_\text{return} \) is the nominal return rate for S&P 500  
\( \text{ukx}\_\text{return} \) is the nominal return rate for FTSE 100  
\( \text{nky}\_\text{return} \) is the nominal return rate for Nikkei 225  
\( c \) is the constant for the single linear regression  
\( \varepsilon \) is the error variable associated with the regression model  
\( x \) is the estimated coefficient from the regression model

Furthermore the paper looks at the correlation between the indices. The correlations are found and placed in a correlation matrix.
The volatility indices will be used as guidance to pick the periods in this section of the paper. The VIX indices will show of which state the indices are in both high or low volatility indices.

Another section of the report finds the correlation, causality and relationship between gold and the indices. As when analyzing the nominal values, single linear regression is used to find the linear relationship and the causality and a correlation matrix shows the correlation between gold and the indices.

In the last section of the report, the index prices are corrected for inflation so it is the real return rate the statistics are made upon. The statistics are again the same. A single linear regression model and a correlation matrix are made to find the causality and relationship. Moreover, a correlation matrix is made.

The three markets, which have been chosen for this analysis, are chosen from the purpose to include as broad an area as possible. FTSE 100 is chosen to represent the European market, Nikkei 225 the Asian market and S&P 500 the American market. Thus, representing the markets other indices will not be included.

In the paper the focus is mainly on four periods in the recent 12 years.

Data with too high p-values have been omitted. Especially between gold and the indices, most of the data did not provide enough statistical evidence.

The data will be in USD and follow the American business calendar. As an investor it is important to be able to see how much your investments really make. Therefore, the research will contain one currency to give consistency and transparency. Furthermore, the dates included will follow the American calendar in order to have the same data observations for the paper.

VIX data is selected where both markets has high or low volatility. The data is selected as high VIX when the indices were approximately above 30, and low VIX when they were below 20. This might leave out areas where one market remains high, but the other is not considered as being high, therefore, the data’s are not included in the analysis.

Real return has only been calculated for the whole period, as data was not sufficient for the four periods, because inflation figures are calculated each month and the number of observations was too low.
Furthermore, gold was calculated for a longer period, from 1984 to 2012. However, the data lead to the same conclusion as the one, which is presented in the paper and has therefore been omitted.

Different transaction costs have not been included in the calculation. Alongside, the different taxes in the different markets are also omitted.

When making single linear relationship, the paper focuses on the relationship and causality between the indices. Therefore, not all indices are modeled as dependent and independent, because the linear relation and causality does not change if the independent - and the dependent variable change places.

Some movement in the model might be caused by the difference in number of companies in the indices. S&P has 500 companies in the index, FTSE has 100 and Nikkei has 225. By this difference there already is accounted for diversification within the indices, however the amount varies.

The analysis in the paper is based on simple linear regression. However, this might not be sufficient to show the exact picture of the relationship between the indices as only one factor is represented in the model. Some data points might be too extreme and will therefore make the model unfit, as outliers would not be deleted.

**Standard & Poor 500 - S&P 500**

Standard and Poor 500 or shortened, S&P 500, is 500 stocks from the American stock exchange. It was first established in 1923 but at that time the index only contained 233 stocks. In 1957 it was enlarged to 500 stocks as it is today. Since mid-November 2012, the index has appreciated with close to 200 points to a value of $1,515 (Bloomberg, 2013a).

Opposite of many other indices, S&P 500 is not the most traded companies in the U.S, but it is instead leading companies within many different sectors. When it was first made, it consisted of 23 different sectors, but today more than 100 sectors are represented in the index. The three most represented sectors are Information technology (17,8%), Financial (15,1%) and Energy (12,7%) (Amadeo, 2011). Because it is not the most traded companies in the U.S. a committee from the firm Standard and Poor selects the companies that are in the index, which makes the difficulty of selecting companies more comprehensive. They are chosen on behalf of
their market size, liquidity and sector. Most of the companies inside the index are mid - or large cap corporations. The index is a market-weighted index, which means that the largest companies also have the biggest impact on the index fluctuation.

Looking at the companies representing the index' value, it is approximately 70% of the total stock market value in USA. This also means that many traders uses S&P 500 as the benchmark of how well the American economy is performing. The Dow Jones index was formerly seen as the standard for the performance of the American stock market, but most people are now using the S&P 500, because it represents 500 companies where the Dow Jones index only consists of the 30 largest companies in the U.S.

The financial system in America has made four reformations. They have all been implemented after a financial crisis to ensure that transactions will be done more ethically right. The first reform was made after the great depression in 1929. The most important in this reform, was the creation of the Federal Depositor's Insurance Corporation (FDIC) and the Securities and Exchange Commission (SEC). Furthermore, no connection between a commercial and an investment bank was banned (Taylor, 2009). The second reform was made after a big sell-out of securities. With this came a time with stagflation, which is a time with inflation and production capacity but also no market growth and unemployment. To make sure this will never happen again, a reform stating that investors cannot sell or buy stocks in the New York Stock Exchange and the Chicago Mercantile Exchange, if the average fell a certain amount on one day (Taylor, 2009). In 2000 a third reform was made, where day-traders must at least have $25,000 on their trading account at all time to trade. This was done to minimize the market risk. The newest reform made, is the Dodd-Frank reform, which was implemented in 2010. A group was made to control the turbulence on the financial market, and afterwards make rules to regulate this turmoil. These rules will be published, so the confidence to traders will be upheld. The two last reforms was made because there were scandals in the beginning of 2000, where many accountants cheated with their companies balance sheets, which lead to a overvaluation of many companies (Taylor, 2009).

**Financial Times Stock Exchange - FTSE 100**

The FTSE 100 is the index, which measures the performance of the London stock exchange and was established in 1984 (Bloomberg, 2013b). The index is based on the 100
most capitalized companies in the UK. The FTSE accounts for 7.8% of the global market capitalization and represent 81% of the market in the United Kingdom. The index is used to measure the wealth of the financial products (FTSE, 2013). It is these facts, which makes the FTSE interesting, as it accounts for a lot of economic activity in the global scene. Since mid-November 2012 the index has seen an increase of close to 700 index points, which indicates a recovery of the economy. Besides FTSE 100, FTSE 250 also exists, which includes the mid-capitalized companies that are not included in the FTSE 100. FTSE 250 accounts for 15% of the market capitalization. The difference between the markets capitalizations are also the reason why FTSE 100 is the most used indicator for the economy in the UK.

For an investor it is important to look at the index and understand what the index is made of and how it is weighted in different sectors. Approximately 66%\(^1\) of the FTSE is concentrated in six sectors; Banks (excluding financial service sector), Basic resources (Mining), oil & gas, pharmaceuticals, personal and household goods and food and beverages (FTSE, 2013). This indicates that the index is concentrated over a few heavy sectors, even though it consists of 21 super sectors.

Before 1986, there were hardly any regulations within the financial market. The regulations were acts, which separately was made to discourage fraud. However, investors were very unprotected in the market, and therefore, to make the market more attractive to foreign investors, a new set of standard were necessary (Edmonds, 2011). The system changed rapidly in 2000, where the Financial Services Authority (FSA) was established to be the single regulator in the market. Before, the bank of England had been regulating and monitoring the market alongside of the Securities & Investments board and self-regulating organizations (Edmonds, 2011). Even though FSA took over most of the responsibility for the financial market, the Bank of England kept the role to control financial stability. The Treasury also had obligations in the market, which made the control of the market tripartite (Edmonds, 2011). Since the financial crisis, protective measurements have been taken in order to protect the market from risk. Therefore, the legislators have introduced the Financial Policy Committee (FPC) in order to monitor or remove systematic risk, to give base for a stabile financial system (Bank of England, 2013). The FPC made the legislation and monitoring more unified and controlled instead of having a tripartite system.

\[^{1}\] 18,27+10,92+13,96+7,94+7,66+7,29 =66.02
Nihon Keizai Shimbun Stock Exchange - Nikkei 225

The economy in Japan is the third largest in the world (Kuepper, 2013). Nikkei 225 consists of the 225 largest companies in Japan and was established in 1949 (Bloomberg, 2013c). The index is a blue chip index, which means that the index follows the top performers of the Japanese stock market. The index had its peak in 1989 where the price was ¥ 38,957 considering the opening price of ¥ 176 in 1949. Since mid-November 2012 Nikkei 225 has appreciated with approximately ¥ 3,000. Even though the index has undertaken a large depreciation in the recent years since its highs in 1989, there are still very strong companies in the index. Among companies in the index there are: Sony, Honda, Toyota and Toshiba, which all have international recognition.

In 1998 the Japanese stock market experienced a reformation in form of new legislations and laws, which should earn back trust to the Japanese market. Investors and foreign companies had been leaving the exchange due to a bust in the 90’s. Futures from Nikkei 225 were now traded on the Singapore stock exchange. The Japanese then looked to London where changes had successfully been implied ten years earlier. The new direction in Japan opened for more direct financing opportunities, where it became easier for companies to issue new shares or bonds to raise capital. Furthermore, the government has enacted better surveillance of the market to identify fraud or illegal trade activity to restore trust within the market (Osaki, 2005). However, the new changes still have to be fully trustworthy and implemented into the system.

Nikkei 225 is used as a benchmark for the Japanese economy. Furthermore, it is used as a benchmark for the Asian stock markets. This is due to the heavy industry and large recognized companies, which are present in the index.

Out of the ten sectors that are represented in the index, the three major sectors are: Industrials (23.51%), consumer discretionary (22.36%) and information technology (14.69%) (Precidianfunds, 2013). These three sectors accounts for around 60% of the total index. Additionally, it is in these sectors where the largest companies are presented. The distribution indicates that Nikkei 225 relies on the performance of these few large sectors.

Like most stock markets, the Japanese market experienced a drop in stock prices in the two major global crises, the Dotcom crisis and the financial crisis. Furthermore, it is visible in the historical data that the index was influenced greatly by the tsunami in March 2011. In one
day the index fell 1,000 points and it took more than one year to recover, to the level it was at before the tsunami hit.

**Why these three markets**

There are several reasons why these markets have been chosen to analyze correlation between international markets. They are all some of the largest markets in the world. Furthermore, they represent three different continents and three different cultures. The Japanese way of exercising business is different from what Americans and Europeans do, when it concerns hierarchy within a corporation. The interesting element also lies with the part of constant battle between west and east.

Looking at the world’s financial market, the three countries chosen have for many decades been some of the largest. The US market is by far the biggest, with 30,43% of the global market in March 2011. The Japanese and the British markets respectively form 7,05% and 6,49% of the global market in March 2011 (Hickey, and Walters, 2011), so combined these three markets accounts for 43,97% of the global financial market.

A new emerging market, which could be interesting to look at instead or together with the other, is the Chinese market. It has been growing very fast since 2005, and is now the second largest with 7,38% of the world market (Hickey, and Walters, 2011). The reason for omitting the Chinese market is the timespan the report is looking at. It is within recent years it has become one of the largest financial markets, and the way it has grown cannot be compared with the way other fully established markets have developed. Nikkei 225 is used as a benchmark for the Asian economy and therefore, will be the most recognized index to use for comparison.

**Gold market description**

Gold has been used as currency for many years and was fixed by Roosevelt from 1934-1967 at $35 per ounce. Once gold was released to the market for trade and speculation the price started to increase rapidly. The graph below visualizes how the movement of the price of gold has been during the period, which is analyzed in the report. It is worth noticing that gold has roughly been appreciating the entire period. Both through down turns and upturns it seems like gold has been unaffected and just kept appreciating. The reasoning for that gold appreciates
even through global crises is that; when markets crash, the trust to the financial markets disappears, capital is moved to gold as it is seen as safe ground for heavy market movements (Shafiee, and Topal 2010).

Graph 1: Price of gold during the chosen period

However, the increase in the price of gold is not only due to investments moving into gold. The demand for gold is increasing in almost all areas, when it comes to investments, jewelry and material production. The supply is not quite following the demand, as what is produced in China, is not reaching the market, as they do not export it. The gap between the aggregated world supply with and without China has recently continued to increase, which puts pressure on the supply side and increases the price of gold. The total gold supply in 2012 was 120 million ounces, whereas, when there has been adjusted for the production and import in China the total supply is close to 90 million ounces (Clark 2012). The difference is 30 million ounces today, previous years it was approximately 7 million ounces. Furthermore, the production costs are increasing as it becomes more difficult to excavate the gold rich material. Also, it becomes even harder to find new deposits of gold, because what was closest to the surface has already been found. However, as the gold price continues to increase it becomes profitable to dig deeper and use more resources to get the gold. The possibility to go deeper as the gold margin rises is seen; as most top ten gold producing countries increased their production in 2011 (Kolesnikova 2012).
**Dotcom bubble 2000 – 2002**

The dotcom bubble popped in the early 2000, where analysts realized, that with their ruthless investing in dotcom companies a new bubble had developed. The bubble burst and NASDAQ depreciated with approximately $3000 in a few months. One of the most extreme examples on the dotcom bubble is the company Microstrategy, which was traded at $3500 before the bubble burst and fell to $4 per share after (Colombo, 2013).

In the mid 1990 many companies were beginning to use computers, and the Internet was made available for the general public. This made it possible for people to communicate via email and browse webpages. Many companies saw a possibility to reach out to even more customers in this way, and even new dotcom companies such as Amazon and eBay was made. These companies quickly became a huge success, which inspired others to make their own dotcom company. Many of these companies went public and raised a lot of money, even though they did not have a decent business plan or a healthy balance sheet. In 1999 there were 457 IPO’s and many of these were dotcom companies. 117 of these companies doubled in price after one day of trading. In 2001 there were only 76 IPO’s and none of them doubled in price on the first day of trading. Many analysts began talking about a “new economy”, where corporate earnings and other financial numbers were unnecessary to take into account before investing in a company, and NASDAQ index appreciated with approximately 4500 points.

The idea of a “new economy” was proven to be wrong and many began to see that most of the companies did not have any business plan or healthy balance sheet. This caused a depreciation of many of the dotcom companies and started a snowball effect, where almost all technology companies lost most of their value. The burst of this bubble lead USA into a recession and the Federal Reserve was forced to lower the interest rates to stop this. Furthermore a big part of the technology professionals lost their jobs, and many of the investors lost their life savings (Colombo, 2013).

**The Housing crisis 2007-2008**

The crisis had its roots back in 2004, where new standards in the banking system, or lack of the regulatory system, were becoming more common. Four reasons were blamed for the mortgage crisis; first zero equity mortgages were introduced. Secondly, the Office of Federal Housing Enterprise Oversight imposed new regulations, which made it profitable for banks to
enter a market, which were formerly kept by Fannie Mae and Freddie Mac. Thirdly, an international change within banking regulation in Basel II increased the off-balance-sheet operations. Lastly, SEC allowed banks to benefit from changes made in the system. Before 2004, banks were allowed a 15:1 debt to net equity ratio but the limit was increased to 40:1. Banks could voluntarily agree to SEC’s oversight with less regulation (Blundell-Wignall, Atkinson, et al, 2008).

The American banks had been under more regulation than the European market, until 2004. In 2004 lobbyists were highly supported by the banking system to get rid of the large regulations and look at the European model, where banks had difference leverage system. The government then established SEC in 2004 as the regulatory body. The financial sector was demanding that Basel II was introduced as quickly as possible, to get an equal playing field in Europe and the US. However, the change to Basel II from Basel I created lucrative opportunities for investment banks to exploit the arbitrage. This made it possible to profit on holding more debt and using off-balance-sheet activity.

