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UNCERTAINTY ALTERING THE STOCK-GOLD CORRELATION

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ABSTRACT

The purpose of this study is to examine the effect of VIX index on stock-gold correlation. The motivation to study this relation relies on previous literature concerning flight-to-quality phenomenon, referring to capital shifting from troubled market to safer markets. This is often observed during crises periods, when uncertainty corners the market and correlations of equity markets are closing unity. This grown uncertainty causes investors to become more risk averse, and to look for alternative investments that would better hold their value in adverse market conditions. Gold is often believed to provide this needed quality and is considered as one of markets primary safe havens.

Markets key measure for uncertainty is VIX index, which is often referred in financial media as the “fear gauge”. In this paper, stock-gold correlation is studied in relation to this uncertainty measure to examine whether uncertainty alters the comovement of stock and gold returns according to flight-to-quality phenomenon. The focus is set on United States markets and the data used runs from 1990 until the beginning of 2014. In the analysis part, first two time varying stock-gold correlation series are created, which are studied in relation to VIX index levels in bootstrapped subgroups. This is followed by regression analyses in which the effect of VIX index on stock-gold correlation during the most uncertain times is emphasized. Finally, VIX changes are studied along with contemporaneous stock and gold return comovements.

The obtained results suggest that stock-gold correlation is negative on average, meaning that gold serves as a hedge for stocks. The relationship between stock and gold returns is also even more negative when VIX is at its highest levels, meaning that the decoupling of returns intensifies in times of increasing uncertainty. The results obtained in regression analyses also support the finding of gold serving as a hedge for stocks. However, regression results also imply that during periods of high uncertainty the decoupling of stock and gold returns weakens as VIX increases. Nevertheless, the effect of VIX still remain negative, implying that gold serves also as a safe haven for stocks in times when uncertainty is at its highest. Weeks of largest VIX increases are in turn accompanied with positive stock-gold correlation, which is however due to very low initial VIX values on the observed weeks.

KEYWORDS: Stock-gold correlation, Flight-to-quality, VIX index, Safe haven, Gold

1. INTRODUCTION

Since the dawn of the new millennium, stock markets all over the world have experienced a number of great declines, and at the same time, volatility has become a defining factor of this era (Hood & Malik 2013). This combination is not however nothing unheard of and several academics have proved stock returns to be negatively related with volatility (Christie 1982; Hood & Malik 2013). In consequence, as investors are interested about the future performance of stock markets, the estimated future volatility is also often of interest of investors. As the probability for poor stock market performance increases, investors are more eager to adjust their portfolios towards safer assets.

The prime measure for estimated future volatility in stock markets is volatility index VIX, which is widely followed throughout the financial world. Therefore VIX index is often referred as the "*fear gauge*", and it is believed to capture the overall sentiment in the markets. (Boscaljon & Clark 2013; Corrado & Miller 2005; Psychoyios, Dotsis & Markellos 2010; Whaley 2000.) Hence, during great stock market declines VIX tends to climb into high levels indicating panic in the markets (Baur & Lucey 2010; Baur & McDermott 2010). Furthermore, VIX is also seen to increase correlations between assets, diminishing the potential benefits of diversification (Psychoyios et al. 2010). So perhaps due to the recent financial distress, a number of academic papers have been published concerning the prediction power of this index (see e.g. Christner 2009; Cohen & Qadan 2010).

As a repercussion of the subprime crisis, the market sentiment has become increasingly fearful of potential catastrophic financial events. Moreover, the ever increasing debt-to-gross domestic product ratios in developed countries, and the liquidity injections provided by central banks, have yet again left people uncertain about the future economic development. (Baur 2013; Boscaljon & Clark 2013.) This has led to situation where investors have grown cautious and forced to look alternatives for stocks which would better hold their value even during the most adverse times (Hood & Malik 2013). This change in preference is caused by the fear of sudden and permanent capital losses, and it makes investors to move from risky assets towards safer assets. The transition described is known as the flight-to-quality phenomenon. (Baur & Lucey 2010; Baur & McDermott 2010; Brocato & Smith 2012.)

A concept closely related to flight-to-quality is safe haven asset. These are assets which hold their value even during the most adverse market conditions, and are often searched when stock markets are facing several negative shocks in a short period of time. (Baur & McDermott 2010.) So as investors are fearful of future negative returns in stocks, they reallocate their assets and tactically rebalance their portfolios towards safer, more tangible, and liquid assets (Boscaljon & Clark 2013). These safer assets preferred by investors are often United States bonds and gold, which are considered as markets primary safe havens (Gulko 2002; Hartmann, Straetmans & de Vries 2004). Baur (2013) suggested that during this new era, gold's role may increase in importance in the eyes of investors, since it is not dependent on any single government and it is free from credit ratings. In addition, gold's price portrays a negative correlation with stock returns, and is hence a great hedging tool against financial losses caused by stock market crisis (Baur & Lucey 2010; Baur & McDermott 2010). This notion is also supported by gold's price increase observed in touch with recent crises in 2008 and 2011, as flight from stocks to gold was experienced (Christner 2009; Dicle, Levendis & Alqotob 2011).

These observations are forming the base for this study, in which the joint performance of stocks and gold is studied in relation to stock market uncertainty. Previous studies concerning gold's safe haven property are mainly restricted on gold returns during crisis periods. In addition, papers concentrating on gold are relatively new, as the first paper formally testing gold's safe haven property was published in 2010 by Baur & Lucey. Since then, a number of papers have been published around this topic but the field of studies is still far from inclusive.

1.1. Purpose of the study

While stock markets have faced a number of great declines and a tremendous amount of volatility during the past decade, the uncertainty has cornered the markets and investors' search for safe havens has intensified (Hood & Malik 2013). Here the uncorrelatedness of gold is highly important quality in ever more correlated markets, causing gold to gain interest among investors (Baur & Lucey 2010; Baur & McDermott 2010). VIX index, on the other hand, is found to provide timing signals for markets to enhance the portfolio performance (Christner 2009; Copeland & Copeland 1999).

The field of studies concerning the relationship between stocks and gold in relation to VIX index is however incomplete, and this paper aims to partly fill this void. Hence the purpose of this study is to examine whether stock-gold correlation varies in relation to VIX index levels. In other words, can uncertainty level give indications about the comovement of stock and gold returns? Additionally, the interest is on whether changes in VIX drive stock and gold returns into opposite directions, and does the magnitude of change count. This is particularly important during the most uncertain times, as stock markets are most likely to provide great negative returns and investors are assumed to adjust their portfolios towards safer assets. Therefore the study also aims to find out if the decoupling of stock and gold returns intensifies at the highest levels of VIX.

1.2. Hypothesis development

The theoretical background presented later in chapter 4 suggests that, during periods of elevated uncertainty investors become increasingly risk averse. This means that they require larger risk premiums per volatility unit. At the same time increased uncertainty, measured with VIX, implies that investors are expecting greater stock market volatility in the near future. Stocks are indeed found to be negatively correlated with VIX, causing investors to look for safer assets during uncertain times, bidding their prices higher.

As proved by Andersson, Krylova & Vähämaa (2008), United States bonds, as markets primary safe haven, have a negative correlation between stocks when VIX rises to its higher levels. Since gold is often considered as markets other primary safe haven, only increasing in importance during the past years, it can be assumed to portray similar patterns in relation to stocks. Building on this assumption the first hypothesis of this study is that stock-gold correlation varies in accordance with VIX levels. Furthermore, an increase in VIX is hypnotized to cause decoupling of stock and gold returns in the immediate future. VIX index effect on stock and gold returns is also hypnotized to intensify when uncertainty is at its highest levels. Finally, this paper studies the hypothesis of largest VIX increases being accompanied with negative contemporaneous stock-gold correlation. More formally, these four hypotheses are stated as follows.