Combined with very low interest rates from FED, the number of house owners started to expand rapidly. Furthermore, when the bad debt started to submerge, a state of fear entered the market. Bad debt had been through a complex process, where the debt were hidden among regular debt and traded. It made it almost impossible to identify which banks were holding bad debt. Combined with the encouragement of the agencies Fannie and Freddie to buy subprime mortgages in order to expand, bad debt was spreading (Taylor, 2009).

On June 30. 2004 FED began to increase the interest rate and they increased it until June 2006. From June 2003 until June 2006 the interest rate increased from 1% to 5.25%. Together with this increase, the house prices began declining and because of this, many of the homeowners defaulted on their loans, which started a snowball effect. Since the subprime borrowers could not pay back their loans, the lenders started to go bankrupt as well. It reached to a point in February and March 2007, where more than 25 sup prime lenders went bankrupt. The bubble had bust and even though many central banks tried to help the financial institutions, it was too late for many of them. Lehman Brothers filed for bankruptcy and the U.S Government took control of Fannie Mae and Freddie Mac. The financial institutions did not have the liquidity to survive by themselves, so in 2008 the U.S. government found it necessary to purchase the bad debt the bank sector had build up during the recent years. This
bailout packages cost the government $700 billion. Additionally, many other countries needed to construct their own bailout packages to help their bank sector with liquidity.

**Market capitalization weighted**

Within the indices all stocks does not have an equal weight, which makes it important, as an investor to understand how the index is calculated. Most indices are calculated by using the capitalization-weighted method. The total market value of the S&P 500 is 11 trillion dollars, a scaling method called a divisor, is used to make the number easier to work with (Blitzer, 2012a). When the divisor first was used to calculate the index price, a starting index price would be quoted at example $1,000. Formula 1 shows how the index level is calculated (Blitzer, 2012a):

\[
\text{Index level} = \frac{\sum P_i \cdot Q_i}{\text{Divisor}}
\]  

(1)

\(P_i\): refers to the price of a stock within the index.
\(Q_i\): refers to the number of stocks available for investors.
\(\sum\): illustrates the sum of all the stock prices and quantities in the index.

To find the divisor for a recent period with an index level of $1,500 the calculation would look as formula 2.

\[
1,500 = \frac{11,000,000,000,000}{\text{Divisor}}
\]

(2)

\[
\text{Divisor} = \frac{11,000,000,000,000}{1,500}
\]

\[
\text{Divisor} = 7,333,333,333.33
\]

Knowing the market value of $11 trillion and the index price the divisor in this case is roughly $7.3 billion. However, the divisor is not a constant number, it is due for changes to
stabilize the index for certain movements within the index. When a company is either added or removed from the index, it should not influence the price of the index. Therefore, the divisor will be adjusted so changes are not affecting the index price. It can be necessary to make changes to the divisor if more shares become available for the investors. The index calculation does not always make use of the total number of stocks in a company. Some stocks are held closely by government entities, Employee and Family Trusts, Holders of restricted shares etc. as a form of control holders (Blitzer, 2012b). To calculate the number of shares that are available for all investors the Investable Weight Factor (IWF) needs to be calculated. IWF has a threshold of 5 %, which means that either group of the control groups, mentioned above, shall posses under 5% of the shares, for the IWF to be 1.00. However, if one group holds 2% of the company shares and other groups have 30% the IWF will be 0.68, as 32% are not tradable for investors (Blitzer, 2012b). To calculate the real number of traded stocks the following equation is used:

\[ Q_i = \text{IWF}_i \times \text{Total Shares}_i \]  

\( Q_i \) will be the total number of shares multiplied by the percentage, which is available for all investors. If a stock is added or removed in the index the divisor adjustment will be done after the market is closed. This means that if the index closes at $1,500 and the new stock is added or removed, and there is a shift in the total market value, adjustment in the divisor is made so the opening price will be $1,500.

When a new stock is added the market value of the firm is implied in the index. However, it does not mean that, if a company is worth $100,000,000, it is that amount which is added to the market value of the index. If IWF has the value of 0.90 the total market value which is added to the index will be $90,000,000.

Number of stocks, which are tradable for all investors, can fluctuate as well as the stock price. This fluctuation changes the IWF and will cause a need for a change in the divisor (Blitzer, 2012b).

**Price-Weighted Index**

Other indices have chosen to use the price weighted index method. It is indices as Nikkei 225 and Dow Jones. When an index is calculated with the price-weighted method, investors’
main focus should be on the share price, and not on the actual value of the company. The price-weighted index is calculated in the following way (Jain and Hamdard, 2009):

\[
\text{index price} = \frac{p_i}{\text{divisor}}
\]

\[p_i = \text{The price of company i} = \text{The sum of all the prices of the companies}\]

The formula above shows that summing the price of all the stocks together and dividing that number with a divisor calculates the index price. The divisor is a number that needs to be adjusted. If e.g. a price of a company’s shares change due to stock splits or a company in the index is swapped with a company outside the index. The new divisor is calculated as seen below (Jain and Hamdard 2009).

\[
\text{New divisor} = \frac{\text{new sum of prices}}{\text{index value before substitution/stock split}}
\]

A fictional example might make it easier to understand. If an index has 3 companies, company A’s share price is 20, company B’s share price is 25 and company C’s share price is 50. Furthermore the, divisor for this index is 3, the index price would therefore be calculated to be:

\[
\text{index price} = \frac{20 + 25 + 50}{3}
\]

\[\text{index price} = 31.67\]

With this index price, the divisor is 3,0. If company C then decides to make a stock split, and issue twice as many stocks, the share price for company C would decrease with 50% and be 25 instead of 50. This should not have any effect on the index price, so a new divisor is calculated.
\[
\text{New divisor} = \frac{20 + 25 + 25}{31.67}
\]
\[
\text{New divisor} = 2.21
\]

Instead of a rapid change in the value of the index, the divisor is changing.

In proportion to the market capitalization weighted index, the price-weighted formula does not take the number of stocks each company has on the market, into account. It makes it simpler to calculate the index price, but one can argue for that it is not as accurate, as the market capitalization weighted formula.

**Volatility index**

The VIX index has become one of the most successful new products for traders, with more than 100,000 contracts per day. Originally the index was established to calculate the thirty-day expected volatility in option prices. However, it was modified in 2003 and fitted to the S&P 500 and became standard for hedging and trading volatility. The calculation of the VIX index uses average weighted puts and calls across different strike prices (Rattray and, Shah 2009).

The option gives you the right to buy or sell a stock at a certain time. If an investor purchase a call option, it gives the right to buy a stock at a price, which is lower than the market price. For example a call option with a price of $45 gives you the right to buy the stock for $45 even if the market price is higher. However, the option could be somewhat worth nothing if the market price does not exceed $45. Furthermore, a put option gives you the right to sell an option at a higher price than the market value. If the option allows you to sell at $45 and the market price goes below $45 you would make a profit. It is important to notice as an investor that, if the stock is in the portfolio and the put is on that stock, the profit from the put could equal the loss on the stock (Hansen, 2006). Normally indices will be calculated by stock prices but volatility is calculated from options and expected volatility. The formula, which can be seen below, is rather extensive and demands certain pre calculations. A simplified explanation of the calculation will be given, in order to understand the complexity and why it is interesting to look at, in combination with the correlation between the international markets.

\[
\sigma^2 = \frac{2}{T} \sum \frac{\Delta K}{K_i^2} e^{\nu T} Q(K_i) - \left[ \frac{F}{K_0} - 1 \right]^2
\]
The T term that is used in the equation above refers to the time of expiration of the option. The calculations of the T term can be seen below. The time to expiration uses a near- and next-term option for the first and second month. When it comes to the near-term it must have at least one week to expiration before the term shifts. This is so abnormalities to strike price close to expiration date does not influence the volatility index. If first and second month is February and March and it is the second Friday of February, the following Monday changes the near-term to March and next-term to April. Moreover, the settlement day is the third Friday of the month (Rattray and Shah, 2009). The time is calculated in minutes to make it as precise as possible by the following equation

\[
T = \left\{ M_{\text{Current day}} + M_{\text{Settlement day}} + M_{\text{Other days}} \right\} / \text{Minutes in a year}
\]

- \( M_{\text{Current day}} \) = minutes remaining until midnight
- \( M_{\text{Settlement day}} \) = minutes from midnight until 8:30 on SPX settlement day
- \( M_{\text{Other days}} \) = total minutes in the days between current day and settlement day

R refers to the risk-free rate. The rate can be different from near- to next-term as the rate that is used is the U.S T-bill maturing closest to the expiration date of the options. \( K_0 \) is an at-the-money strike price with out-of-the-money calls and puts. It is the first strike price before the forward index level, which is \( F \). \( \Delta K_i \) is calculated by half the distance of either side of \( K_i \), where \( K_i \) refers to the strike prices. It is a call if \( K_i > K_0 \) and a put if \( K_i < K_0 \) and both put and call if \( K_i = K_0 \). In order to find \( F \), a table consisting of the different strike prices and put and calls is used. To find the suitable strike price, the price is chosen from where the difference from the put and call is smallest. \( F \) is found for both the near- and next-term by the formula

\[
F = \text{Strike Price} + e^{RT} \#(\text{Call Price} - \text{Put Price})
\]

To select the calls and puts it is important to notice that there must not exists zero bid prices. If there exists two following strike prices on the call side, with zero bid prices, the higher strike prices will not be considered. Likewise, with puts if two following bid prices are zero, the lower strike prices will not be considered in the calculation.

Once the calculations are done for both the near- and next-term \( \sigma^2 \), it is now possible to calculate the 30 days weighted average VIX level by the following equation.
With this formula it is possible to weight the near- and next-term. When there is less than 30 days for the near-term and more than 30 days for the next-term, the near-term will have less weight than the next-term. However, when the periods have changed and both terms have more than 30 days the near-term will have a weight more than one, and the next-term will consist of a negative number (Rattray and Shah, 2009).

**Single linear regression theory**

**Deterministic vs. Probabilistic**

A simple linear regression is, compared to the most common equations, which are deterministic models, a probabilistic model. The difference between the two is that all the independent variables are known in a deterministic model and the independent variables will therefore give an exact estimation of the dependent variable. A probabilistic model on the other hand, is a real life process that shows how strong an impact the independent variable has on the dependent variable. Because it is a real life process, an error variable is added to the model. This variable accounts for all the unexplained variables, which the independent variable does not capture. (Keller and Rotman, 2008).

A probabilistic model will therefore look like.

\[ y = b_0 + b_1 x + e \]

\( y \) = dependent variable
\( x \) = independent variable
\( b_0 \) = y-intercept
\( b_1 \) = slope of the line
\( e \) = error variable
Estimating the Coefficients

When calculating the coefficients, it will always be a sample of the entire population that is used. Because it is samples of the entire population, it will always be an estimate that are found and not the exact parameters.

If the equation were deterministic it would be possible to make a straight line that captures all the data points used to make the line. But because the equation also have an error variable, it is almost always impossible to make a perfect straight line. The produced straight line is made by the least square line. This means that the line would make would be closest to the sample data and will look like.

\[ \hat{y} = b_0 + b_1 x \]

The least squared method is used to calculate the best fitted straight line. The least squared method is seen below.

\[ \sum_{i=1}^{n} (Y_i - \hat{Y}_i)^2 = (Y_i - (b_0 + b_1 X_i))^2 \]

Below is seen how the y-intercept and the slope of the line is computed. To find these, the sample variance and the sample covariance must be calculated.

\[ b_1 = \frac{s_{xy}}{s_x^2} \]

\[ b_0 = \bar{y} - b_1 \bar{x} \]

To find the sample variance and the sample covariance the equations below is used.

\[ s_x^2 = \frac{1}{n} \sum_{i=1}^{n} x_i^2 - \frac{1}{n} \left( \sum_{i=1}^{n} x_i \right)^2 \]
When the two samples are found, the slope of the line can be found. To find the intercept with
the y-axis, both the sample variance and the mean for the dependent variable must be found.
Furthermore, the mean for the independent variable needs to be found. When these are
established, the intercept with the vertical axis is computed in the following way.

\[ s_{xy} = \frac{1}{n} \sum_{i=1}^{n} x_i y_i \]

To access the model and see how fit it is, the residuals needs to be calculated. The residuals
show the distance from the regression line to the actual data points. The residuals are found in
the following way.

\[ b_0 = \bar{y} - b \bar{x} \]

\[ \bar{y} = \frac{\sum y_i}{n} \]

\[ \bar{x} = \frac{\sum x_i}{n} \]

To access the model and see how fit it is, the residuals needs to be calculated. The residuals show the distance from the regression line to the actual data points. The residuals are found in the following way.

\[ e_i = y_i - \hat{y}_i \]

\[ y_i \text{ refers to the actual data points and } \hat{y}_i \text{ is the fitted values on the regression line. To show the combined error from the fitted line to all the data points the sum of squares for error (SSE) is found by.} \]

\[ SSE = (n-1) \left( s_y^2 \frac{s_{xy}}{S_x^2} \right) \]

SSE becomes important for coefficient of determination and to test if a linear relationship exists.

**Assumptions**

1. The probability distribution is normal.

   To see if this assumption is accepted, a histogram can be made. If it is bell-shaped, there is normality between the residuals and the assumption is accepted. The histogram
does not have to be totally normal distributed for this assumption to be accepted and a little skewness to one of the sides makes it critical, but not rejected.

2. The mean of the distribution is 0; that is: \( E(\ ) = 0 \)
   This assumption can be calculated as a normal mean calculation. It is nearly never 0, but many times it is a very small decimal number, which also is accepted.

3. The standard deviation of \( \) is \( \sigma \), which is a constant regardless of the value of \( x \).
   The paper uses Whites heteroscedasticity test to see if this assumption is accepted.

4. The value of associated with any particular value of \( y \) is independent of associated with any other value of \( y \).
   By graphing the residuals and the time, it can be seen if a pattern is seen. If there is a pattern between the residuals, this assumption is rejected.
   (Keller and Rotman, 2008)

**Test if a linear relationship exists**

Before testing if there is a linear relationship, the standard error of estimate must be computed. The standard error of estimate additionally shows the suitability of using a linear model. If this number is small the suitability is good, and vice versa if it is large.

\[
S_e = \sqrt{\frac{SSE}{n-2}}
\]

To test if there is a linear relationship between the independent and dependent variable, a one or two-tailed t-test is conducted. A two-tailed test is normally used because it is more sufficient than a one-tailed test. If a two-tailed t-test were conducted, the hypothesis would look like.

\[
H_0 : b_1 = 0 \\
H_1 : b_1 \neq 0
\]

To find the estimated standard error of the independent variable we use the standard error of estimate and the sample variance.

\[
S_{b_1} = \frac{s}{\sqrt{(n-1)S_e}}
\]

When the estimated standard error of the independent variable is found, the test statistic for can be computed.
This test statistic settles if the hypothesis is accepted or rejected. If the hypothesis is accepted, and \( H_0 \) is true, there will not be enough statistical evidence for a linear relationship between the two variables. If \( H_0 \) is false, there might be a linear relationship between the variables and further calculations must be conducted to see if this is the case. A rejection region for the t-statistic can be found as seen below. If the t-statistic lies within the rejection region \( H_0 \) must be accepted, and with the chosen significance value there is not enough evidence for a linear relationship.

\[
b_1 \pm t_{/2, v}
\]

\[
v = n - 2
\]

If the purpose of the test was to only look at, whether two random variables are linear related a test on coefficient of correlation should be used. However, this paper wants to access the relationship between the two variables, and therefore, the test of the slope is made.