Hypothesis 1: *Stock-gold correlation becomes increasingly negative when moving towards higher VIX index levels.*

Hypothesis 2: *VIX index is negatively related with upcoming stock-gold correlation.*

Hypothesis 3: *The negative effect of VIX index on stock-gold correlation intensifies when VIX index is at its highest quantiles.*

Hypothesis 4: *Greatest weekly increases in VIX are accompanied contemporaneous negative stock-gold correlations.*

1.3. Structure of the paper

The rest of this paper consists of five main chapters. First of these is chapter 2 introducing the commodity gold as an investment, by describing its markets, ways to invest, and how gold has performed in the past. This is followed by chapter 3, which concentrates on volatility index VIX. This common measure for market uncertainty is depicted by its background, computation model, and past behavior, in order to build a solid understanding of the index.

In chapter 4, phenomena of contagion and flight-to-quality are introduced, which are in turn related to concept of safe haven. Markets primary safe haven is United States bonds, and its relationship with stock markets is widely studied. Thus the stock-bond correlation is dealt here more thoroughly, to illustrate the behavior of safe haven assets. The other safe haven of markets is gold, which is left with considerably less attention among academics compared to bonds. However, since gold is the primary asset of interest in this study, its safe haven property is here presented more in detail. The remaining of the chapter draws a link between assets of stocks and gold through a common driver VIX index, creating a base for the analysis part.

The chapter 5 forms the actual analysis part in which two time series are constructed based on S&P 500 stock market index and S&P GSCI Gold Spot – price index to depict the time varying stock-gold correlation. These correlation series are in turn studied in relation to VIX index levels to portray the possible influence of market sentiment on stock-gold correlation. This is followed by regression analyses, which are performed to capture the effect of VIX index on stock-gold correlation, paying particular attention to the safe haven quantiles, since investors are assumed to be more eager to make withdrawals in their portfolios when uncertainty is at its highest. Finally, weekly stock and gold returns are studied in relation to contemporaneous VIX changes. This is to examine whether extensive increases in market uncertainty are causing investors to flee from stocks to gold.

This paper is summarized in the last chapter concluding the results obtained in the analysis part. The most important notions rising from the results are discussed and suggestions for future researches are provided.

2. GOLD AS AN ASSET

Gold is an asset that has been used as a means of exchange for millenniums (Jastram & Leyland 2009: 9). A 17th century mercantilist Sir William Petty claimed gold, among silver and jewels, to be an asset that has a value which is not bound up in time or place. The image of gold being the preserver of value has been embedded deep into the modern mankind, and reinforced by times such as prevalence of gold standard monetary system, and its idea of linking the value of money directly to gold. In addition to general public, a number of nations still count on gold having it in their reserves, enabling them to hedge against exchange rate risks. (Baur & McDermott 2010.) However, even if general public and nations have trust in gold, the opinions among financial media vary from gold being an "ancient relic", to an end of it being a great "each way bet" for investors to hedge against risks of financial losses or inflation (The Economist 2005; The Economist 2009).

In the following pages of this chapter, gold is introduced first from the historical perspective, to illustrate this asset's importance among humans across time. Second part gives an outlook to gold market's supply and demand flows, giving the sense about the size of market in gold investing. This is followed by section in which investment market for gold is broken down to its majority holders. The modes of gold investing are briefly introduced in the second to last section of this chapter before ending the chapter with section concerning gold's price development and notifications about possible drivers behind its price movements.

2.1. History of gold

Within past 6 000 years, gold has been estimated been produced 125 to 150 thousand tons, of which 80 percent is still in circulation whilst the remaining 20 % is believed to be lost at seas. Despite of gold's long history, most of the produced gold is mined during recent history and even 90 percent after mid-19th century. (Schofield 2007: 45–46.) First documented findings of gold date back to ancient Egypt, 3600 years before Christ, when goldsmiths of that time tried to extract gold from other metals by melting. Around 3000 years later, after gold refining had advanced, King Croesus minted world's first gold currency which was universally accepted as a medium of commerce and traded with confidence. (World Gold Council 2011.)

Closing in the modern society, the importance of gold has increased steadily and it has only gained in value amongst people. Gold stabilized its role as a medium of commerce, and in year 1300 in London's Goldsmith's Hall the first hallmarking was established, to guarantee the quality of precious metals. However, gold was still a very scarce resource and all great mines in Europe became exhausted between years 1370 and 1420. This caused decrease in production and an increase in price. Despite the scarcity, the use of gold as a medium of commerce did not diminish. A prime example of this is the record breaking 1.2 million gold coins minted by the Venice Mint in 1422, which proved to be extremely useful due to their lightness, carry of value and easiness to mint. Because of Europe's shortage in gold, Spanish sailed to America in 1511 with an objective, set by their king, to acquire all available gold possible. By carrying out their mission they infamously destroyed both Inca and Aztec civilizations. In similar vein, 300 years later, a gold discovery was made in Sacramento, California, which led people to head to North America in hope of finding gold. This movement is best known as "*The California gold rush*" as 40 000 diggers flocked to California, this being the greatest gold rush of all times. Nearly half a century later, another significant gold discovery was made in South America causing yet another gold rush. From that age onwards South Africa still carries on to become the source of 40 % the world's gold. (World Gold Council 2011.)

In year 1717, Britain's *de facto gold standard* commenced, as government linked its currency to gold with a fixed rate being 77 shillings and ten a half shillings per ounce of gold at the time (Bernstein 2004: 189). Later between years 1870 and 1900, most major countries excluding China, abandoned their bimetallism practices and switched to value their currencies in relation to gold. This practice was carried out until the year 1944, with two exceptions. First Britain temporarily abandoned gold standard for six years at the outbreak of World War I. Second departure occurred as President Roosevelt decided to suspend dollars convertibility to gold in 1933, also forbidding all export of all transactions and private holdings in gold. (World Gold Council 2011.)

As said, the *de facto gold standard* lasted until year 1944, when Bretton Woods conference was held and the post-war monetary system was initiated. The new monetary system was known as the "*Gold Exchange Standard"*, linking US dollars to gold with fixed conversion rate of 35 dollars per gold ounce, simultaneously linking other currencies with fixed terms to United States dollar. This system came to an end in year 1971 as the current President of the USA, Richard Nixon, suspended United States dollars convertibility to gold and the world entered to its current state of floating exchange rates. (World Gold Council 2011.)

More recently, in 1999, first *Central Bank Gold Agreement (CBGA)* was agreed on as 15 European central banks declared gold to remain as one of the a key element in central banks' reserves. Central banks also collectively decided to restrict gold sales at 400 tonnes per year over the following five years. This agreement was renewed twice after year 1999 and the current prevailing agreement is third of its kind and similar to its predecessors in terms and contents. (European Central Bank 2009; World Gold Council 2011.)

2.2. Gold supply and demand

Gold markets can be roughly divided into demand and supply side. Composition of supply side being relatively fixed, the demand side is however constantly changing. The demand side consists of jewellery, industrial, dental, and investment demand. (Baur & McDermott 2010; Schofield 2007: 49; World Gold Council 2011.) While both jewellery and industrial demand are highly dependent on the economic state and the purchasing power of consumers, the investment demand can rather be described as counter-cyclical, meaning that in times of recession gold's investment demand is rising. (Baur & McDermott 2010.) Apart from business and private investment demand, the investment demand of central banks is also to be considered, although it has gone through drastic changes during recent decades. Earlier central banks, among other investors, used gold as a diversifier in their portfolios, and a hedge against changes in economic environment. Though gold was not able to produce enough real returns, and at the moment returns are mainly made by gold leasing. (Schofield 2007: 49.)