**Coefficient of determination**

The previous test only showed whether there was a linear relation. The coefficient of determination shows the strength of the relationship, which may be found in the test statistic.

\[
R^2 = 1 - \frac{SSE}{\sum(y - \bar{y})^2}
\]

\( R^2 \) will always be a number between zero and one. When \( R^2 \) moves closer to one, more of the variance in the dependent variable is explained by the variance in the independent variable. The remaining part from \( R^2 \) to one is the unexplained part of the variance.

**Example**

To illustrate how the theory is used in practice an example of, whether a relationship between Nikkei 225 and S&P 500 exists and how much of the variance in S&P 500 is explained by the variance in Nikkei 225. This will provide an interpretation of the formulas. The example uses the first four return on investment used in this paper.
The probabilistic model is:

\[ \text{SPX} = \beta_0 + \beta_1 \text{NKY} + \epsilon \]

The sample size of the population is given by

\[ \overline{\text{SPX}} = b_0 + b_1 \text{NKY} \]

To find the slope of the line the variance of Nikkei 225 and the standard deviation of Nikkei 225 and S&P 500 is calculated

\[ s_x^2 = \frac{1}{4} \cdot 0,000641061 \cdot \left( \frac{-0,0198847097}{4} \right)^2 = 0,000180737 \]

\[ s_y = \frac{1}{4} \cdot 0,000242466 \cdot \frac{-0,000915203}{4} = 0,000157089 \]

\[ b_1 = \frac{0,000180737}{0,000157089} = 1,150539281 \]

To find the intercept with the y-axis \( b_0 \) is calculated

\[ b_0 = 0,011506365 - 1,150539281 \cdot -0,004971177 = 0,0172259 \]

The regression line for the sample is:

\[ \overline{\text{SPX}} = 0,016919627 + 1,150539281 \cdot \text{NKY} \]

From this short sample of just four observations the starting point of S&P 500 is 0,017 and every time Nikkei 225 increases with 1 S&P 500 will increase with 1,15. The error term will identify how fit the model is and how it is used to test the relationship between the two indices. First the SSE is calculated by:
\[
\text{SSE} = (4 - 1) \cdot 0,003239083 - \left(\frac{(0,003239083)^2}{0,000641061}\right) = 0,009601767
\]

\[
S = \sqrt{\frac{0,009601767}{4 - 2}} = 0,069288408
\]

Normally when \( s_e \) is small, the fit of the model is good. The t-test of the slope of the model is made. The hypothesis is:

\[
H_0 : \beta_1 = 0 \\
H_1 : \beta_1 \neq 0
\]

The standard error for \( b_1 \) is:

\[
s_{b_1} = \frac{0,069288408}{\sqrt{(4 - 1)0,000641061}} = 1,579975275
\]

The test statistic is calculated as follows:

\[
t = \frac{1,150539281 - 0}{1,579975275} = 0,728200814
\]

It seems that \( H_0 \) will be accepted but to confirm this the rejection region is found

\[
t < -t_{0.025,2} = -4,303 \text{ or } t > t_{0.025,2} = 4,303
\]

Because the test statistic lies inside the rejection region, there is statistical evidence for that \( H_0 \) is accepted and there is no linear relationship between Nikkei 225 and S&P 500.

The final step is to calculate \( R^2 \)

\[
R^2 = \frac{0,000157089^2}{0,000002076} = 0,011884177
\]
From the calculation of $R^2$ there is 1.2% of the variance in S&P 500 which can be explained by the variation in Nikkei 225. When $R^2$ comes closer to one the more of the variation in S&P 500 will be explained by the variation of Nikkei 225.

**The Correlation equation**

In order to calculate the correlation for three variables, the sample covariance needs to be calculated in the following way:

$$s_{xy} = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{n-1}$$

The denominator above is $n-1$, to make it unbiased compared to being just $n$.

Furthermore, the standard deviation for the variables needs to be calculated as well, by the following equation:

$$s = \sqrt{s^2}$$

From the standard deviation equation, the variance of the variables needs to be found:

$$s_x^2 = \frac{1}{n} \sum_{i=1}^{n} x_i^2 - \frac{1}{n} \sum_{i=1}^{n} x_i \cdot \frac{1}{n}$$

The equation for coefficient of correlation:

$$r = \frac{s_{xy}}{s_x s_y}$$

*(Keller and Rotman, 2008)*

**Example**

To clarify these formulas, an example is made with three numbers from the S&P 500 and Nikkei 225 is made.

Firstly, the covariance is calculated:
Secondly, the correlation between the two variables, the standard deviation is needed and therefore the variance of the variables must be calculated.

\[
\bar{x}^2 = \left(0.008\right)^2 + \left(0.0177\right)^2 + 0.0243^2 + 0.0476^2 = 0.00324
\]

\[
\bar{y}^2 = \left(0.008\right)^2 + \left(0.0177\right)^2 + 0.0243^2 + 0.0476^2 = 0.04603
\]

\[
\bar{x} \div = 0.00212
\]

\[
\bar{s}^2 = \frac{1}{4} \frac{0.00324 - 0.00212}{4} = 0.0009
\]

The standard deviation for variable x can now be calculated by taking the square root of the variance.

\[
s_x = \sqrt{0.0009} = 0.03005
\]

The same calculations are done for variable y, which gives a variance at 0.00018 and a standard deviation at 0.01344.

To find the correlation between the two indices the coefficient of correlation can now be calculated. To do this, the standard deviation and the covariance are needed.

\[
s_y = 0.000157
\]

\[
\text{sample coefficient of correlation: } r = \frac{0.000157}{0.03005 \times 0.01344} = 0.38874 = 38.874\%
\]

This means, that the two indices are 38.874% correlated. However, when the coefficient of correlation is calculated it only provides a precise interpretation when there are perfect correlation, negative correlation or no correlation at all between the two variables. This report sees the correlation above 50% as significant, as the variables will follow each other more than half of the time.
Return on investment calculation

In this paper the return on investment refers to the difference between the next day stock price and today’s stock price divided by the initial stock quote.

\[ \text{ROI} = \frac{P_{t+1} - P_t}{P_t} \]

The method calculates the percentage return over a period of time, which will allow seeing the change in the movement of the investment.

Real rate of return

Calculating statistics on the nominal return on investment does not give the actual result of how much a return on an investment generates. The real rate of return also takes inflation into account when calculating the return on the investment. The formula for the real return is found in on investment is calculated in the following way:

\[ \text{real rate of return} = \frac{(1 + \text{nominal rate})}{(1 + \text{inflation rate})} - 1 \]

The difference between the nominal and the real interest rate is, that the nominal interest rate shows the increase of your money, while the real interest rate is an indication of how much purchasing power has grown. It is not false to look at the nominal interest rate, but it does not give the investor a truthful sign of how much the investment has given him. Looking at the real rate of return does this.

Assumptions between S&P 500 and Nikkei 225 during the IT bubble:

Normality:

Looking at the histogram of the residuals it shows that the residuals are bell shaped, which means that normality is accepted. If the histogram was skewed to one of the sides, the assumption will be critical but not rejected. A rejection of this assumption happens if there is no sign of a bell shaped histogram.
Mean of residuals is 0:

This can be seen at the above histogram to the right. The mean should be 0 or very close to it. At this single linear regression the number is so close to 0 that this assumption can be seen as accepted.

Heteroscedasticity:

A chi-squared hypothesis test is made to see if the variances of the residuals are constant. Heteroscedasticity occurs when the variance of the residuals is not constant. The test is made and a rejection region for the test is found. Below an output from eViews of the f-statistic and the chi-squared can been seen. However, the focus is on $\chi^2_K$ shown as Obs*R-squared when finding the rejection region for the chi-squared test. The rejection region for the significance value is found to be 3.84 and heteroscedasticity is therefore rejected. To conclude on these numbers, the Chi-squared test shows that heteroscedasticity is rejected and the assumption is accepted. If there is heteroscedasticity, a correction can be made to make the model more fit. It will happen in some of the later models in this paper, but also commented on, so the reader knows when it will be done.

Table 1: Heteroscedasticity test on the residuals

<table>
<thead>
<tr>
<th>Heteroskedasticity Test: White</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-statistic</td>
</tr>
<tr>
<td>Obs*R-squared</td>
</tr>
<tr>
<td>Scaled explained SS</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews
No independence:
At this graph the residuals is at the y-axis and the timespan is at the x-axis. To accept this assumption there should not be any pattern between the data plots. This graph shows that the independence of the residuals does not exists because no pattern occurs between them. Therefore this assumption is also accepted.

![Figure 2: Scatterplot of residuals and the dates](source: Retrieved from eviews)

All the assumptions are accepted and the analysis of the relationship between S&P 500 and FTSE 100 is seen as valid. If more than one of the assumptions is rejected the analysis will not have the same validity and the statistics will not be seen as good as now.

Critical assumptions between the indices:
All these assumptions are made on all regressions in all the periods and all VIX periods. All the accepted assumptions are not elaborated further on and are omitted from the appendix, whereas the assumptions that are critical or should be rejected is looked at further and can be seen in the appendix.

In the period after the It-bubble the data shows heteroscedasticity between S&P 500 and Nikkei 225, as the chi-squared test is 1.4 (appendix p. 67) and falls within the rejection region and therefore heteroscedasticity is accepted, which needs to be corrected in the model. A new output is calculated and corrected with White’s model. The output shows the same coefficients and R squared, however, the standard error and p-value have increased while the t-statistic has decreased.
New analysis

Table 2: Output of the single linear regression between the return of S&P 500 and Nikkei 225

Dependent Variable: SPX_RETURN
Method: Least Squares
Date: 04/12/13   Time: 09:47
Sample: 10/10/2002 8/07/2007
Included observations: 1206
White heteroskedasticity-consistent standard errors & covariance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NKY_RETURN</td>
<td>0.063216</td>
<td>0.019885</td>
<td>3.179061</td>
<td>0.0015</td>
</tr>
<tr>
<td>C</td>
<td>0.000508</td>
<td>0.000242</td>
<td>2.095430</td>
<td>0.0363</td>
</tr>
</tbody>
</table>

R-squared   0.009338  Mean dependent var 0.000552
Adjusted R-squared 0.008515  S.D. dependent var 0.008449
S.E. of regression 0.008413  Akaike info criterion -6.716466
Sum squared resid 0.085213  Schwarz criterion -6.708017
Log likelihood 4052.029  Hannan-Quinn criter. -6.713284
F-statistic 11.34866  Durbin-Watson stat 2.227949
Prob(F-statistic) 0.000779

Source: Retrieved from eviews

In the same period the assumption concerning homogeneity when the test is done on FTSE 100 and Nikkei 225 is violated. The correction is done and makes the model fit. The new output is shown in the table below.

Table 3: Output of the single linear regression between the return of S&P 500 and Nikkei 225

Dependent Variable: UKX_RETURN
Method: Least Squares
Date: 04/12/13   Time: 13:34
Sample: 10/10/2002 8/07/2007
Included observations: 1206
White heteroskedasticity-consistent standard errors & covariance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NKY_RETURN</td>
<td>0.198597</td>
<td>0.022898</td>
<td>8.673100</td>
<td>0.0000</td>
</tr>
<tr>
<td>C</td>
<td>0.000564</td>
<td>0.000272</td>
<td>2.070708</td>
<td>0.0386</td>
</tr>
</tbody>
</table>

R-squared   0.069337  Mean dependent var 0.000702
Adjusted R-squared 0.068564  S.D. dependent var 0.009741
During the financial crisis between S&P 500 and Nikkei 225 the p-value is 0,26 (appendix p. 69), which shows that the model does not represent enough to conclude on.

The date concerning S&P 500 and Nikkei 225 in the period after the financial crisis violates both homogeneity and has a too high p-value, even after the correction (appendix p. 71). The model is therefore not suitable for analysis. The model is rejected, because there is not enough statistical evidence to accept it. To make a better p-value and a fit model, manipulation with the statistics can be made, this includes erasing outliers from the data. In this paper this is not done, because it does not seem realistic to erase a date from the calendar, because it makes the statistical evidence better.

**Data analysis - Nominal values**

**IT-bubble**

When looking at the indices’ statistics, it is the t-statistics that determines if there is or is not a linear relationship between them. Because the t-statistic between S&P 500 and FTSE 100 is so high (11,37) and the rejection region lies between -1,92 to 1,92, there is a linear relationship between all the indices during the IT-bubble. This t-statistics is in fact so much higher than the rejection region, that there is overwhelming evidence for a linear relationship between the indices. The t-statistics between Nikkei 225 and the other indices also shows that a linear relationship exists, but it is significantly lower. Furthermore, the coefficient is positive between all indices, meaning that the linear regression line’s slope is increasing, which means that the relationships between the indices are positive.

The coefficient of determination between FTSE 100 and S&P 500 can be found in appendix (p. 65) and is 16,65%, which is the highest amongst two indices during the IT-bubble. This means that the fit of the estimated regression line is best between these indices. Moreover it shows, that 16,65% of the variance in one of the variables is defined by the variance in the other variable. Looking at this in a more financial way, when one of the indices e.g. is increasing,
16.65% of this appreciation will impact the other index in the same direction. Taking the coefficient, which is 0.42, every time the return of FTSE 100 increases with 1 the impact, the variance there is in FTSE 100, will make S&P 500 increase with 0.42. The last 83.35% that have an impact on the indices is unexplained. Because there are so much unexplained variance between the two indices, they must be seen as having very little impact on one another, which means that the causality between the indices are very low. The lowest coefficient of determination is between Nikkei 225 and S&P 500, which is 0.83%. Between these two indices there is nearly 100% of the variance that remains unexplained.

Table (4) shows the correlation between the indices during the IT bubble. The table illustrates that Nikkei 225 has a lower correlation with the other markets, than they have with each other. Comparing the correlation and the causality this is not surprising, because the causality between S&P 500 and FTSE 100 is also higher. Even though the correlation is 40.8% it cannot be seen as significant, because the markets will not go in the same direction in more than half of the dates. Moreover, the correlation is lowest between S&P 500 and Nikkei 225, which was the same case with causality.

<table>
<thead>
<tr>
<th></th>
<th>SPX RETURN</th>
<th>NKY RETURN</th>
<th>UKX RETURN</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPX RETURN</td>
<td>1.000000</td>
<td>0.091307</td>
<td>0.408092</td>
</tr>
<tr>
<td>NKY RETURN</td>
<td>0.091307</td>
<td>1.000000</td>
<td>0.153174</td>
</tr>
<tr>
<td>UKX RETURN</td>
<td>0.408092</td>
<td>0.153174</td>
<td>1.000000</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

The graph below shows the accumulated return on investment during the IT bubble. The graph reveals that the IT-bubble lasted for 641 American business days. This is the second shortest period and every date has more influence on the correlation and the single linear regression. An outlier will have more effect on this period. Furthermore, the graph shows that Nikkei 225 had the most negative return on investment during the IT bubble. This indicates that the IT bubble hit Japan hardest. One factor to this can be because the Japanese technology sector is very large, which was the main sector that was hit.
Graph 2: Shows the accumulated return on investment for the three indices during the IT bubble

**Accumulated ROI IT bubble**

[Graph showing accumulated ROI for SPX acc, UKX acc, and NKY acc]

Source: Retrieved from excel

**Between crisis**

As under the IT-bubble, there is also a linear relationship between all three indices at the period after. The t-statistics are also at this time much higher than the rejection region. The t-statistics are respectively 15,27; 3,38 and 9,47 (Appendix p. 66-68) and the rejection region is again -1,92 and 1,92 and therefore there will again be a linear regression between all the indices. Moreover, all the coefficients are also positive and therefore the slope of the estimated linear regression will be increasing.