The composition of gold demand being constantly changing, the jewellery demand has still traditionally been dominant as can be seen in Figure 1 (Baur & McDermott 2010; Schofield 2007: 49; World Gold Council 2011). Jewellery demand is however extremely sensitive to price changes and its proportion of the total demand has been decreasing since mid-1990. This can be seen to be a result of high gold prices and weakened consumer purchasing power. (Baur & McDermott 2010; Schofield 2007: 49.) For instance, the volume of gold demanded by jewellery dropped 11 % in year 2008 and in the first quarter of 2009 the decline was 24 % compared to previous year respectively. The investment demand of gold has on the other hand soared, especially after the market entrance of exchange traded funds (*ETFs*), and is soon to be the biggest driver in gold demand. In year 2008 investor demand rose 64 % and in first quarter of 2009 investment activity saw a record high, with the demand of ETFs increasing 540 % in year-to-year terms. (Baur & McDermott 2010.)

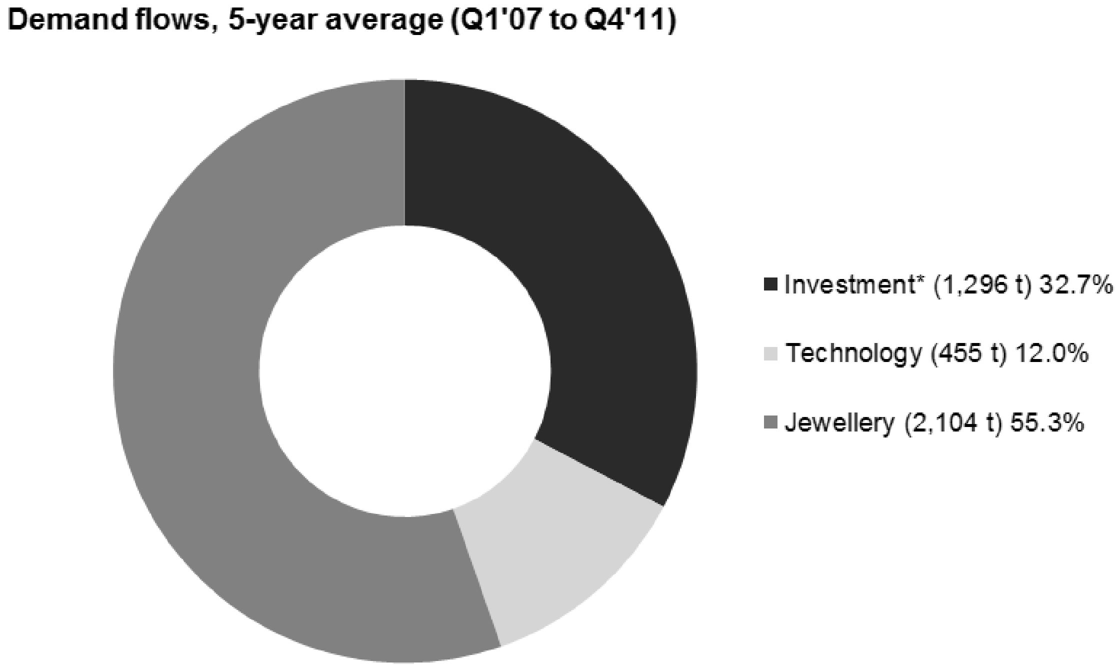

Figure 1. Gold demand's 5-year average reported in tonnes (Investors does not include central banks) (World Gold Council 2012).

Gold's supply is relatively fixed and is made mainly by new gold production, central banks gold reserves and recycled gold (Figure 2) (Schofield 2007: 42). From the year 1980 onwards gold's supply has developed in a way that the proportion of mining gold supply has increased, the importance of central bank gold reserve selling has grown and among risen gold prices the recycling of scrap gold has increased. Hedging against gold's price changes has also become more common, which ads its own contribution to statistical gold supply. The statistical increase in gold supply is partly caused by double counting of the gold which central banks lends forward to investment banks. These investment banks in turn sell the lend gold forward in open markets. In statistics, central banks still have the lent gold, because they are not obligated to announce the amount of gold they have lent to other parties. (Schofield 2007: 46–47.)

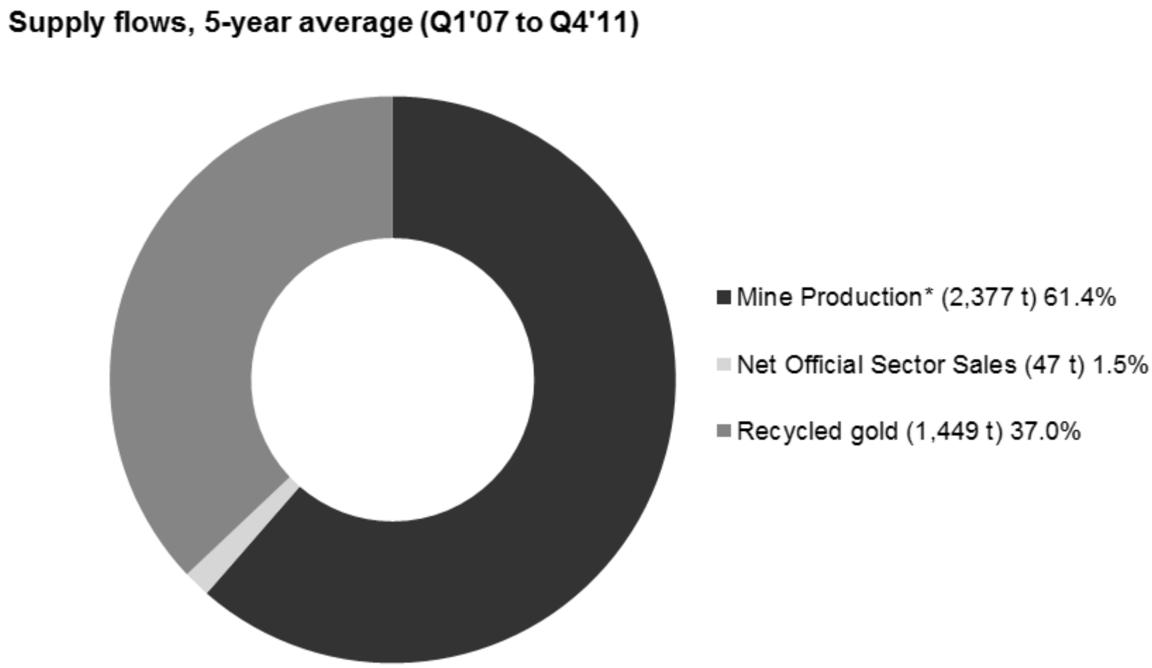

Figure 2. Gold supply's 5-year average reported in tonnes (World Gold Council 2012).

2.3. Main participants of gold market

There are several big market participants in gold markets, which can roughly be divided into public sector, institutional investors, and private gold production such as mining and refining. For the most parts, these big investors are very slow in their movements creating good opportunities for smaller traders to ride the wave created by these colossal players. (Jagerson & Hansen 2011: 37.)

2.3.1. Central banks

The central bank of United States is world's biggest gold owner, but apart from United States, the Western Europe is also strongly present in gold markets. In fact, when summing up gold holdings of Germany, France, and Italy, the amount exceeds the gold holdings of United States. This is also observable in figure 3, which portrays gold holding distribution from year 2007. In recent years, these big gold owners have been net gold purchasers, but if some of these players become a net seller of gold it would strongly effect on gold supply creating downward pressure in gold prices. (Jagerson & Hansen 2011: 46.)

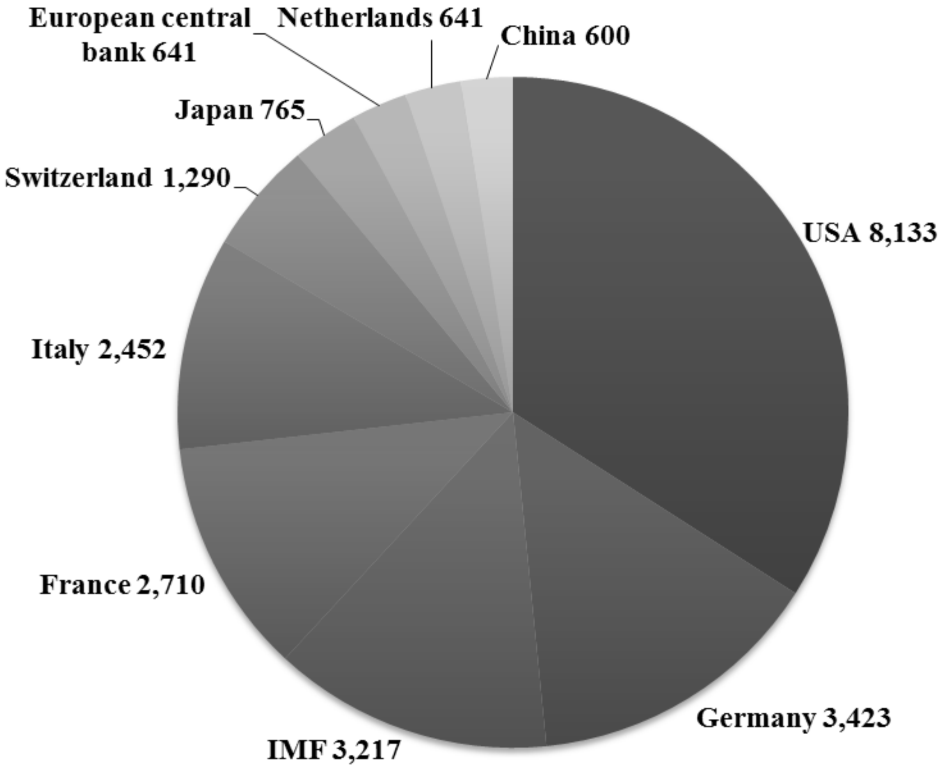

Figure 3. Gold holdings in year 2007, reported in tonnes (Schofield 2007: 49).

Unlike other investors, central banks' acts are driven by politics which makes it difficult to predict their actions (Jagerson & Hansen 2011: 46). For this reason, the biggest central banks have made agreements, in which they control the amount and time span of gold selling. These agreements are though shared with the market, and therefore known among all other investors. (Jagerson & Hansen 2011: 46; Schofield 2007: 49–50.)

The most important of current agreements is called ”*The Third Central Bank Gold Agreement*”, which is signed by central banks of European Union, central banks of Sweden and Switzerland and the International Monetary Fund (IMF). This agreement is valid until September 2014, and it sets a limit of yearly gold selling into 400 tonnes. The agreement was made to ensure that markets are capable of handling the gold supply and to prevent disruptions in gold prices caused by central banks' actions. Agreements are thereby made for the common good. (European Central Bank 2009; Jagerson & Hansen 2011: 47.)

For central banks gold represents an asset which can be used to build trust in money supply and monetary policy actions. However apart from this, there are three primary reasons for central banks to hold gold in their portfolios, first of which is diversification. Gold markets are suitable for official level diversification, because it is one of the largest and most liquid markets. It is one of the few markets, which is large enough to be effective still being relatively independent. (Jagerson & Hansen 2011: 38–46; World Gold Council 2014.) Second reason for central banks to acquire gold is economic independence. Central banks want to be unaffiliated of third party actions and therefore invest in gold. When investing in foreign currencies and bonds, there is always a possibility that their value is being regulated with political actions. One example of this kind of situation is the relation between China and United States, since China owns a billion dollar worth of United States bonds and is forced to buy more if United States issues new bonds to support dollar's value, and therefore its own reserves. One possible way out of this situation is diversifying into gold in the long run. The third reason for owning gold is to hedge against unexpected major losses. Gold is therefore used for the same reason as put-options. If for example United States dollar goes through a speculative attack and its rate plunges, gold would still keep its value in real terms and some of the losses can be avoided. This situation is highly unlikely, but like insurances, gold brings protection in this implausible scenario where currency's value drops dramatically. (Jagerson & Hansen 2011: 38–46.)

2.3.2. International Monetary Fund

Perhaps a bit surprisingly, The International Monetary Fund, is not until third largest gold investor in the world (Jagerson & Hansen 2011: 48). It has several important missions, such as support international exchange rates, provide loans for struggling economies, and stabilize international markets. Nonetheless, all of these acts could be seen to aim for one purpose, that being restoring and creating confidence. (Bordo, Mody & Oomes 2005; Jagerson & Hansen 2011: 48.)

In year 2008, International Monetary Fund adjudicated to sell one-eighth of its gold holdings. This was carried out by offering gold first to other major players in the markets, before trying to sell it to private investors. Gold selling is meant to fund its lending activities and to diversify IMF's own assets. The income received from the gold selling, International Monetary Fund has invested in loans to economies, in order to stabilize the markets. IMF's strategy is to invest the proceeds in growing mature markets for profits that would cover the losses from loans it makes with troubled economies. So far this have not caused any major problems in gold markets, but if International Monetary Fund faces severe losses in bond markets, it may be forced to sell more gold to cover the losses increasing the supply of gold in the markets simultaneously pushing the price of gold lower. (IMF 2013; Jagerson & Hansen 2011: 48–50; Truman 2008.)

2.3.3. Gold funds and exchange traded funds

In year 2004 gold markets changed, when the SPDR Gold Shares ETF was launched. This was a new secure, innovative and easy way to invest in gold. (World Gold Council 2011.) Although, a number of investors still prefer investing in physical gold bullions, these bullion backed ETFs have already raised a major amount of investors. Gold ETFs popularity is based on their easiness, liquidity, and low-cost access to the asset. Due to the market entrance of these gold funds, gold investing has become within the reach of great masses. (Jagerson & Hansen 2011: 51.)

As private and institutional investors' demand for gold rises, funds have acquired more gold to be able to issue more shares. This increased demand has its own contribution to gold's price development. If small and medium size investors keep on hoarding gold and utilizing it to diversify their portfolios, gold's demand stays high. This supports its positive price development and enlarges also the size of the gold funds. (Jagerson & Hansen 2011: 51.)

Gold investment funds and ETFs have become very large market players, despite the fact that they usually do not buy or sell gold very quickly (Jagerson & Hansen 2011: 51). Their combined power in gold markets is however significant. For example SPDR Gold Shares ETF, the biggest gold fund measured in market value, owns 1 244 tonnes of gold, which represents approximately 16 % of United States central banks gold holdings. (Hum 2011; SPDR Gold Shares 2011.)

2.3.4. Private gold production

In gold markets, its producer's role is self-evident. Producing an ounce of gold has been estimated to cost approximately 300 U.S. dollars, why the production of gold can be highly dependent on its market price. During times of high gold prices gold producers mine more low-quality gold, where as in times of lower gold prices producers invest in mining more high-quality gold. In recent decades, the geographic focus of gold production has been shifting steadily from South-Africa and North America, towards Latin America and Russia. (Schofield 2007: 46–47.)

Gold producers have been relatively stable in recent years, and their influence on gold prices has been mainly positive after year 2000, when the industry changed its hedging practices against price changes. This change has benefitted market participants in a way that they can now assume gold prices to stay high also in the future. (Jagerson & Hansen 2011: 53–54.)