Looking generally at the coefficients of determination, they are more alike at this period than during the IT-bubble. The highest percentages is once again between S&P 500 and FTSE 100 and is 16,22% and the lowest is between Nikkei 225 and S&P 500, which is 0,93%.

The correlation after the IT bubble is very similar to the correlation during the IT bubble. The only correlation that has changed is between Nikkei 225 and FTSE 100. It has increased with 11 percentage points from 15,3% to 26,3% (Appendix p. 68). It is crucial to notice that the correlations between the other indices are nearly unchanged while the correlation between these two has increased meaningfully. One would think when the correlations would stay unchanged between these indices as well. A significant correlation between two indices does not appear at this period as well. It is not only in the correlation an increase between Nikkei 225 and FTSE 100 is seen. At appendix (p. 68) the coefficient of determination amongst the two indices can be found. It reveals that an increase in the causality between the indices is 4,6 percentage points from 2,3% to 6,9%.
Table 5: Correlation between the indices between the crisis

<table>
<thead>
<tr>
<th></th>
<th>SPX RETURN</th>
<th>NKY RETURN</th>
<th>UKX RETURN</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPX RETURN</td>
<td>1.000000</td>
<td>0.096632</td>
<td>0.402751</td>
</tr>
<tr>
<td>NKY RETURN</td>
<td>0.096632</td>
<td>1.000000</td>
<td>0.263319</td>
</tr>
<tr>
<td>UKX RETURN</td>
<td>0.402751</td>
<td>0.263319</td>
<td>1.000000</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

Graph 2 is the accumulated return on investment between the IT-bubble and the financial crisis. It is important to know, that the return on investment is only for this period and does not consider the performance of the indices from the former periods. As the horizontal axis shows, there are 1191 observations, which is large compared to previous. Additionally, this period all indices increased, with Nikkei 225 as the best performer. Nikkei 225 also has more fluctuations, where the two other indices have a more steady growth. SPX 500 is the index that performs the poorest looking at the end of the period, but is also the index, which has the steadiest increase.

Graph 3: Shows the accumulated return on investment for the three indices between the crises. Note that the accumulated return on investment represent each investment period, therefore starting with 0.

[Graph showing Accumulated ROI Between crises]

Source: Retrieved from excel

Financial crisis

During the financial crisis the statistics still shows a linear relationship between FTSE 100 and the other indices, but $H_0$ is accepted between S&P 500 and Nikkei 225, which means that a linear relationship does not exists between them (Appendix p. 69). At this time the coefficients of determination is higher between the indices with an exception of S&P 500 and Nikkei 225, and the models fit is generally much better than during the two previous periods. The poorest fit is found between Nikkei 225 and S&P 500, 0.3% (Appendix p. 69), which is considered to be no
fit at all and the estimated linear line lies far away from the data plots, which gives very high residual numbers. The best fit is found between S&P 500 and FTSE 100, which is 28.0%.

During the financial crisis two observations can be made. Firstly, the correlation between S&P 500 and Nikkei 225 decreases 4.2 percentages point to 5.5%. Secondly, FTSE 100 becomes more correlated with the other indices, where the most important increase happens with S&P 500. It is noteworthy to see that the correlation between the two remaining indices decreases. The correlation during the financial crisis is 52.9% between FTSE 100 and S&P 500 and must be seen as very important, because it crosses the 50% line where the indices follows each other more often than not. Having this in mind, it will at this period be more critical to diversify a portfolio between these markets. In addition to this point, table (6) shows that the correlation between FTSE 100 and Nikkei 225 increases again.

Table 6: Correlation between the indices during the financial crisis

<table>
<thead>
<tr>
<th></th>
<th>SPX_RETURN</th>
<th>NKY_RETURN</th>
<th>UKX_RETURN</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPX_RETURN</td>
<td>1.000000</td>
<td>0.055260</td>
<td>0.528985</td>
</tr>
<tr>
<td>NKY_RETURN</td>
<td>0.055260</td>
<td>1.000000</td>
<td>0.362987</td>
</tr>
<tr>
<td>UKX_RETURN</td>
<td>0.528985</td>
<td>0.362987</td>
<td>1.000000</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

Graph 4 shows the accumulated return on investment during the financial crisis. With only 409 observations, the financial crisis is the period that has the least number of data. In addition, the graph shows that the indices are steady around 0, for the first 277 days, but then drops rapidly. Moreover it reveals that the poorest performer is FTSE 100, even though the housing bubble burst in America first, UK was the country that was hit the most.

Graph 4: Shows the accumulated return on investment for the three indices during the financial crisis. Note that the accumulated return on investment represent each investment period, therefore starting with 0.

Source: Retrieved from excel
After the financial crisis

The period after the financial crisis look a lot like the period during the financial crisis. There is still a linear relationship between the markets except S&P 500 and Nikkei 225. The t-statistic between these two indices is 1.09 and \( H_0 \) is therefore accepted. The coefficient of determination between S&P 500 and FTSE 100 is 48.31%, which is the highest during all the periods. It is seen that the causality between FTSE 100 and S&P 500 is increasing during the periods, meaning that these indices impact on one another increases. The coefficient of determination between S&P 500 and Nikkei 225 it is 0.13% and between Nikkei 225 and FTSE 100 it is 3.5% (Appendix p. 72). This does not only mean, that the model has a poor fit, but also that Nikkei 225 is behaving differently than the other indices. The low causality means that other factors than the indices changes the return of investment. One factor can be the tsunami that hit Japan in March 2011 and had a huge impact on the Japanese market, but did not influence the other markets as significant.

After the financial crisis the correlation between Nikkei 225 and the other indices decreases respectively, 17.4 and 2 percentages point with the other indices. One factor of the decrease in the correlation can be because of the tsunami that hit Japan in March 2011. The Japanese market was highly impacted by this, whereas this did not have the same influence on the other markets. Furthermore, the correlation between the two other markets is again increasing. The correlation is now 69.5% and the markets should be seen as highly correlated.

Table 7: Correlation between the indices after the financial crisis

<table>
<thead>
<tr>
<th></th>
<th>SPX_RETURN</th>
<th>NKY_RETURN</th>
<th>UKX_RETURN</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPX_RETURN</td>
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<td>0.035615</td>
<td>0.695102</td>
</tr>
<tr>
<td>NKY_RETURN</td>
<td>0.035615</td>
<td>1.000000</td>
<td>0.188471</td>
</tr>
<tr>
<td>UKX_RETURN</td>
<td>0.695102</td>
<td>0.188471</td>
<td>1.000000</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

Graph 5 exposes that all indices increases in the aftermath of the financial crisis. They all follow each other until observation 488, which is March 11 2011 where the tsunami hit Japan. All indices experienced a decrease, but Nikkei 225’s decrease is more severe than the two other indices’ decrease. The two other indices drops down to the same as Nikkei 225 in the late June, beginning of July, but then increases again, where Nikkei 225 stays steady at approximately 0.34 and ends as the index that an investor would gain the least of at this period.
Graph 5: Shows the accumulated return on investment for the three indices after the financial crisis. Note that the accumulated return on investment represent each investment period, therefore starting with 0.

Source: Retrieved from excel

### The Whole period

Looking at the t-statistics and the coefficients there is a similar pattern to all the indices. All of them have a positive coefficient and the t-statistics are bigger than the rejection regions. It can therefore be concluded, that a linear relationship between all the indices exists and that the slope of the estimated regression line is positive (Appendix p. 72-73).

At the whole period it becomes clear, that Nikkei 225 stands out as the index that has least causality with the two other indices. Nikkei’s coefficient of determination is respectively 0,48% and 6,46% with S&P 500 and FTSE 100, whereas the two other indices have an R-squared at 27,7% (Appendix p). Looking at the causality of the three indices over 12 years, the statistics shows that Nikkei 225 stands out as having the lowest impact on the other indices. Between Nikkei 225 and S&P 500 the causality is nearly 0, which shows that they do not have any impact on one another. Nikkei 225 and FTSE 100’s causality is higher, but approximately 95% of the variance in these two indices is because of other factors. Between S&P 500 and FTSE 100 the highest causality is found and the impact between these two indices can be seen as being significant so the variance in one of the indices have an influence on the other index.

Looking at the correlation for the whole period below, it becomes clear that the two least correlated markets are Nikkei 225 and S&P 500. They have been the two markets, that have correlated least during all the periods, and with only a 7,0% correlation, they should be seen as highly uncorrelated. This means that a diversification of a portfolio amongst these two markets will be possible. In the middle lies FTSE 100, which correlation with the two markets becomes
more significant as time progresses. The correlation with S&P 500 increases through all the periods and after the financial crisis it is nearly 70%, which makes international diversification between these two markets difficult. The overall correlation amongst FTSE 100 and Nikkei 225 is 25.4%, so the markets could be used to diversify a portfolio. When this is said, the two markets, which correlates least is S&P 500 and Nikkei 225, so over the 12 years this report is looking at, international diversification will be best to practice between these two.

<table>
<thead>
<tr>
<th></th>
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<th>UKX_RETURN</th>
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</thead>
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<td>0.526124</td>
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<tr>
<td>NKY_RETURN</td>
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<td>UKX_RETURN</td>
<td>0.526124</td>
<td>0.254344</td>
<td>1.000000</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

The graph below reveals how the indices have performed during the entire period. It is important to notice how the graph shows the different periods of up and down turns. The graph shows when there has been a period of negative returns and positive returns. However, when Nikkei 225 is examined it shows that the index had difficulties with recovering from the first crisis. Actually, the index did not see much positive accumulated return across the whole period. The graph also shows that Nikkei 225 has had more extreme movement compared to the two other indices.

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Graph 6: Shows the accumulated return on investment for the three indices for the whole period. Note that the accumulated return on investment represents the investment period for this paper and does not consider previous data, hence starting with 0.

**Accumulated ROI the whole period**

Source: Retrieved from eviews
Critical assumptions for VIX

In the test of S&P 500 and Nikkei 225, when there exists low volatility, the assumption concerning heteroscedasticity is violated. The obs*R-squared falls within the critical region as the rejection region for $X^2$ is 3.84 which indicates that there is heteroscedasticity. Furthermore, the p-value is very high at 0.8174 which makes the model invalid and needs to be corrected (Appendix p. 76). The figure below shows the test when there has been corrected for heteroscedasticity.

Table 9: Output of single linear regression between S&P 500 and Nikkei 225 in low volatility

<table>
<thead>
<tr>
<th>Dependent Variable: SPX_LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method: Least Squares</td>
</tr>
<tr>
<td>Date: 04/12/13   Time: 09:32</td>
</tr>
<tr>
<td>Included observations: 776</td>
</tr>
</tbody>
</table>

White heteroskedasticity-consistent standard errors & covariance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NKY_LOW</td>
<td>0.028366</td>
<td>0.023733</td>
<td>1.195201</td>
<td>0.2324</td>
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<tr>
<td>C</td>
<td>0.000414</td>
<td>0.000240</td>
<td>1.724313</td>
<td>0.0851</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.001725</td>
<td>Mean dependent var</td>
<td>0.000435</td>
<td></td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.000435</td>
<td>S.D. dependent var</td>
<td>0.006681</td>
<td></td>
</tr>
<tr>
<td>S.E. of regression</td>
<td>0.006680</td>
<td>Akaike info criterion</td>
<td>-7.176891</td>
<td></td>
</tr>
<tr>
<td>Sum squared resid</td>
<td>0.034535</td>
<td>Schwarz criterion</td>
<td>-7.164896</td>
<td></td>
</tr>
<tr>
<td>Log likelihood</td>
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<td>Hannan-Quinn criter.</td>
<td>-7.172277</td>
<td></td>
</tr>
<tr>
<td>F-statistic</td>
<td>1.337362</td>
<td>Durbin-Watson stat</td>
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<td></td>
</tr>
<tr>
<td>Prob(F-statistic)</td>
<td>0.247857</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

The table shows that even after the correction the p-value is still too high and makes the statistic invalid. There is not enough evidence for the probability of the hypothesis to hold, which does not make it suitable to conclude from.

When the VIX indices have low volatility and the model contains FTSE 100 and Nikkei 225 the assumption for heteroscedasticity is violated. The obs*R-squared is 1.49 and falls within the rejection region and accept heteroscedasticity. Additionally, the p-value is at 0.4744 and makes the model invalid and will be corrected.
Table 10: Heteroscedasticity test on residuals between S&P 500 and Nikkei 225 in low volatility

<table>
<thead>
<tr>
<th>Heteroskedasticity Test: White</th>
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</thead>
<tbody>
<tr>
<td>F-statistic</td>
</tr>
<tr>
<td>Prob. F(2,779)</td>
</tr>
<tr>
<td>Obs*R-squared</td>
</tr>
<tr>
<td>Prob. Chi-Square(2)</td>
</tr>
<tr>
<td>Scaled explained SS</td>
</tr>
<tr>
<td>Prob. Chi-Square(2)</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

When there has been corrected for heteroscedasticity the output below shows, that the error term has increased but the other statistic remain unchanged.

Table 11: Output of single linear regression between FTSE 100 and Nikkei 225 in low volatility

Dependent Variable: UKX_LOW
Method: Least Squares
Date: 04/12/13   Time: 09:47
Sample: 1 782
Included observations: 782
White heteroskedasticity-consistent standard errors & covariance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NKY_LOW</td>
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<td>0.0000</td>
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<td>C</td>
<td>0.000471</td>
<td>0.000266</td>
<td>1.770923</td>
<td>0.0770</td>
</tr>
</tbody>
</table>

R-squared 0.096276   Mean dependent var 0.000637
Adjusted R-squared 0.095117   S.D. dependent var 0.007789
S.E. of regression 0.007409   Akaike info criterion -6.969713
Sum squared resid 0.042816   Schwarz criterion -6.957790
Log likelihood 2727.158   Hannan-Quinn criter. -6.965128
F-statistic 83.09532   Durbin-Watson stat 2.192733
Prob(F-statistic) 0.000000

Source: Retrieved from eviews

Data analysis – VIX

In this section the volatility index for each of the three countries will be used to calculate the correlation between the indices. Prior, the period for the correlation has been determined by crisis or upturns; however, another interesting factor to consider is when the markets experience high and low volatility. The analysis will provide an indication of how the correlation between the markets is effected and might change when there is high or low volatility. Each pair of data will be tested by simple linear regression to test whether there is a linear relation. Furthermore, the test will reveal how much of one variable is explained by another, which makes it possible to determine the influence the variables have on each other.
**S&P 500 and Nikkei 225**

From the statistical output in (Appendix p. 74) the coefficients from the S&P 500 and Nikkei 225 during a period with high VIX indices shows that, when Nikkei increases with 10 the S&P will only increase with 0.84. This indicates that there exists a minimum form of correlation between the two indices. However, the test statistic will show whether a linear relation exists and the R squared will present the correlation within the variables. The test has 843 observations and the t-statistic is 2.56, which provides enough evidence to reject $H_0$, as it falls outside the rejection region of ±1.96. When the $H_0$ is rejected there exists a linear relation between the two indices. The validity of the model is proven by the p value, which is 0.01. In order to make use of the linear relation, it is important to know how much of the variation in S&P 500 is explained by the variation in Nikkei 225. With a R-squared of 0.0077 it is possible to conclude that only 0.7% of the variation in S&P 500 is explained by Nikkei 225. However, this leaves out close to 100%, which is unexplained by the test. From a portfolio managers perspective it is not possible to follow a change in Nikkei 225 and apply it to the S&P 500, as when an appreciation in Nikkei 225 occurs there is nearly zero chance that the same change will occurs in the S&P 500. It is possible to say that the indices have a low relationship and they do not follow the same overall market movement. However, with so much of the variation, which is not explained in the correlation between the two indices, one would say that the two indices would contribute to diversifying a portfolio. The causality described the interconnection between the two variables, how much one variable was described in the other variable. In the figure below, the correlation matrix shows how connected the two indices are.