Jewellery is gold's primary demander, but dental demand and other industries have their shares too (Baur & McDermott 2010). Jewellery industry's gold demand rose between years 1980 and 2006 by over 440 % which represents two-thirds of gold's total demand. During this period the increased gold demand was particularly caused by steady decrease in gold price. However, since mid-90's the jewellery demand has declined from the times of cheap gold. Still jewellery has absorbed the increase in gold supply created by new mine production and central banks' shift from buyers to sellers of gold. (Schofield 2007: 50.)

In times when economy is booming, jewellery industry's demand tends to grow which can lead to increase in gold price. The demand of individuals is highly scattered and thereby hard to measure. For the same reason picking up trends is also quite challenging. The individual investors and retailers often invest in gold via banks or alternatively buy gold bars or coins. The retail investors are also surprisingly active in gold markets and for example in 2010, they bought almost 1 000 tonnes of gold altogether. The gold demand was already strong before the break of financial crisis in 2007, and it can be expected that current issues in Euro-area and lack of economic growth in United States are not at any rate going to change this trend. (Jagerson & Hansen 2011: 53–54.)

2.4. Types of gold investment

When talking about gold, there is a large number of investing opportunities which are cheap, liquid, flexible, and transparent regardless of investors risk tolerance or activity level. Making of comprehensive list of different products would be futile, since new gold products emerge constantly. Because of this, here is presented the most important products of gold investing. (Jagerson & Hansen 2011: 101–102; Kinsman 1990: 139.)

2.4.1. Exchange traded funds

Exchange traded funds (*ETF*) sell shares which can be traded like stocks. They are liquid, efficient, and highly convenient. (Boscaljon & Clark 2013.) Moreover, the overall charges of ETFs are relatively minor. The gold investing ETFs carry some special risk, but they are a great tool for portfolio diversification. Furthermore most of the gold ETFs own the amount of gold that their shares are worth, so investor’s moneys are that way insured. (Jagerson & Hansen 2011: 102; Schofield 2007: 51.)

ETFs are gold markets cheapest way to access the skills of professional management. Their cost-structure is light, because they are passively managed and built to follow the index, meaning that they are not trying to beat the performance of gold with active trading. (Jagerson & Hansen 2011: 102–103.)

The popularity of gold backed ETFs or bullion ETFs is partly based on their liquidity. One example is the world’s largest gold bullion ETF, SPDR Gold Trust ETF, which bullions are currently worth approximately 68.6 billion U.S. dollars. These kinds of ETFs are favored by investors due to the ability to invest in gold with lowest costs. By buying shares, investors do not have to worry for instance, about the costs of storing physical bullions, or their convertibility since ETF shares can be traded like stocks every trading day. (Boscaljon & Clark 2013; Gwilym, Clare, Seaton & Thomas 2011; Jagerson & Hansen 2011: 104–105.)

As problems of ETF investing are discussed, first to mention is indexing error which can be caused by the costs of acquiring gold, managing the inventory, issuing shares, and paying management fees. This difference is nevertheless very small and the alternative option of buying physical gold bullions includes a far greater deal of expenses and risks. Second problem is the transparency of ETFs, meaning that investors may not always have all the information available, that they would have wanted. This problem is anyhow assumed to vanish as new ETFs emerge in the gold markets and the competition matures, leading the transparency becoming a norm. One problem always is the credit risk. In case of a bankruptcy, ETF's shareholders may not have the same rights as they would have as public owned company's stockholders. So even though these ETFs are backed with physical gold their managers may end up in bankruptcy or frauds might occur. Nonetheless this scenario is highly unlikely and the level of risk involved is therefore very low. (Jagerson & Hansen 2011: 105.)

In addition to ETFs investing in physical gold, there are also ETFs which invest in stocks of gold producers. These ETFs are also very liquid and contain a wide diversification, which is nearly impossible for individual investor to replicate without great costs. The gold stock ETFs are however much more volatile compared to bullion ETFs, but in exchange they also come with higher expected returns. (Jagerson & Hansen 2011: 107–109.)

2.4.2. Stocks and derivatives

When talking about gold stocks or gold companies, often is referred to actively gold producing companies or companies that provide gold mining equipment or properties. Largest of these companies are mainly in North America, in which largest stock exchanges these companies are listed. (Jagerson & Hansen 2011: 109–111.) Investing in gold stocks is therefore one of the easiest way to invest in gold, because markets are accessible to all investors and stocks are traded every trading day (Kinsman 1990: 140).

Gold producers' stocks often follow gold's price, but their returns are however much more volatile compared to gold (Gwilym et al. 2011). Gold stocks provide an leveraged exposure to the price of gold, meaning that as gold price increases (decreases) the gold producers' profits will increase (decrease) proportionally (Boscaljon & Clark 2013). Tufano (1998) interviewed gold companies' managers and the results implied, that according to managers a one percent increase in gold price should lead to 3–10 % increase in gold stocks price. Therefore gold stocks can be well applied in portfolio diversification when there is a strong growth potential in gold price. (Jagerson & Hansen 2011: 111–112; Kinsman 1990: 140.)

Gold derivatives on the other hand, are the most speculative form of gold investing due to their high leverage and periodic expiration dates. Using derivatives enables high returns by bearing higher risks. (Kinsman 1990: 140.) However, gold producers often use derivatives, not to obtain high returns, but to hedge against gold price changes. In a simplest way this can mean buying a put option, which gives its holder the possibility to sell a predetermined amount of gold in fixed price in a predetermined date in the future. As for forward and futures contracts, the holder is obligated to conduct a certain amount of gold at fixed price, in a predetermined date in the future. The main difference between forwards and futures is that futures are traded on an organized exchange. Futures also require collateral to be deposited when trade is executed, and the remittance of profits and losses may also take place on an ongoing basis. (Schofield 2007: 2, 59.)

2.4.3. Physical gold

Despite the new possibilities in gold investing, the traditional way of buying gold bars and coins is still very popular. The value of physical gold does not depend on its future cash flows or its possibility to default and gold always has its intrinsic value. (Baur & McDermott 2010.) The downsides of owning physical gold are storage costs and the risks that investor has to bear by storing the gold themselves. (Boscaljon & Clark 2013; Jagerson & Hansen 2011: 133).

One of the modes in physical gold investing is gold coins. It has been the most popular way of gold investing for decades. If the collectible component in its value is not taken into account, the value of coins can be easily determined. Dealers of gold coins will usually sell coins at 4–6 % higher price than their melt value is. The primary reason why individual investors often prefer coins is their convenience and easiness to store. (Jagerson & Hansen 2011: 133–134; Kinsman 1990: 139.)

Another popular way in holding physical gold is buying bullions. It is a fundamental form of gold investing and the standard trading unit for bullion is 400-troy-ounces. The purity of bars can vary from 99.5 percent up to 99.999 percent. (Jagerson & Hansen 2011: 134–135; Kinsman 1990: 139.) When buying gold bullions, investor has to take care of the storage costs and insurances, especially when the amount is large (Boscaljon & Clark 2013). Thus, it is often recommended to buy gold bullions from dealers, who will also offer audited and vaulted storages for the bullions. This way, if gold holdings are decided to be liquidated, investor does not have to deal with shipping issues and selling bullions back to dealer is a lot easier. Even though the dealer has the gold physically, it is still a property of the investor. Therefore if the dealer faces a bankruptcy, it cannot liquidate the bullions that it has in its vaults. (Jagerson & Hansen 2011: 134–135; Kinsman 1990: 139.)

Selling, buying and storing obviously have their own costs which are charged as premiums from investors. These charges are naturally higher than for example charges in ETF's. However now investor really owns the gold in dealer's vaults, where it is audited, secured, and insured. Perhaps because of these properties, investors are willing to pay a little extra just to get some certainty which physical gold owning brings. (Jagerson & Hansen 2011: 135–136.)

2.5. Gold's price development

In the 1950s the price of gold was around 35 U.S. dollars per troy ounce, when the central bank of United States was regulating the gold price. However, during the following decades, as the regulation ended and gold markets could act freely, the true gold price started to reveal. By the year 1980 the gold price had risen up to 850 U.S. dollars per troy ounce. (Schofield 2007: 46.) The price of gold today is not only based on sheer supply and demand as gold is nearly indestructible, and great amounts of gold are stored around the globe. Besides, the true amount of gold in the markets cannot be accurately measured due to leverage in gold supply created by central banks. (Jagerson & Hansen 2011: 51–53.) This means that, in occurrence of a great peak in gold demand the supply of gold could also be increased by using existing gold reserves. One example of this could be from year 2003, when the net amount of gold supplied outgrew the amount of gold demanded despite of which the price of gold kept increasing. The phenomenon behind the price increase was investor's speculative demand and weakened U.S. dollar, which made gold relatively cheap in terms of other currencies. (Schofield 2007: 45.)

Traditionally gold has been used as a hedge against inflation and weakening U.S. dollar. As a result of gold being valued in U.S. dollars, its price varies according to U.S. dollar's value. This makes it possible for investors who have dollar-denominated investments to hedge against exchange rate changes. (Baker & van Tassel 1985; Capie, Mills & Wood 2010; Tandon & Urich 1987.) The price of gold and U.S dollar have been seen portray a very strong positive correlation, and the floating of U.S. dollar against other major currencies creating unstableness to gold price (Ghosh 2004; Sherman 1983; Sjaastad & Scacciavillani 1996). Especially the EUR/USD exchange rate has been seen to strongly correlate between gold and from the beginning of 21st century the positive correlation has been even 0.9, indicating almost perfect linear relation. Therefore gold can even be seen as a currency rather than a commodity. (Schofield 2007: 45.)

Among the effect of U.S. dollar, also macroeconomic factors of United States are found to affect significantly into gold's price (Baker & van Tassel 1985). The gold markets have been noted to be very sensitive to negative macroeconomic news in United States, and to produce higher returns in the occurrence of the negative news. The United States macroeconomic announcements that have been seen to have greatest impact on gold price are relating to employment, gross domestic product, consumer price index, or personal income. (Cai, Cheung & Wong 2001; Christie-David, Chaudhry & Koch 2000.) Sherman (1983) found in his study that employment reports, gross domestic product and personal incomes are affecting in gold markets in two ways. First they sum up the economic activity thus expressing the demand in industry and retail. Secondly they reflect the growth of factor of product incomes, which are transmitted into the demand of different kinds of investment assets, including gold.

In addition to factors mentioned earlier the increased inflation expectations can also be seen in gold price development, and gold has been noticed to be extremely sensitive to changes in real rate. This in combination with gold's acclaimed unique role as a safe haven manifests itself as a counter-cyclical reaction to surprise news (Chua & Woodward 1982; Feldstein 1980; Roache & Rossi 2009). During periods between 1975–1980 and 2001–2007 when gold price has grown the most, negative real rates also prevailed, whereas the 20 year long gold price decline, starting from the 1980, coincided with a period of tight monetary policy. Real rates could be seen to have an effect in gold price changes faced during past years. Between years 1975 and 2009 a strong negative relationship can be seen to exist between gold price movements and real rates. So if in the future real rates are close to zero or even negative, due to central bank's policy, gold price can be assumed to keep on increasing. (Gwilym et al. 2011.) Psychological barriers have been also noticed to affect gold price development and round numbers have been documented to act as psychological barriers and to have an important effect on the conditional mean and variance around these barriers (Aggarwal & Lucey 2007).

During recent decade, a great deal of volatility has been seen in commodity markets. The most widely noted cases are high prices of oil and gold. (Gwilym et al. 2011.) In past few years gold, among other commodities, has increased in value. In March 2008 gold's value has increased 222 % in ten years and after a brief decline it has carried on its uphill path. This dramatic price increase during last few years can be explained by investors growing interest towards gold. The grown interest is in turn a result of emerging need to be protected. This reasserts the perception of gold's role as a store of value. (Baur & McDermott 2010.)

In year 2010 crisis and the fear of inflation kept the price of gold high, and in 2011 gold kept on appreciating (The Economic Times 2011; Regan 2011; World Gold Council 2011). Analytics believe that the lack of economic growth and declining stock prices are going to increase gold's demand as investors are trying to hedge against weak currencies. In 2012 gold price was assumed to rise above a record high 2200 U.S. dollars per troy ounce as Europe struggles with debt issues. (Bloomberg 2011.)

3. VOLATILITY INDEX

Volatility is undoubtedly one of the most important variables in finance and it is a crucial element in many theories and practices, such as asset pricing, portfolio theory, risk management, derivatives investment evaluation, and econometrics (Psychoyios et al. 2010). Implied volatilities are daily reported in financial news and widely followed by investors and finance professionals around the world (Corrado & Miller 2005). The index that marks the future volatility in stock markets is called the volatility index, which is probably better known by the name VIX. The VIX has become a highly popular indicator for stock market uncertainty and it has been said to express fear in the markets, why it also goes by the name "*fear gauge*". It is supposed to forecast stock market's future volatility, which in turn reflects the overall sentiment and nervousness in the markets. (Corrado & Miller 2005; Psychoyios et al. 2010; Whaley 2000.) Due to its wide recognition and information content it is an important topic also in academic financial researches.

In this chapter, a profound introduction to the volatility index is given. Before going to the particular index, the term volatility is introduced both from the historic and forward looking point of view. After explaining the basic idea behind volatility, a background of the volatility index is discussed. This is followed by section concerning VIX index value formation, which is gone through by step-by-step process. The last part of this chapter is describing historic values of VIX and how it has behaved during the past decades.

3.1. Volatility

Volatility is a measure of risk, which describes the uncertainty in asset's returns and how much they vary across time (Cuthbertson & Nitzsche 2001: 751; Rhoads 2011: 2). By plain description, it tells how much the value of an asset has changed. Therefore the bigger the asset's daily price changes are in relation to mean daily changes, the higher the asset's volatility becomes. (Hull 2009: 282–285.) Volatility can either be calculated from historical data or alternatively deriving it from option prices, when it is referred as implied volatility.

3.1.1. Historical volatility

When determining stock's historical volatility, stock prices are usually observed at fixed time intervals. The volatility is calculated using standard deviations of daily prices and presented often in percentages. The standard deviations are obtained by taking square root from the variances of the observations, which measures the amount of spread in a quantitative data set. Volatility can be thus calculated according to equation 1. (Hull 2009: 282–285; Sincich 1992: 97.)

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

where

σ	=	Volatility
n	=	Number of observations
u_i	=	Single observation
$\bar{u}$	=	The mean of u_i.

Volatility is often presented in yearly form, but it can also be calculated for shorter periods. In any case, it is good to understand that the shorter the period, the easier volatility rises to high values. That is why it is important to know whether volatility is presented in monthly or yearly form. (Millers 1992: 60–61.)

3.1.2. Implied volatility

In addition to traditional way of calculating volatility from historical data, it is also possible to derive stock's volatility from its option prices. This forward looking volatility is called implied volatility (Kennedy 2010: 120; Millers 1992: 62). Implied volatility has been noticed to provide more precise estimate for stocks' upcoming volatility than standard deviations calculated using historical data (Chiras & Manaster 1978; Latané & Rendleman 1976). To compute implied volatilities, the option pricing model for call option created by Black and Scholes (1973) must be used. This model is as follows in equation 2.