<table>
<thead>
<tr>
<th></th>
<th>SPX_HIGH</th>
<th>NKY_HIGH</th>
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</thead>
<tbody>
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<td>SPX_HIGH</td>
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</tr>
<tr>
<td>NKY_HIGH</td>
<td>0.088011</td>
<td>1.000000</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

The table above shows perfect correlation as 1 and none correlation as 0. During this period, it shows that the correlation between S&P 500 and Nikkei 225 was very close to zero, exactly 0.088. Thus, showing that there existed no correlation, verifies the possibility for international diversification, as market movements are different in the two indices.
The graph above shows a clear indication of decline when the markets experience much volatility. High volatility is often associated with fear in the market, and makes investors tend to sell. The number of observations shows that in the entire period, the two markets experienced high volatility at the same time in 844 days. The data shows that observation 530 to 700 represent the period 16-04-2008 to 19-05-2009. This period represent the financial crisis and afterwards. The high volatility had very high impact on the return on investments as the lowest point was close to an aggregated -0.6. Thus, the correlation in the whole data set has low correlation; it is in the period from 16-04 where the lines are closest.

To look at the two indices in more stable markets where the volatility is fairly low, to see if it influences the correlation between the indices. The coefficient has changed to have less impact on the S&P 500 when changes happen in Nikkei 225. For times with low VIX indices, S&P 500 will change with 0.28 when Nikkei 225 increases with 10, which is a much less than the previous period. The output in (Appendix p. 76) indicates that change in the causality occurs when there are low VIX indices compared to high. However, when the output is examined there is not enough evidence to conclude much, as there is no linear relationship when the t-statistic falls within the rejection region. Furthermore, the p-value is close to 0.25, which rejects the model. The correlation between the two indices can still be examined in the following table.
Table 13: Correlation between S&P 500 and Nikkei 225 in markets with low volatility

<table>
<thead>
<tr>
<th></th>
<th>SPX_LOW</th>
<th>NKY_LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPX_LOW</td>
<td>1.000000</td>
<td>0.041532</td>
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<tr>
<td>NKY_LOW</td>
<td>0.041532</td>
<td>1.000000</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

The table above shows that the correlation has decreased even further, and is now half of what it was the previous period with high volatility levels. The change in the correlation indicates that, when the markets are less volatile they move in more independent patterns. This knowledge will be useful when allocation of investments is chosen within the area of risk management.

Graph 8: Shows the accumulated return on investment in periods where the two markets have experienced VIX indices of 20 or below.

Accumulated ROI in periods with low VIX indices

Source: Retrieved from excel

The graph above shows, when there have been little uncertainty in the two markets the indices tends to appreciate. As the graph indicates the indices have moved in the same direction, however the correlation between them is very little. The sample size is medium as it consists of 777 observations, whereas most of them have been positive returns. The data reveals that Nikkei 225 has been experiencing the highest return, when the markets have been in some state of stabile.

**S&P 500 and FTSE 100**

Appendix (p.74) shows how the S&P 500 and FTSE 100 are connected during periods of high VIX indices. The two indices have a fairly higher coefficient, where the S&P 500 increases by 4,9 when FTSE 100 increases with 10. The H₀ is being rejected as the t-statistic falls outside
the rejection region, which shows that there is a linear relation between the two indices. In this case the degree of causality is much higher than between the other indices. The R squared is 0.2934, which conclude that 29.34% of the variation in S&P 500 is explained by the change in FTSE 100. This indicates that they are fairly dependent however, there is 71.66% which is unexplained. When the markets have high volatility it will not provide much diversification to a portfolio, to add both of these indices, as they will much likely follow the same course. However, it will still provide a diversification in form of foreign market speculation as the R squared indicates, there is still close to 72% of the movement which is explained by other factors. An interesting factor lies within the correlated movement of the indices, which can be examined by the table below

Table 14: Correlation between the S&P 500 and FTSE 100 in markets with high volatility

<table>
<thead>
<tr>
<th></th>
<th>SPX_HIGH</th>
<th>UKX_HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPX_HIGH</td>
<td>1.000000</td>
<td>0.541675</td>
</tr>
<tr>
<td>UKX_HIGH</td>
<td>0.541675</td>
<td>1.000000</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

Table 14 shows a significant correlation between S&P 500 and FTSE 100. The correlation is 0.5417 and provides enough evidence to conclude that there exists a reasonable correlation. In a perspective of risk management the two indices will give little diversification to a portfolio, when the markets are experiencing high volatility.

Graph 9: Shows the accumulated return on investment in periods where the two markets have experienced VIX indices of 30 or above.

Accumulated ROI in periods with high VIX indices

Source: Retrieved from excel
Between the S&P 500 and FTSE 100 there is far less observations where both markets experienced high volatility. Both in the correlation data but also in visually in the graph it shows much higher correlation than between Nikkei 225 and S&P 500. However, the combined return on investments was -0.5 at the lowest point. In the first part of the graph it shows somewhat stable movement around 0, whereas the last part shows a significant decrease in returns. This could be an indication of how severe a crisis could have.

From appendix (p. 74-75) it is possible to show the difference from markets with high volatility to markets with low volatility. If the markets were much connected in uncertain markets, one would also think that they would be equally correlated in less volatile markets. However, the data shows that the coefficient decreases to 3.8 compared from 4.9 in the above period, when FTSE 100 increases with 10. There is still evidence for a linear relation as the $H_0$ is rejected. R squared is 0.2113 compared to 0.2934 in the period with high volatility. In markets where the VIX indices are fairly low there is evidence for, that the variation, which is explained in S&P 500 by FTSE 100 decreases. This makes more room for factors, which are unexplained, and also makes the indices posses less causality in this period. However, the amount of what is explained in the dependent variable by the independent variable is still reasonable. This shows that the causality is higher in periods with high VIX levels. When the causality decreases the period of low volatility indicate that correlation follows. This is shown in the table below.

<table>
<thead>
<tr>
<th></th>
<th>SPX_LOW</th>
<th>UKX_LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPX_LOW</td>
<td>1.000000</td>
<td>0.459647</td>
</tr>
<tr>
<td>UKX_LOW</td>
<td>0.459647</td>
<td>1.000000</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

The correlation drops below 0.5, which indicates a low level of correlation, however the correlation is still high at 0.46. From an investors point of view this provides an opportunity to use information concerning the volatility in the market to hedge risk in the market. From this analysis it is possible to say, that the indices could be used as diversification when markets have low volatility. However, in the situation with high volatility indices the markets would be too correlated to use as diversification.
Graph 10: Shows the accumulated return on investment in periods where the two markets have experienced VIX indices of 20 or below.

**Accumulated ROI in periods with low VIX indices**

![Graph showing accumulated ROI for SPX and UKX in periods with low VIX indices](image)

Source: Retrieved from excel

Between the S&P 500 and FTSE 100 there are significantly more data, where the two indices experience the same low volatility level. There is 1446 observations in the data, however it also shows that the correlation between the two indices has decreased compared to the previous period. The graph shows that FTSE 100 has increased significantly more than the S&P 500, close to 0.9 and 0.6 respectively.

**Nikkei 225 and FTSE 100**

In (Appendix p. 75) the coefficient from Nikkei 225 and FTSE 100 shows that when Nikkei 225 appreciates with 10, FTSE 100 will increase by 4.2 as well. It is possible to prove that a relationship exists between the two indices as the null hypothesis is rejected as it falls outside the rejection region. The R-squared shows that only 12.18% of the change in FTSE 100 is explained by the variation in Nikkei 225. This leaves close to 87.82% which is unexplained in the model. From a risk management point of view the two markets will not have to high causality and will provide diversification to an international portfolio when both markets experience high volatility in the market. It is not only the R-squared, which allows to conclude on the connection between the two indices. The correlation verifies how much or how little the two indices have in common. The table below shows a fairly low correlation between the two indices and therefore, they will be suitable for international diversification.
Table 16: Correlation between FTSE 100 and Nikkei 225 in markets with high volatility

<table>
<thead>
<tr>
<th></th>
<th>UKX_HIGH</th>
<th>NKY_HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td>UKX_HIGH</td>
<td>1.000000</td>
<td>0.348976</td>
</tr>
<tr>
<td>NKY_HIGH</td>
<td>0.348976</td>
<td>1.000000</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

The smallest data sample is between FTSE 100 and Nikkei 225. This indicates that the markets do not experience quite the same amount, or at the same time, of high volatility. However, the overall return still seems negative, with both indices seeing returns decrease with -0.6 and -0.45. FTSE 100 shows the least decrease in returns, whereas Nikkei 225 seems to be below during the whole period. The graph also indicates that the indices have the same recovery periods, however, the correlation remains low at 0.345.

Graph 11: Shows the accumulated return on investment in periods where the two markets have experienced VIX indexes of 30 or above.

Accumulated ROI in periods with high VIX indices

When the two markets experience low volatility some changes occurs to the overall correlation between the two indices. (Appendix p. 76) shows that the coefficient changes rapidly, as when Nikkei 225 increases with ten FTSE 100 decreases to 2.48. It is quite noteworthy that in all other comparisons, the coefficients have decreased when there was low volatility in the market. As in the other models there is statistical evidence for a linear relation between the indices as the null hypothesis is rejected. The R squared has decreased to 0.096, which has been significant for all of the models. It is then possible to conclude that, when there exist low volatility in the markets the causality decreases and it is other factors, which determines the course. This is also the case in the correlation matrix below, where the table
shows a slight decline of 0.039 points. However, there still exists a low correlation between the indices.

Table 17: Correlation between FTSE 100 and Nikkei 225 in markets with low volatility

<table>
<thead>
<tr>
<th></th>
<th>UKX_LOW</th>
<th>NKY_LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>UKX_LOW</td>
<td>1.000000</td>
<td>0.310284</td>
</tr>
<tr>
<td>NKY_LOW</td>
<td>0.310284</td>
<td>1.000000</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

The graph below shows that both indices are appreciating in periods with low volatility. In the beginning of the graph it shows that FTSE 100 still is better performing than Nikkei 225. However, the rest of the graph shows that Nikkei 225 is outperforming FTSE 100 and ends up with a slightly higher return than FTSE 100 close to 0.52 and 0.5 respectively. During this period the data also shows that the correlation decreases. It might be because of the fairly large appreciation, which is shown in the graph from 300-370. The FTSE 100 is consistently appreciating whereas Nikkei 225 experiences a significant increase over a short period.

Graph 12: Shows the accumulated return on investment in periods where the two markets have experienced VIX indexes of 20 or below.

Conclusion on three indexes with nominal values and volatility index

To conclude on the information from the preceding pages it is possible to use all three indices to diversify a portfolio, however, some periods are not suitable for diversification. The index, which diversifies the most, is Nikkei 225, so this index will minimize the risk more than the two other indices. From a Japanese matter it will be best to diversify with S&P 500, as the
correlation between these two indices are decreasing while the correlation between Nikkei 225 and FTSE 100 is increasing.

Looking at FTSE 100 and S&P 500, they generally become more correlated as the time progresses. The correlation between these two indices during the whole period is higher than with Nikkei 225. This is also visualized in both correlation and the R squared which between FTSE 100 and S&P 500 remains the highest. This means that among the indices they have the most impact on each other, as variation in one of the indices has the greatest influence on the other index. From the risk management point of view the FTSE 100 and S&P 500 would give the least amount of diversification compared to Nikkei 225. In other words, a portfolio manager from UK or USA should use the Japanese index to diversify the portfolio, thus reducing risk.

From the graphs with the accumulated return on investment, it can be seen that the worst performing index during a time of crisis is also the index, which is recovering best. This is shown in the two graphs during the It-bubble and the period after. Nikkei 225 is showing the most negative return on investment during the crisis. However, Nikkei 225 outperforms the other indices in the period after the crisis. There could be an indication of an increased interest of buying the index, which has decreased most during a crisis. That could be due to a significantly lower index price compared to the other two. This might also affect correlation between the indices, as one index is taking both extreme cases as being the worst and best performer.

The graph, which contains the entire period, shows that across the 12 years period Nikkei 225 ends at the same return as it started. This means that an investor who invested in Nikkei 225 for this 12 year period would not have gained any return. Looking at the other two indices, which were more correlated and had a higher causality, ended up with close to the same return.

When the markets are examined by periods of high and low volatility in the markets it shows, that S&P 500 and FTSE 100 are more correlated than the other index combinations. The analysis shows, when there exists low volatility in the markets the correlation and causality is decreasing.

The graphs in the above analysis shows where the markets are exposed to low volatility, the return of the indices will generally increase. When the markets show low volatility, an
investor could use this information as a buy sign and increase the number of stocks in a portfolio, whereas, high volatility would indicate a sell signal.

**Critical assumptions between gold and the three indices**

The first critical assumption occurs during the IT-bubble between gold and S&P 500. There is not heteroscedasticity, but the p-value for the test is 7.52% (Appendix p. 77), which is considered to be fairly high. This does not mean that the test is not significant, but the amount of statistical evidence is critical.

The next assumption that is critical is between gold and Nikkei 225 between the two crisis. Heteroscedasticity is here rejected, and a new model is made that corrects for this. At first the model is rejected, but the model is modified, so single linear regression can be used.

At the period after the financial crisis, heteroscedasticity is again accepted between gold and Nikkei 225. The model is therefore corrected for this, as the above critical assumption was.

Many of the models between gold and the indices have too high a p-value for the model to be accepted and the models are not a part of the analysis. The models that have a too high p-value is between gold and FTSE 100 and gold and Nikkei 225 during the IT-bubble. Between the crises it is between S&P 500 and gold that is rejected, which also is the case during the financial crisis. After the financial crisis the model between Nikkei 225 and gold is rejected and for the whole period it is between S&P 500 and gold the p-value is too high.

**Analysis on the statistics between gold and the indices**

**IT-bubble**

The statistics shows a linear relationship between the indices and gold through the IT-bubble. The relationship between the indices and gold is negative, thus, when gold is increasing the indices are decreasing. Graph 2 shows that the indices at this period are decreasing at the most of the period, which means that the price of gold accumulated rate of return would have increased at this period. The data also shows this.

The coefficient of determination is very low for all the indices, so the causality of gold and the indices are very low. The correlation between gold and the indices are also negative, but
they are so low, that a negative correlation cannot be seen. The correlation should at least be -0.5, if the correlation can be used, so because it is so low, it can only be seen as no correlation.

Table 18: The correlation between the indices and gold during the IT-bubble

<table>
<thead>
<tr>
<th></th>
<th>RETURN_GOLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>RETURN_SPX</td>
<td>-0.175467</td>
</tr>
<tr>
<td>RETURN_UKX</td>
<td>-0.036414</td>
</tr>
<tr>
<td>RETURN_NKY</td>
<td>-0.036414</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

**Between crisis**

There is also a linear relationship between gold and the indices between the crises, but at this period the relationship is positive. The coefficient of determination is also very small, so the causality is very low (appendix p. 79-80). It is not surprising that the relationship at this period is positive, because both the indices and gold’s return are positive at this period. The correlation is also positive at this period, though it is not above 50%, which is good because using gold to diversify a portfolio will be less profitable if the correlation was over 50%. The correlation table also shows that the correlation between S&P 500 is much different than the other indices.