(2) $$c = SN(d_1) - Xe^{-r(T-t)}N(d_2),$$

where

d_1	=	$\frac{\ln\left(\frac{S}{X}\right)+(r+\frac{\sigma^2}{2})(T-t)}{\sigma\sqrt{T-t}}$
d_2	=	$d_1 - \sigma\sqrt{T-t}$
c	=	Price of a call option
S	=	Stocks current price
X	=	Options strike price
r	=	Risk-free interest rate
$T-t$	=	Options time to maturity
σ	=	Volatility.

Thus, it is possible to derive markets' expectation about future volatility when other components in the option pricing formula are known. If the markets are efficient, all relevant information should be included in options' prices. That is why implied volatility should be an unbiased estimate for option's mean volatility during its maturity. (Cuthbertson & Nitzsche: 2001: 260–261; Fleming 1998; Millers 1992: 62.)

3.2. Volatility index backgrounds

VIX is Chicago Board Options Exchanges (*CBOE*) formed volatility index, which is a common measure for investors' uncertainty. Just like other indexes, its value is computed every trading day in real-time basis. Although the difference between VIX and other indices is, that it does not measure prices but volatilities. Volatility index was introduced to public in 1993, with two main purposes in mind. First, it was meant to produce a reliable benchmark for expected short-term market volatility, and second, to form an index upon which volatility options and futures could be written. (Whaley 2008.)

Volatility index expresses investors' expectations about stock market volatility in following 30 days. The index, of which options volatility index was originally based on, was Standard & Poor's 100 index (*S&P 100*). The implied volatilities of options were then calculated in such a way that VIX would represent at-the-money option's volatility of 30 calendar days or 22 trading days. (Brealey, Myers, Allen 2011: 569; Psychoyios et al. 2010; Whaley 2000.)

In September 2003, Chicago Board Options Exchange changed VIX calculation process in two ways, partly based on a study by Demeterfi, Derman Kamal, and Zou (1999). First the index which options it was following changed to Standard & Poor's 500 index (*S&P 500*), because its options had become most actively traded. The second alteration concerned out-of-the-money options, which were now included in the VIX calculation formula. This decision was justified with a notion that these options are seen to contain important information concerning market volatility not fully captured by earlier calculation process. (Dicle et al. 2011; Psychoyios et al. 2010.) Adding more options into the process also makes VIX less sensitive to any single options price changes and vulnerable to manipulation. However it is worth noting that changing the index affected quite little to VIX levels, since S&P 100 and S&P 500 are very similar in their movements and their correlation is near perfect. So in case of ceteris paribus, it is almost irrelevant in risk management perspective which index options are used. Nonetheless, due to option market wideness and liquidity, it is justified to use S&P 500 index options. (Whaley 2008.)

As mentioned before, the value of volatility index is calculated in real-time basis every trading day since year 1993. The history of volatility index though extends until year 1986 when the original volatility index (ticker code VXO) was introduced. In 1993 when VIX was established CBOE provided an opportunity to compare both indexes' values also historically by calculating them back to 1986. By this it was possible to get benchmark values from events such as 1987 market crash (Whaley 2008). Similarly, as the new VIX calculation method was based on 2003, the preceding values were calculated retrospectively back to the beginning of 90s' using the new method (Boscaljon & Clark 2013). The historical comparability is in fact considered as one of the most important features of VIX, since it enables a comparison of option price movements in relation to volatility. (Chicago Board Options Exchange 2009.)

Before the market crash of 1987, different strike prices and expiration dates formed a volatility surface that was relatively flat as the theory by Black and Scholes (1973) suggests. However after the year 1987 volatility surface has been seen to skew across index markets all around the world. This skewness has often referred as the volatility smile, in which the level of volatility varies as a function of strike price and expiration. In reality the volatility surface is constantly changing and it often takes shape similar to figure 4. (Derman 2003.)

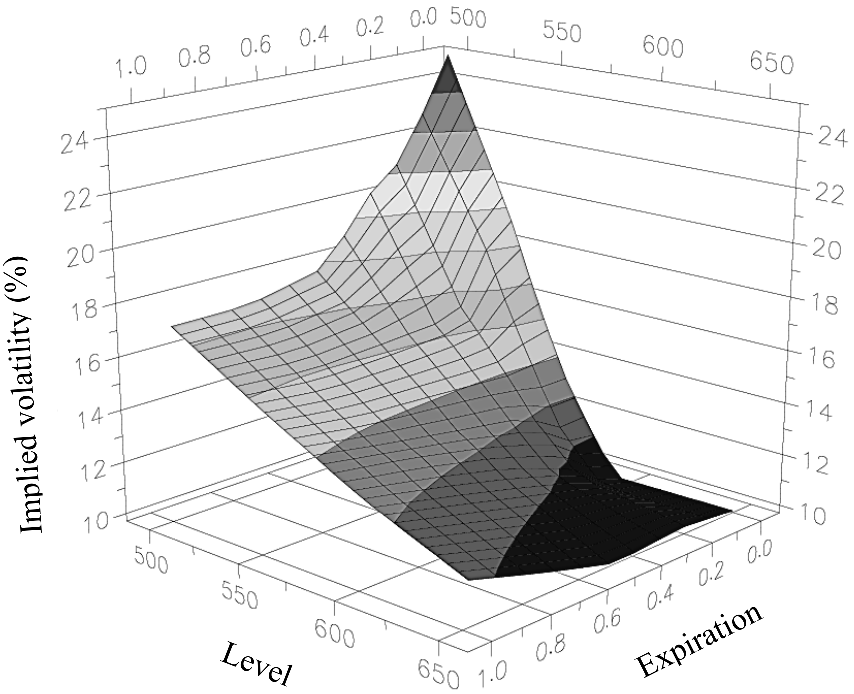

Figure 4. Volatility surface comprised by index options (Derman 2003).

Volatility index has also been criticized for example by Becker, Clements and White (2007), who stated VIX to be incapable of providing any additional information compared to other volatility forecasting models. Additionally, the prediction power of volatility index over future volatility has been questioned and it has been said to contain several weaknesses, which cause predicting errors (Lamoureux & Lastrapes 1993). Cannina and Figlewski (1993) claimed also that historical estimates provide more accurate forecasts about future volatility compared to option implied volatilities. The time period preceding year 1994 has in fact been proved to contain several significant predicting errors, but the prediction power has been seen to improve considerably since year 1994 (Corrado & Miller 2005). Later a numerous studies indicate that VIX is able to predict future volatility and because of this it is closely followed by financial media and practitioners (Boscaljon & Clark 2013).

3.3. Volatility index values formation

When determining the value of indexes such as S&P 500, the price of their component stocks are used. However, here VIX differs from the price indexes as it is comprised of options rather than stocks. These options represent market's best guess about future stock market volatility, although VIX values have often noticed to be slightly greater than realized volatility, due to risk premiums included in option prices. (Chicago Board Options Exchange 2009; Traub, Ferreira, McArdle & Antognelli 2000.) The generalized formula used in VIX calculation is in accordance with equation 3.

(3) $$\sigma^2 = \frac{2}{T}\sum_i \frac{\Delta K_i}{K_i^2} e^{RT} Q(K_i) - \frac{1}{T}\left[\frac{F}{K_0} - 1\right]^2,$$

where

σ	=	VIX/100 => VIX = σ × 100
T	=	Time to expiration
F	=	Forward index level derived from index option prices
K_0	=	First strike below the forward index level, F
K_i	=	Strike price of i[th] out-of-the-money option; a call if $K_i > K_0$ 0 and a put if $K_i < K_0$; both put and call if $K_i = K_0$
ΔK_i	=	$\frac{K_{i+1}+K_{i-1}}{2}$
R	=	Risk-free interest rate to expiration
$Q(K_i)$	=	The midpoint of the bid-ask spread for each option with strike K_i.