Table 19: The correlation between the indices and gold between the crises

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>RETURN_SPX</td>
<td>-0.027695</td>
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<tr>
<td>RETURN_UKX</td>
<td>0.272703</td>
</tr>
<tr>
<td>RETURN_NKY</td>
<td>0.211171</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

**Financial crisis**

There is also a positive linear relationship between gold and the indices during the financial crisis. Additionally, it is notable to see that the coefficient of determination is very low for all the single linear regression models. Moreover, the coefficients do not show much change from the coefficients from the last period. The correlation between gold and FTSE 100 and Nikkei 225 has decreased 11.5 and 8 percentage points, respectively. The correlation with S&P 500 is still very close to zero, which does not change from the last period.
After the financial crisis

After the financial crisis gold has a positive relationship with S&P 500 and FTSE 100. The causality between gold and these two indices does not have a significant change compared to during the financial crisis. The table below displays the correlation between the indices and gold. It reveals that the correlation between gold and S&P 500 has increased approximately 10 percentage points, while the correlation between gold and Nikkei 225 has decreased the same. The correlation matrix also shows that the index, which has the highest correlation with gold is FTSE 100, thus, it should be seen as the index that is least effective when differentiating a portfolio with gold, whereas the most gainful index to use gold as a diversification is Nikkei 225.

### Table 20: The correlation between the indices and gold at the financial crisis

<table>
<thead>
<tr>
<th>Index</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>RETURN_SPX</td>
<td>0.010374</td>
</tr>
<tr>
<td>RETURN_UKX</td>
<td>0.157547</td>
</tr>
<tr>
<td>RETURN_NKY</td>
<td>0.130902</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

The whole period

For the whole period, a positive linear relationship can be seen between gold and all the indices. Furthermore, the low coefficient of determination reveals that the indices and gold does not have a high impact on one another (Appendix p. 84-85). Because of this, it is possible to use gold as diversification of a portfolio for all the indices. The correlation matrix below is also an indication on this. The most correlated index with gold is FTSE 100, which have a correlation with gold on 17.4%. This is not enough correlation to conclude; that they follow each other during the 12-year period this paper data goes back. The index, which is least correlated with gold is S&P 500. The correlation between these two lies very close to 0. The best result would
be that the indices had a negative correlation on -1, because this would mean that they would go in different directions and diversification would be of great advantage.

Table 22: The correlation between the indices and gold for the whole period

<table>
<thead>
<tr>
<th>Index</th>
<th>RETURN_GOLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>RETURN_SPX</td>
<td>0.002265</td>
</tr>
<tr>
<td>RETURN_UKX</td>
<td>0.173664</td>
</tr>
<tr>
<td>RETURN_NKY</td>
<td>0.137633</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

**Critical assumptions with inflation**

Between S&P 500 and FTSE 100 the data in (Appendix p. 85-86) shows that there is heteroscedasticity, which needs to be corrected. The Obs*R-squared is very low at 0,3378 and it has a p-value of 0,8446. After the correction the linear relationship and fit of the model is still accepted.

**Analysis on the statistic on real return**

After the data in appendix (p. 86) has been corrected for inflation, the relationships between the indices are changing significantly. The data shows that there exists linear relation between the S&P 500 and FTSE 100. The coefficient is 0,7852, which is higher, compared with the previous models. This means that when the S&P 500 moves 1 FTSE 100 moves 0,7852 in the same direction. The R squared is significantly high as well at 0,6833, which indicates a close connection between the two indices, as one index has a high influence on the other.

The relationship between S&P 500 and Nikkei 225 seems lower compared to the previous combination. However, there still exist a linear relationship with a coefficient of 0,5402 and the R squared is 0,4093 (appendix p. 86). This is a quite significant increase compared to the nominal values where the coefficient was 0,059 and R squared 0,0049. This might be due to the much lower number of observations combined with the adjustment for inflation. The statistic reveals that without the inflation a much higher connection between the indices exists.

(Appendix p. 87) shows FTSE 100 and Nikkei 225 have a linear relationship, however the causality between the two remains low. The coefficient is 0,5203 with a R squared of 0,3427.
This shows that the lowest connection between indices exists between this pair after the correction for inflation.

<table>
<thead>
<tr>
<th></th>
<th>SPX_CORRECTED</th>
<th>UKX_CORRECTED</th>
<th>NKY_CORRECTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPX_CORRECTED</td>
<td>1.000000</td>
<td>0.826640</td>
<td>0.639785</td>
</tr>
<tr>
<td>UKX_CORRECTED</td>
<td>0.826640</td>
<td>1.000000</td>
<td>0.585370</td>
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<tr>
<td>NKY_CORRECTED</td>
<td>0.639785</td>
<td>0.585370</td>
<td>1.000000</td>
</tr>
</tbody>
</table>

Source: Retrieved from eviews

The correlation between the indices changes drastically compared to the periods where the data have not been corrected with inflation. The correlation matrix shows that correlation between all indices exists. The highest correlation is found between the S&P 500 and FTSE 100 with 0.8266. Furthermore, the lowest is found between FTSE 100 and Nikkei 225. The correlation matrix shows that international diversification becomes increasingly difficult, when the data is adjusted for inflation. In nominal values the data showed that the causality was low, and much of the change was due to unexplained factors. However, the data, which have been corrected with inflation, shows a significant increase in causality and correlation. Inflation does seem to have been much of the unexplained factor in the previous models. The table above proves that S&P 500 has the highest correlation with the other indices. This indicates that most of the indices have most in common with the S&P 500.

**Discussion**

With this analysis in mind FTSE 100 and S&P 500 will become more correlated as the time goes by. The paper has shown, that both the causality and the correlation between these two indices has increased during the 12-year period, the paper have examined. The paper therefore predicts that this increase will not stop. One factor that plays a role for the increased causality between these two markets is the level of difficulties when buying international stocks. It has become easier in the past years to buy international stocks. This makes it easier for foreign investors to invest in domestic stocks, which has caused globalization among the countries. The increased globalization can also be seen during the crisis. All the indices are affected by the crisis, which would not have happened if the markets had no correlation between them.
The level of transaction barriers might have reached a low-point. It is hard to imagine how the trade in foreign stocks could be made easier. The development indicates that international diversification could become difficult as markets move closer. However, there are still some possibilities when it comes to diversifying with Nikkei 225. Taking the inflation into consideration the correlation increased, however, it is worth noticing that Japan had very long periods with negative inflation numbers. This might change in the future which would make it possible to get an international diversification even when the inflation is accounted for.

Gold seems to be a way of diversifying in the future as well as the markets seems to have a small correlation. In the future, as well as now, the paper suggests that investors still will look at gold when markets are experiencing crisis. Alongside, it might mean that one could see that gold could decrease when the markets are in a better condition.

**Conclusion**

From a practical viewpoint it is possible for an investor to use international diversification as a tool to minimize the risk of the portfolio. No matter, whether there is a crisis or not, the two least correlated indices are S&P 500 and Nikkei 225. When this is said, using other combinations of diversification is impossible, but does not have the same effect as the between the two mentioned indices. It is also seen from the statistics that the causality between S&P 500 and Nikkei 225 is smaller than between the other indices.

The data shows, which periods would provide the most diversification for an investor. During the first two periods all combinations does not have a high correlation or causality, thus, this will provide diversification. However, through time the US and UK indices have become closer connected, whereas Japan has decreased its correlation. The analysis shows a possibility for an investor when it comes to times after a crisis, as the index which has performed the worst is recovering most after the crisis. This could be used as a strategy to modify ones portfolio to fit the market when these situations occur. The whole period shows that the correlation between UK and US is too high to give diversification, whereas Japan would have given a higher diversification. However, Japan is affected by the crisis worst.

The analysis tells that Nikkei 225 did not recover as well or as fast from crisis’ as the other indices. One could argue that Nikkei 225 never recovered from the It-bubble, before the market experienced a second shock. Furthermore, the Japanese market did not yet recover from the
housing bubble in the same manner as the other two indices. The total return for the twelve years with Nikkei 225 would have been zero, whereas the other two indices ended up with a positive return.

Market volatility goes up and down, which changes the correlation between the indices in these markets. When the markets become less volatile, hence more predictive and stable, the market correlations are moving away from each other. High volatility indicates larger market movements and as the graphs showed the return was negative in these periods. An investor should be aware, that high volatility in US and UK markets leads to too high correlation and should therefore not be used to diversify. However, the statistic revealed that the remaining market combinations and conditions were suitable for diversification, though the relationship between US and UK remains high.

Gold would play an important role in diversifying a portfolio as the data proved to have low correlation and causality between gold and the indices. Through the twelve years gold did not have a correlation with the other indices and was independent of the indices. However, the correlation statistic showed that during the first period there was a small negative correlation. However, over time the negative correlation turns positive, though remaining a low correlation, which will allow diversification. During the whole period the correlation between Gold and the US market was the lowest.

As an investor the real return on investment is what really is gained in the market when inflation is removed from the return. The data shows a quite unique change in the correlation when there the correction is made. During the entire period, the correlation increases drastically, so there now is high correlation between all markets. This is interesting, as the data shows that international diversification becomes hard with these three markets, when the inflation is accounted for. However, it should be noticed that it is each markets individual inflation which is adjusted with. The influence the market returns have on the other markets have increased significantly, which also is indicated by the higher correlation.

There is evidence for that gold, combined with the other indices, does provide the most amount of diversification. Most of this might be due to the, close to constant, appreciation of gold through the period analyzed. Furthermore, the real return would not lower the risk as the market seems too correlated, whereas gold remains isolated from the indices.
References

http://useconomy.about.com/od/glossary/g/SP500.htm

http://www.noozhawk.com/article/100211_craig_allen/

http://www.bankofengland.co.uk/financialstability/pages/default.aspx

Financial Services LLC.


## Appendix

### Nominal values

#### IT bubble

Dependent Variable: SPX\(_{\text{RETURN}}\)
Method: Least Squares
Date: 04/10/13   Time: 11:52
Included observations: 649

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
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<td>0.0000</td>
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<td>-0.794057</td>
<td>0.4275</td>
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</tbody>
</table>

R-squared 0.166539
Mean dependent var -0.000742
Adjusted R-squared 0.165251
S.D. dependent var 0.014633
S.E. of regression 0.013369
Akaike info criterion -5.788671
Schwarz criterion -5.774879
Log likelihood 1880.424
F-statistic 129.2815
Durbin-Watson stat 2.276288

Dependent Variable: SPX\(_{\text{RETURN}}\)
Method: Least Squares
Date: 04/10/13   Time: 11:55
Included observations: 649

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<thead>
<tr>
<th>Variable</th>
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<th>Std. Error</th>
<th>t-Statistic</th>
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<tbody>
<tr>
<td>NKY(_{\text{RETURN}})</td>
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<td>0.000574</td>
<td>-1.113171</td>
<td>0.2660</td>
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</table>

R-squared 0.008337
Mean dependent var -0.000742
Adjusted R-squared 0.006804
S.D. dependent var 0.014633
S.E. of regression 0.013369
Akaike info criterion -5.614874
Schwarz criterion -5.601082
Log likelihood 1824.027
Hannan-Quinn criter. -5.609524
F-statistic 129.2815
Durbin-Watson stat 2.276288

Prob(F-statistic) 0.000000
### Between crisis

Dependent Variable: SPX_RETURN  
Method: Least Squares  
Date: 04/10/13 Time: 11:58  
Sample: 10/10/2002 8/07/2007  
Included observations: 1206

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<th>Std. Error</th>
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<th>Prob.</th>
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<td>0.1704</td>
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</table>

R-squared     0.162209 Mean dependent var 0.000552  
Adjusted R-squared 0.161513 S.D. dependent var 0.008449  
S.E. of regression 0.007737 Akaike info criterion -6.884071  
Sum squared resid 0.072064 Schwarz criterion -6.875621  
Log likelihood 4153.095 Hannan-Quinn criter. -6.880889  
F-statistic 233.1121 Durbin-Watson stat 2.482571  
Prob(F-statistic) 0.000000  

---

Dependent Variable: UKX_RETURN  
Method: Least Squares  
Date: 04/10/13 Time: 11:57  
Included observations: 649

<table>
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<th>Prob.</th>
</tr>
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<tbody>
<tr>
<td>NKY_RETURN</td>
<td>0.120202</td>
<td>0.030487</td>
<td>3.942694</td>
<td>0.0001</td>
</tr>
<tr>
<td>C</td>
<td>-0.000599</td>
<td>0.000547</td>
<td>-1.093750</td>
<td>0.2745</td>
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R-squared     0.023462 Mean dependent var -0.000765  
Adjusted R-squared 0.021953 S.D. dependent var 0.014055  
S.E. of regression 0.013990 Akaike info criterion -5.710764  
Sum squared resid 0.125009 Schwarz criterion -5.696973  
Log likelihood 1855.143 Hannan-Quinn criter. -5.705415  
F-statistic 15.54483 Durbin-Watson stat 2.034645  
Prob(F-statistic) 0.000089

---

66 of 87
Dependent Variable: SPX_RETURN
Method: Least Squares
Date: 04/10/13   Time: 11:59
Sample: 10/10/2002 8/07/2007
Included observations: 1206

<table>
<thead>
<tr>
<th>Variable</th>
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<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NKY_RETURN</td>
<td>0.063216</td>
<td>0.018765</td>
<td>3.368777</td>
<td>0.0008</td>
</tr>
<tr>
<td>C</td>
<td>0.000508</td>
<td>0.000243</td>
<td>2.093049</td>
<td>0.0366</td>
</tr>
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R-squared          0.009338  Mean dependent var 0.000552
Adjusted R-squared 0.008515  S.D. dependent var 0.008449
S.E. of regression 0.008413  Akaike info criterion -6.716466
Sum squared resid  0.085213  Schwarz criterion -6.708017
Log likelihood     4052.029  Hannan-Quinn criter. -6.713284
F-statistic        11.34866  Durbin-Watson stat 2.227949
Prob(F-statistic)  0.000779

Assumptions

Heteroskedasticity Test: White

<table>
<thead>
<tr>
<th></th>
<th>F-statistic</th>
<th>Prob. F(2,1203)</th>
<th>Ob*R-squared</th>
<th>Prob. Chi-Square(2)</th>
<th>Scaled explained SS</th>
<th>Prob. Chi-Square(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.700223</td>
<td>0.4967</td>
<td>1.402306</td>
<td>0.4960</td>
<td>3.389628</td>
<td>0.1836</td>
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New analysis

Dependent Variable: SPX_RETURN
Method: Least Squares
Date: 04/12/13   Time: 09:47
Sample: 10/10/2002 8/07/2007
Included observations: 1206
White heteroskedasticity-consistent standard errors & covariance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NKY_RETURN</td>
<td>0.063216</td>
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<tr>
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<td>2.095430</td>
<td>0.0363</td>
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R-squared          0.009338  Mean dependent var 0.000552
Adjusted R-squared 0.008515  S.D. dependent var 0.008449
S.E. of regression 0.008413  Akaike info criterion -6.716466
Sum squared resid  0.085213  Schwarz criterion -6.708017
Log likelihood     4052.029  Hannan-Quinn criter. -6.713284
F-statistic        11.34866  Durbin-Watson stat 2.227949
Prob(F-statistic)  0.000779
Dependent Variable: UKX_RETURN  
Method: Least Squares  
Date: 04/10/13   Time: 12:00  
Sample: 10/10/2002 8/07/2007  
Included observations: 1206

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NKY_RETURN</td>
<td>0.198597</td>
<td>0.020969</td>
<td>9.471092</td>
<td>0.0000</td>
</tr>
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<td>C</td>
<td>0.000564</td>
<td>0.000271</td>
<td>2.081230</td>
<td>0.0376</td>
</tr>
</tbody>
</table>

R-squared     0.069337  
Adjusted R-squared  0.068564  
S.E. of regression  0.009401  
Sum squared resid   0.106400  
Log likelihood     3918.133  
F-statistic        89.70158  
Prob(F-statistic)  0.000000

Assumptions

Heteroskedasticity Test: White

| F-statistic | 2.148486 | Prob. F(2,1203) | 0.1171 |
| Obs*R-squared | 4.292356 | Prob. Chi-Square(2) | 0.1169 |
| Scaled explained SS | 9.995047 | Prob. Chi-Square(2) | 0.0068 |

Corrected for heteroskedasticity

Dependent Variable: UKX_RETURN  
Method: Least Squares  
Date: 04/12/13   Time: 13:34  
Sample: 10/10/2002 8/07/2007  
Included observations: 1206  
White heteroskedasticity-consistent standard errors & covariance

<table>
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<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NKY_RETURN</td>
<td>0.198597</td>
<td>0.022898</td>
<td>8.673100</td>
<td>0.0000</td>
</tr>
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<td>0.000564</td>
<td>0.000272</td>
<td>2.070708</td>
<td>0.0386</td>
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R-squared     0.069337  
Adjusted R-squared  0.068564  
S.E. of regression  0.009401  
Sum squared resid   0.106400  
Log likelihood     3918.133  
F-statistic        89.70158  
Prob(F-statistic)  0.000000
### Financial crisis

Dependent Variable: SPX_RETURN  
Method: Least Squares  
Date: 04/10/13   Time: 12:04  
Included observations: 411

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
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<td>-0.000437</td>
<td>0.000985</td>
<td>-0.443448</td>
<td>0.6577</td>
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R-squared: 0.279825  
Mean dependent var: -0.001216  
S.D. dependent var: 0.023459  
Akaike info criterion: -4.988111  
Schwarz criterion: -4.968556  
Log likelihood: 1027.057  
Hannan-Quinn criter.: -4.980375  
Durbin-Watson stat: 2.803079

---

Dependent Variable: SPX_RETURN  
Method: Least Squares  
Date: 04/10/13   Time: 12:05  
Included observations: 411

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NKY_RETURN</td>
<td>0.053907</td>
<td>0.048162</td>
<td>1.119272</td>
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<td>C</td>
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<td>-1.005202</td>
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R-squared: 0.003054  
Mean dependent var: -0.001216  
S.D. dependent var: 0.023459  
Akaike info criterion: -4.662908  
Schwarz criterion: -4.643353  
Log likelihood: 960.2275  
Hannan-Quinn criter.: -4.655172  
Durbin-Watson stat: 2.452633
Dependent Variable: UKX_RETURN
Method: Least Squares
Date: 04/10/13   Time: 12:06
Included observations: 411

<table>
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<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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<tbody>
<tr>
<td>NKY_RETURN</td>
<td>0.399926</td>
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<td>7.878310</td>
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R-squared                   0.131760
Mean dependent var         -0.001663
Adjusted R-squared       0.129637
S.D. dependent var       0.026495
S.E. of regression     0.024718
Akaike info criterion  -4.557736
Sum squared resid     0.249886
Schwarz criterion    -4.538180
Log likelihood        938.6147
Hannan-Quinn criter.  -4.550000
F-statistic            62.06776
Durbin-Watson stat    2.550247
Prob(F-statistic)      0.000000

After financial crisis

Dependent Variable: SPX_RETURN
Method: Least Squares
Date: 04/10/13   Time: 12:08
Sample (adjusted): 4/01/2009 12/28/2012
Included observations: 938 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
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<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
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<tbody>
<tr>
<td>UKX_RETURN</td>
<td>0.573570</td>
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<td>0.000295</td>
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R-squared                   0.483167
Mean dependent var         0.000673
Adjusted R-squared       0.482615
S.D. dependent var       0.011948
S.E. of regression     0.008594
Akaike info criterion  -6.673320
Sum squared resid     0.069134
Schwarz criterion    -6.662992
Log likelihood        3131.787
Hannan-Quinn criter.  -6.669382
F-statistic            875.0297
Durbin-Watson stat    2.689410
Prob(F-statistic)      0.000000
Dependent Variable: SPX_RETURN
Method: Least Squares
Date: 04/10/13   Time: 12:09
Sample (adjusted): 4/01/2009 12/28/2012
Included observations: 938 after adjustments

<table>
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<tr>
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<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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<tbody>
<tr>
<td>NKY_RETURN</td>
<td>0.031982</td>
<td>0.029333</td>
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<td>C</td>
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<td>1.686881</td>
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</table>

R-squared 0.001268  Mean dependent var 0.000673
Adjusted R-squared 0.000201  S.D. dependent var 0.011948
S.E. of regression 0.011947  Akaike info criterion -6.014553
Sum squared resid 0.133595  Schwarz criterion -6.004226
Log likelihood 2822.826  Hannan-Quinn criter. -6.010616
F-statistic 1.188745  Durbin-Watson stat 2.180237
Prob(F-statistic) 0.275863

Assumptions

Heteroskedasticity Test: White

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<tr>
<th>Statistic</th>
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<th>Prob.</th>
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<tbody>
<tr>
<td>F-statistic</td>
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<td>Obs*R-squared</td>
<td>2.710286</td>
<td>0.2579</td>
</tr>
<tr>
<td>Scaled explained SS</td>
<td>6.424747</td>
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</table>

After adjustments

Dependent Variable: SPX_RETURN
Method: Least Squares
Date: 04/12/13   Time: 09:49
Sample (adjusted): 4/01/2009 12/28/2012
Included observations: 938 after adjustments
White heteroskedasticity-consistent standard errors & covariance

<table>
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<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NKY_RETURN</td>
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<td>0.000391</td>
<td>1.683241</td>
<td>0.0927</td>
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</table>

R-squared 0.001268  Mean dependent var 0.000673
Adjusted R-squared 0.000201  S.D. dependent var 0.011948
S.E. of regression 0.011947  Akaike info criterion -6.014553
Sum squared resid 0.133595  Schwarz criterion -6.004226
Log likelihood 2822.826  Hannan-Quinn criter. -6.010616
F-statistic 1.188745  Durbin-Watson stat 2.180237
Prob(F-statistic) 0.275863
Dependent Variable: UKX_RETURN
Method: Least Squares
Date: 04/10/13   Time: 12:10
Sample (adjusted): 4/01/2009 12/28/2012
Included observations: 938 after adjustments

<table>
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<tr>
<th>Variable</th>
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<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
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R-squared 0.035521
Adjusted R-squared 0.034491
S.E. of regression 0.014228
Sum squared resid 0.189477

Dependent Variable: SPX_RETURN
Method: Least Squares
Date: 04/10/13   Time: 10:41
Included observations: 3204 after adjustments

<table>
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<th>Variable</th>
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<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>UKX_RETURN</td>
<td>0.471629</td>
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<td>35.00835</td>
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</tr>
<tr>
<td>C</td>
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<td>0.000203</td>
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<td>0.7813</td>
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</table>

R-squared 0.276807
Adjusted R-squared 0.276581
S.E. of regression 0.011503
Sum squared resid 0.423706
Log likelihood 9760.976

### SPX_RETURN

**Method:** Least Squares  
**Date:** 04/10/13  
**Time:** 10:42  
**Sample (adjusted):** 3/10/2000 12/28/2012  
**Included observations:** 3204 after adjustments

<table>
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<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NKY_RETURN</td>
<td>0.059202</td>
<td>0.014954</td>
<td>3.958975</td>
<td>0.0001</td>
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<td>0.414568</td>
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</table>

**Statistics:**  
- **R-squared:** 0.004871  
- **Mean dependent var:** 9.84E-05  
- **Adjusted R-squared:** 0.004560  
- **S.D. dependent var:** 0.013525  
- **S.E. of regression:** 0.013494  
- **Akaike info criterion:** -5.772550  
- **Schwarz criterion:** -5.768760  
- **Sum squared resid:** 0.583028  
- **Durbin-Watson stat:** 2.260047  
- **Prob(F-statistic):** 0.000077

### UKX_RETURN

**Method:** Least Squares  
**Date:** 04/10/13  
**Time:** 10:43  
**Sample (adjusted):** 3/10/2000 12/28/2012  
**Included observations:** 3204 after adjustments

<table>
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<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NKY_RETURN</td>
<td>0.240678</td>
<td>0.016173</td>
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</table>

**Statistics:**  
- **R-squared:** 0.064691  
- **Mean dependent var:** 8.90E-05  
- **Adjusted R-squared:** 0.064399  
- **S.D. dependent var:** 0.015087  
- **S.E. of regression:** 0.014593  
- **Akaike info criterion:** -5.772550  
- **Schwarz criterion:** -5.768760  
- **Sum squared resid:** 0.681930  
- **Durbin-Watson stat:** 2.266894  
- **Prob(F-statistic):** 0.000000
### VIX

#### High VIX levels

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NKY_HIGH</td>
<td>0.084034</td>
<td>0.032797</td>
<td>2.562275</td>
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<td>C</td>
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<td>0.000722</td>
<td>-0.201829</td>
<td>0.8401</td>
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</table>

| R-squared      | 0.007746    | Mean dependent var | -0.000183 |
| Adjusted R-squared | 0.006566 | S.D. dependent var | 0.021030 |
| S.E. of regression | 0.020961 | Akaike info criterion | -4.899555 |
| Sum squared resid | 0.369498 | Schwarz criterion | 4.878717 |
| Log likelihood  | 2063.116    | Hannan-Quinn criter. | 4.885648 |
| F-statistic     | 6.565251    | Durbin-Watson stat | 2.317100 |
| Prob(F-statistic) | 0.010572 |

---

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>UKX_HIGH</td>
<td>0.494163</td>
<td>0.041167</td>
<td>12.00385</td>
<td>0.0000</td>
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<tr>
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</table>

| R-squared      | 0.293412    | Mean dependent var | -0.000341 |
| Adjusted R-squared | 0.291376 | S.D. dependent var | 0.027881 |
| S.E. of regression | 0.023470 | Akaike info criterion | -4.660445 |
| Sum squared resid | 0.191147 | Schwarz criterion | 4.638353 |
| Log likelihood  | 815.2477    | Hannan-Quinn criter. | 4.651651 |
| F-statistic     | 144.0925    | Durbin-Watson stat | 2.755344 |
| Prob(F-statistic) | 0.000000 |
### Dependent Variable: UKX_HIGH
**Method:** Least Squares  
**Date:** 04/10/13  **Time:** 11:33  
**Sample:** 1 348  
**Included observations:** 348

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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</thead>
<tbody>
<tr>
<td>NKY_HIGH</td>
<td>0.417794</td>
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<td>-0.007275</td>
<td>0.9942</td>
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</tbody>
</table>

- **R-squared:** 0.121784  
- **Mean dependent var:** -0.000396  
- **S.D. dependent var:** 0.030593  
- **Akaike info criterion:** -4.257315  
- **Schwarz criterion:** -4.235175  
- **Log likelihood:** 742.7727  
- **Hannan-Quinn criter.:** -4.248501  
- **F-statistic:** 47.98051  
- **Durbin-Watson stat:** 2.392354

### Low VIX levels
**Dependent Variable:** SPX_LOW  
**Method:** Least Squares  
**Date:** 04/10/13  **Time:** 11:39  
**Sample:** 1 1445  
**Included observations:** 1445

<table>
<thead>
<tr>
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<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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<tbody>
<tr>
<td>UKX_LOW</td>
<td>0.380662</td>
<td>0.019362</td>
<td>19.66051</td>
<td>0.0000</td>
</tr>
<tr>
<td>C</td>
<td>0.000160</td>
<td>0.000170</td>
<td>0.941007</td>
<td>0.3469</td>
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</tbody>
</table>

- **R-squared:** 0.211275  
- **Mean dependent var:** 0.000393  
- **S.D. dependent var:** 0.007255  
- **Akaike info criterion:** -7.249588  
- **Schwarz criterion:** -7.242286  
- **Log likelihood:** 5239.827  
- **Hannan-Quinn criter.:** -7.246863  
- **F-statistic:** 386.5355  
- **Durbin-Watson stat:** 2.385615

Prob(F-statistic): 0.000000
Dependent Variable: SPX_LOW
Method: Least Squares
Date: 04/10/13   Time: 11:28
Sample: 1 776
Included observations: 776

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<th>Prob.</th>
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<tbody>
<tr>
<td>NKY_LOW</td>
<td>0.028366</td>
<td>0.024529</td>
<td>1.156443</td>
<td>0.2479</td>
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<td>C</td>
<td>0.000414</td>
<td>0.000240</td>
<td>1.722662</td>
<td>0.0853</td>
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R-squared 0.001725  Mean dependent var 0.000435
Adjusted R-squared 0.000435  S.D. dependent var 0.006681
S.E. of regression 0.006680  Akaike info criterion -7.176891
Sum squared resid 2786.634  Hannan-Quinn criter. 0.000000
Durbin-Watson stat 2.085334

Assumptions

Heteroskedasticity Test: White

| F-statistic             | Prob. F(2,773) | 0.8180 |
| Obs*R-squared           | Prob. Chi-Square(2) | 0.8174 |
| Scaled explained SS     | Prob. Chi-Square(2) | 0.6927 |

Dependent Variable: UKX_LOW
Method: Least Squares
Date: 04/10/13   Time: 11:35
Sample: 1 782
Included observations: 782

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<tr>
<th>Variable</th>
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<th>Prob.</th>
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<tbody>
<tr>
<td>NKY_LOW</td>
<td>0.247972</td>
<td>0.027203</td>
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<td>0.0000</td>
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<td>C</td>
<td>0.000471</td>
<td>0.000266</td>
<td>1.773288</td>
<td>0.0766</td>
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R-squared 0.096276  Mean dependent var 0.000637
Adjusted R-squared 0.095117  S.D. dependent var 0.007789
S.E. of regression 0.007409  Akaike info criterion -6.969713
Sum squared resid 2727.158  Hannan-Quinn criter. -6.957790
F-statistic 83.09532  Durbin-Watson stat 2.192733

Heteroskedasticity Test: White

| F-statistic             | Prob. F(2,773) | 0.4754 |
| Obs*R-squared           | Prob. Chi-Square(2) | 0.4744 |
| Scaled explained SS     | Prob. Chi-Square(2) | 0.3579 |
### Gold

#### It-bubble

Dependent Variable: RETURN_SPX
Method: Least Squares
Date: 04/12/13   Time: 11:12
Included observations: 633

<table>
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<tbody>
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<td>-0.306410</td>
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<td>C</td>
<td>-0.000812</td>
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R-squared 0.030789  Mean dependent var -0.000885
Adjusted R-squared 0.029253  S.D. dependent var 0.014558
S.E. of regression 0.129828  Schwarz criterion -5.633761
Sum squared resid 1789.536  Hannan-Quinn criter. -5.642362
Log likelihood 20.04486  Durbin-Watson stat 1.967152
Prob(F-statistic) 0.000009

Dependent Variable: RETURN_UKX
Method: Least Squares
Date: 04/12/13   Time: 11:13
Included observations: 633

<table>
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R-squared 0.001326  Mean dependent var -0.000780
Adjusted R-squared -0.000257  S.D. dependent var 0.014111
S.E. of regression 0.014344  Akaike info criterion -5.647823
Sum squared resid 0.129828  Schwarz criterion -5.633761
Log likelihood 1899.536  Hannan-Quinn criter. -5.642362
F-statistic 20.04486  Durbin-Watson stat 1.967152
Prob(F-statistic) 0.000009
Dependent Variable: RETURN_NKY
Method: Least Squares
Date: 04/12/13   Time: 11:15
Included observations: 633

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<tr>
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<td>0.067336</td>
<td>-0.915325</td>
<td>0.3604</td>
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<tr>
<td>C</td>
<td>-0.000765</td>
<td>0.000561</td>
<td>-1.363914</td>
<td>0.1731</td>
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R-squared: 0.001326  Mean dependent var: -0.000780
Adjusted R-squared: -0.000257  S.D. dependent var: 0.014111
S.E. of regression: 0.0125679  Akaike info criterion: -5.680297
Sum squared resid: 0.125679  Schwarz criterion: -5.666236
Log likelihood: 1799.814  Hannan-Quinn criter.: -5.674836
F-statistic: 0.837820  Durbin-Watson stat: 1.961024
Prob(F-statistic): 0.360371

Between the crisis

Dependent Variable: RETURN_SPX
Method: Least Squares
Date: 04/12/13   Time: 11:19
Sample: 10/10/2002 8/07/2007
Included observations: 1206

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<th>t-Statistic</th>
<th>Prob.</th>
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<tbody>
<tr>
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<td>-0.021297</td>
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R-squared: 0.000767  Mean dependent var: 0.000552
Adjusted R-squared: -0.000063  S.D. dependent var: 0.008449
S.E. of regression: 0.008449  Akaike info criterion: -6.707852
Sum squared resid: 0.085951  Schwarz criterion: -6.699402
Log likelihood: 4046.835  Hannan-Quinn criter.: -6.704670
F-statistic: 0.924218  Durbin-Watson stat: 2.152366
Prob(F-statistic): 0.336563
### Dependent Variable: RETURN_UKX

**Method:** Least Squares  
**Date:** 04/12/13   **Time:** 11:22  
**Sample:** 10/10/2002 8/07/2007  
**Included observations:** 1206

<table>
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<th>Prob.</th>
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<td>RETURN_GOLD</td>
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**R-squared** 0.074367  
**Mean dependent var** 0.000702

**Adjusted R-squared** 0.073598  
**S.D. dependent var** 0.009741

**S.E. of regression** 0.009375  
**Akaike info criterion** -6.499835

**Sum squared resid** 0.105825  
**Schwarz criterion** -6.491385

**Log likelihood** 96.73138  
**Durbin-Watson stat** 2.232314

**Prob(F-statistic)** 0.000000

### Dependent Variable: RETURN_NKY

**Method:** Least Squares  
**Date:** 04/12/13   **Time:** 11:23  
**Sample:** 10/10/2002 8/07/2007  
**Included observations:** 1206

<table>
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<tr>
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<td>7.496401</td>
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**R-squared** 0.044593  
**Mean dependent var** 0.000692

**Adjusted R-squared** 0.043800  
**S.D. dependent var** 0.012915

**S.E. of regression** 0.012629  
**Akaike info criterion** -5.903991

**Sum squared resid** 0.192027  
**Schwarz criterion** -5.895542

**Log likelihood** 96.73138  
**Durbin-Watson stat** 2.079402

**Prob(F-statistic)** 0.000000

### Assumptions

**Heteroskedasticity Test: White**

<table>
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<th>Statistic</th>
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<th>Prob.</th>
</tr>
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<tr>
<td>F-statistic</td>
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<td>0.1056</td>
</tr>
<tr>
<td>Obs*R-squared</td>
<td>4.498969</td>
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</tr>
<tr>
<td>Scaled explained SS</td>
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Dependent Variable: RETURN_NKY
Method: Least Squares
Date: 04/12/13   Time: 11:24
Sample: 10/10/2002 8/07/2007
Included observations: 1206
White heteroskedasticity-consistent standard errors & covariance

<table>
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<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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<tr>
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</table>

R-squared    | 0.044593    | Mean dependent var | 0.000692   |
Adjusted R-squared | 0.043800    | S.D. dependent var | 0.012915   |
S.E. of regression | 0.012629    | Akaike info criterion | -5.903991 |
Sum squared resid  | 0.192027    | Schwarz criterion | -5.895542  |
Log likelihood    | 3562.107    | Hannan-Quinn criter. | -5.900809 |
F-statistic       | 56.19603    | Durbin-Watson stat | 2.079402   |
Prob(F-statistic) | 0.000000    |                      |            |

Financial crisis

Dependent Variable: RETURN_SPX
Method: Least Squares
Date: 04/12/13   Time: 11:26
Included observations: 411

<table>
<thead>
<tr>
<th>Variable</th>
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<th>Std. Error</th>
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<th>Prob.</th>
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<tr>
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<td>0.001160</td>
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R-squared    | 0.000108    | Mean dependent var | -0.001216  |
Adjusted R-squared | -0.002337   | S.D. dependent var | 0.023459   |
S.E. of regression | 0.023486    | Akaike info criterion | -4.659957 |
Sum squared resid  | 0.225604    | Schwarz criterion | -4.640402  |
Log likelihood    | 959.6212    | Hannan-Quinn criter. | -4.652221 |
F-statistic       | 0.044023    | Durbin-Watson stat | 2.401770   |
Prob(F-statistic) | 0.833915    |                      |            |
### Dependent Variable: RETURN_UKX
Method: Least Squares
Date: 04/12/13   Time: 11:27
Included observations: 411

<table>
<thead>
<tr>
<th>Variable</th>
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<th>t-Statistic</th>
<th>Prob.</th>
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<td>0.1469</td>
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R-squared 0.024821  Mean dependent var -0.001663
Adjusted R-squared 0.022437  S.D. dependent var 0.026495
S.E. of regression 0.026196  Akaike info criterion -4.441583
Sum squared resid 0.280663  Schwarz criterion -4.422028
Log likelihood 914.7453  Hannan-Quinn criter. -4.433847
F-statistic 10.41014  Durbin-Watson stat 2.211115
Prob(F-statistic) 0.001354

### Dependent Variable: RETURN_NKY
Method: Least Squares
Date: 04/12/13   Time: 11:28
Included observations: 411

<table>
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<th>Variable</th>
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<th>Std. Error</th>
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<th>Prob.</th>
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<td>-0.960031</td>
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R-squared 0.017135  Mean dependent var -0.000968
Adjusted R-squared 0.014732  S.D. dependent var 0.024048
S.E. of regression 0.023870  Akaike info criterion -4.627554
Sum squared resid 0.233034  Schwarz criterion -4.607999
Log likelihood 952.9624  Hannan-Quinn criter. -4.619819
F-statistic 7.130576  Durbin-Watson stat 2.355724
Prob(F-statistic) 0.007880
### After financial crisis

**Dependent Variable: RETURN_SPX**  
**Method: Least Squares**  
**Date: 04/12/13**  
**Time: 11:32**  
**Sample: 4/01/2009 12/28/2012**  
**Included observations: 938**

<table>
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<tr>
<th>Variable</th>
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<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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<tbody>
<tr>
<td>RETURN_GOLD</td>
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<td>1.482690</td>
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- **R-squared**: 0.016790  
- **Mean dependent var**: 0.000673  
- **Adjusted R-squared**: 0.015740  
- **S.D. dependent var**: 0.011948  
- **S.E. of regression**: 0.011854  
- **Akaike info criterion**: -6.030217  
- **Schwarz criterion**: -6.019889  
- **Log likelihood**: 2830.172  
- **Hannan-Quinn criter.**: -6.026279  
- **F-statistic**: 15.98378  
- **Durbin-Watson stat**: 2.151875  
- **Prob(F-statistic)**: 0.000069

---

**Dependent Variable: RETURN_UKX**  
**Method: Least Squares**  
**Date: 04/12/13**  
**Time: 11:33**  
**Sample: 4/01/2009 12/28/2012**  
**Included observations: 938**

<table>
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<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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<tbody>
<tr>
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<td>0.308370</td>
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- **R-squared**: 0.053507  
- **Mean dependent var**: 0.000660  
- **Adjusted R-squared**: 0.052495  
- **S.D. dependent var**: 0.014480  
- **S.E. of regression**: 0.014095  
- **Akaike info criterion**: -5.683918  
- **Schwarz criterion**: -5.673591  
- **Log likelihood**: 2667.758  
- **Hannan-Quinn criter.**: -5.679981  
- **F-statistic**: 52.91332  
- **Durbin-Watson stat**: 1.955253  
- **Prob(F-statistic)**: 0.000000
**Dependent Variable: RETURN_NKY**

Method: Least Squares

Date: 04/12/13   Time: 11:34

Sample: 4/01/2009 12/28/2012

Included observations: 938

<table>
<thead>
<tr>
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<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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<tbody>
<tr>
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R-squared: 0.003650
Adjusted R-squared: 0.002585
S.D. dependent var: 0.013305
S.E. of regression: 0.013288
Sum squared resid: 0.165276
Akaike info criterion: -5.801748
Schwarz criterion: -5.791420
Log likelihood: 2723.020
Hannan-Quinn criter.: -5.797810

F-statistic: 3.428738
Durbin-Watson stat: 2.305926
Prob(F-statistic): 0.064386

**Assumptions**

Heteroskedasticity Test: White

<table>
<thead>
<tr>
<th>Assumption</th>
<th>F-statistic</th>
<th>Prob. F(2,935)</th>
<th>Obs*R-squared</th>
<th>Prob. Chi-Square(2)</th>
<th>Scaled explained SS</th>
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<tr>
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**Dependent Variable: RETURN_NKY**

Method: Least Squares

Date: 04/12/13   Time: 11:34

Sample: 4/01/2009 12/28/2012

Included observations: 938

White heteroskedasticity-consistent standard errors & covariance

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<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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R-squared: 0.003650
Adjusted R-squared: 0.002585
S.D. dependent var: 0.013305
S.E. of regression: 0.013288
Sum squared resid: 0.165276
Akaike info criterion: -5.801748
Schwarz criterion: -5.791420
Log likelihood: 2723.020
Hannan-Quinn criter.: -5.797810

F-statistic: 3.428738
Durbin-Watson stat: 2.305926
Prob(F-statistic): 0.064386
The whole period

Dependent Variable: RETURN_SPX
Method: Least Squares
Date: 04/12/13   Time: 11:38
Sample: 4/03/2000 12/28/2012
Included observations: 3188

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RETURN_GOLD</td>
<td>0.002624</td>
<td>0.020531</td>
<td>0.127822</td>
<td>0.8983</td>
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<tr>
<td>C</td>
<td>7.25E-05</td>
<td>0.000240</td>
<td>0.302733</td>
<td>0.7621</td>
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</table>

R-squared   0.000005
Adjusted R-squared -0.000309
S.E. of regression 0.013507
Sum squared resid 0.581237
Log likelihood 9200.360

Dependent Variable: RETURN_UKX
Method: Least Squares
Date: 04/12/13   Time: 11:38
Sample: 4/03/2000 12/28/2012
Included observations: 3188

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RETURN_GOLD</td>
<td>0.225072</td>
<td>0.022612</td>
<td>9.953634</td>
<td>0.0000</td>
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<tr>
<td>C</td>
<td>-5.19E-05</td>
<td>0.000264</td>
<td>-0.196635</td>
<td>0.8441</td>
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</table>

R-squared   0.030159
Adjusted R-squared 0.028955
S.E. of regression 0.014876
Sum squared resid 0.705011
Log likelihood 8892.629

### Real return on investment

#### The whole period

Dependent Variable: SPX_CORRECTED  
Method: Least Squares  
Date: 04/15/13   Time: 12:39  
Sample (adjusted): 2000M03 2012M12  
Included observations: 154 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>UKX_CORRECTED</td>
<td>0.785161</td>
<td>0.043353</td>
<td>18.11077</td>
<td>0.0000</td>
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<tr>
<td>C</td>
<td>-0.006661</td>
<td>0.002420</td>
<td>-2.751992</td>
<td>0.0066</td>
</tr>
</tbody>
</table>

| R-squared        | 0.683333    | Mean dependent var | -0.023066 |
| Adjusted R-squared | 0.681250   | S.D. dependent var | 0.049333  |
| S.E. of regression | 0.027852   | Akaike info criterion | -4.310909 |
| Sum squared resid | 0.117913    | Schwarz criterion | -4.271468 |
| Log likelihood   | 333.9400    | Hannan-Quinn criter. | -4.294888 |
| F-statistic      | 328.0000    | Durbin-Watson stat | 1.688313  |

| Prob(F-statistic) | 0.000000    |

#### Assumptions

Heteroskedasticity Test: White

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
<th>Prob.</th>
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<tr>
<td>F-statistic</td>
<td>0.165970</td>
<td>0.8472</td>
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<tr>
<td>Obs*R-squared</td>
<td>0.337792</td>
<td>0.8446</td>
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<tr>
<td>Scaled explained SS</td>
<td>0.362630</td>
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## Corrected for heteroskedasticity

Dependent Variable: SPX_CORRECTED  
Method: Least Squares  
Date: 04/15/13   Time: 12:40  
Sample (adjusted): 2000M03 2012M12  
Included observations: 154 after adjustments  
White heteroskedasticity-consistent standard errors & covariance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>UKX_CORRECTED</td>
<td>0.785161</td>
<td>0.040388</td>
<td>19.44052</td>
<td>0.0000</td>
</tr>
<tr>
<td>C</td>
<td>-0.006661</td>
<td>0.002420</td>
<td>-2.752634</td>
<td>0.0066</td>
</tr>
</tbody>
</table>

R-squared 0.683333  
Adjusted R-squared 0.681250  
S.E. of regression 0.027852  
Sum squared resid 0.117913  
Log likelihood 333.9400  
F-statistic 328.0000

Dependent Variable: SPX_CORRECTED  
Method: Least Squares  
Date: 04/15/13   Time: 12:40  
Sample (adjusted): 2000M03 2012M12  
Included observations: 154 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NKY_CORRECTED</td>
<td>0.540169</td>
<td>0.052632</td>
<td>10.26316</td>
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<tr>
<td>C</td>
<td>-0.023742</td>
<td>0.003066</td>
<td>-7.743753</td>
<td>0.0000</td>
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</tbody>
</table>

R-squared 0.409325  
Adjusted R-squared 0.405439  
S.E. of regression 0.038039  
Sum squared resid 0.219942  
Log likelihood 285.9369  
F-statistic 105.3325

Prob(F-statistic) 0.000000
Dependent Variable: UKX_CORRECTED  
Method: Least Squares  
Date: 04/15/13  Time: 12:41  
Sample (adjusted): 2000M03 2012M12  
Included observations: 154 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NKY_CORRECTED</td>
<td>0.520335</td>
<td>0.058456</td>
<td>8.901353</td>
<td>0.0000</td>
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<td>C</td>
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<td>0.003405</td>
<td>-6.327214</td>
<td>0.0000</td>
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</table>

R-squared       0.342657  Mean dependent var -0.020895
Adjusted R-squared 0.338333  S.D. dependent var 0.051939
S.E. of regression 0.042249  Akaike info criterion -3.477593
Sum squared resid 0.271311  Schwarz criterion -3.438152
Log likelihood   269.7746  Hannan-Quinn criter. -3.461572
F-statistic      79.23409  Durbin-Watson stat 1.842468
Prob(F-statistic) 0.000000