VIX measures 30-day expected volatility of the S&P 500 index. It is hence the .risk-neutral expected volatility in timespan between current time point t and future time point $T = t + 30$ (Psychoyios et al. 2010). The components being near- and next term put and call options, which are usually in the first and second S&P 500 contract months. The near term options must have at least one week time to expiration. This is to avoid minimize pricing anomalies, which may occur close to expiration. In the VIX calculation formula, time to maturity is measured in calendar days and each day is divided into minutes in order to get required precision. The risk-free interest rates that are used are United States treasury bills which mature closest to relevant S&P 500 index options. (Chicago Board Options Exchange 2009; Cohen & Qadan 2010.)

Forming the option base in which VIX is calculated, the out-of-the-money call and put options which are centered around at-the-money strike price K_0, are taken into account.

However options quoted with zero bid-prices are excluded. It is to be noticed, that as the volatility rises or falls, the range of strikes also tends to expand or subtract. This means that as volatility rises, bids are made for options of which strike prices are further away from the current value of the index. In consequence, the amount of options included in VIX value formation, may vary even minute-to-minute. (Chicago Board Options Exchange 2009.)

For each contract month, the forward level of S&P 500 index F must be determined by identifying the strike in which the difference between call and put option prices is smallest. Thereby the level of index is determined according to equation 4. (Chicago Board Options Exchange 2009.)

(4) $$F = Strike\ price + e^{RT}(call\ price - put\ price)$$

The strike price K_0 is determined right below the forward index level F for both terms. Choosing the out-of-money put options starts from put strikes below the determined forward index level and moves successively to lower prices until two consecutive strike prices with zero bids are reached. These two strikes and strikes below them are not taken into VIX calculation. Similar process is done with out-of-the-money call options, and the two consecutive zero bid call option strikes and call option strikes above them are not taken into account. Finally at the strike level of K_0, put and call option prices are included. Then for each strike price an average of bid and ask quotations are calculated. (Chicago Board Options Exchange 2009.)

Since volatility index is an amalgam of information reflected in the prices of options included in it, each of the option's contribution to the value of VIX is proportional to ΔK and the price of that option. So it is also inversely proportional to the square of the option's strike price. Generally, ΔK_i is half the difference of the between strikes on either side of K_i. Calculating option values at both upper and lower edges, ΔK_i is simply the difference between K_i and its adjacent strike price. For example, if the lowest strike for the put option is 400 and second lowest being 425, then $\Delta K_{400\ put} = 425 - 400 = 25$. Therefore this particular options contribution to volatility index value is calculated according to equation 5.

(5) $$\frac{\Delta K_{400\ put}}{{K^2}_{400\ put}} e^{RT_1} Q(400\ put)$$

For each of the options, the contribution is calculated in a similar manner. Then sum of the contributions is calculated for both terms, which are then multiplied with factor $2/T_{1,2}$. This step is followed by equation 6, forming the value for the given term. (Chicago Board Options Exchange 2009.)

(6) $$\frac{1}{T}\left[\frac{F}{K_0}-1\right]^2$$

Applying the generalized formula of VIX calculation, the received values can be set into following equations (equations 7 and 8), to solve the expected volatilities for each term. (Chicago Board Options Exchange 2009.)

(7) $$\sigma_1{}^2=\frac{2}{T_1}\sum_i\frac{\Delta K_i}{K_i^2}e^{RT_1}Q(K_i)-\frac{1}{T_1}\left[\frac{F_1}{K_0}-1\right]^2$$

(8) $$\sigma_2{}^2=\frac{2}{T_2}\sum_i\frac{\Delta K_i}{K_i^2}e^{RT_2}Q(K_i)-\frac{1}{T_2}\left[\frac{F_2}{K_0}-1\right]^2$$

Finally the volatility index value can be determined according to equation 9. Here the square root is taken from 30-day weighted averages of both terms volatilities and multiplied by hundred.

(9) $$VIX=100\times\sqrt{\left\{\sigma_1{}^2T_1\left[\frac{N_{T_2}-N_{30}}{N_{T_2}-N_{T_1}}\right]+\sigma_2{}^2T_2\left[\frac{N_{30}-N_{T_1}}{N_{T_2}-N_{T_1}}\right]\right\}\times\frac{N_{365}}{N_{30}}},$$

where
N_{T_1} = Number of minutes to settlement of the near-term options
N_{T_2} = Number of minutes to settlement of the next-term options
N_{30} = Number of minutes in 30 days (30 × 1,440 = 43,200)
N_{365} = Number of minutes in a 365-day year (365 ×1,440 = 525,600).

When the near-term options have less than 30 days to expiration and next-term options more than 30 days, the resulting VIX value reflects an interpolation of $\sigma_1{}^2$ and $\sigma_2{}^2$. In this case the weights of the options are varying between 0 and 1, and the sum of the weights is exactly 1. At the time of volatility index "rollover", both terms' options have more than 30 days to expiration. In this case volatility index value is an extrapolation of $\sigma_1{}^2$ and $\sigma_2{}^2$. The weights can now be also negative or greater than 1, but they always sum up to 1. It is for example possible that the weight of the near term is 1.25 whilst the next term is -0.25. (Chicago Board Options Exchange 2009.)

3.4. Behavior of the volatility index

Markets' expectation about stock market's future volatility varies across time. For example the general economic state effects on companies future revenues, and thus stock prices. (Cuthbertson & Nitzsche 2001: 260–261.) Naturally the option markets are also affected by general economic state. As uncertainty about the future rises, investors feel the need to hedge against sudden dramatic price changes, which increases the demand of options. Implied volatility reacts to option market's demand in a way that, the buying of options increases implied volatility as the selling of options decreases it. Thus increased option prices are often causing increased volatility index values. (Dicle et al. 2011; Rhoads 2011: 2–3.)

An example of implied volatility changes could be companies' quarterly earnings reports, which often have a strong effect on stock prices. This is due to event's information content concerning company's profits and business prospects. Stock prices often fluctuate around these events which can also be seen in the option markets. Options tend to react in advance to these kinds of information events which can be seen in options increased demand leading to elevated prices. After quarterly earnings report, or any important information event, the risk of major price changes in stock prices drops leading options to become cheaper. This drop in price is due to lower implied volatility. (Rhoads 2011: 2–3.) From the behavioral point of view, implied volatilities can be assumed to be highest when market movements are likely to cause greatest shock and awe (Derman 2003).

When looking at the historic levels of VIX, it is easy to extract abnormal behavior from the normal, more modest values. Between years 2004 and 2013 the median value for VIX is 20.17, standard deviation being 9.90. As you can see from table 1, the differences between years are significant. Widest range within a year was observed in 2008, as VIX was moderate 16.3 at lowest, but reaching its peak at 80.86. The standard deviation in that particular year was also far from ordinary standing at 16.38, whereas only two years earlier it was only 2.25. This well depicts VIX index behavior in relation to the state of the market and its sentiment. (Chicago Board Options Exchange 2014.)

VIX has been observed to portray a mean reverting behavior during its existence (Hood & Malik 2013). Thus, an essential factor in assessing the market uncertainty is the persistence of extraordinary volatility index levels (Whaley 2008). Psychoyios et al. (2010) observed in their study that VIX is characterized by fast mean reversion especially at high levels. They also noticed VIX to have level effects, meaning that as VIX increases, its volatility increases proportionally. Moreover the VIX jumps are also proportional to the level of VIX. (Psychoyios et al. 2010.)

Table 1. VIX closing values between years 2004-2013 (Chicago Board Options Exchange 2014).

Year	**Number of observations**	**Average**	**Minimum**	**Maxinum**	**Standard deviation**
All	2517	20.17	9.89	80.86	9.90
2004	252	15.48	11.23	21.58	1.92
2005	252	12.81	10.23	17.74	1.47
2006	251	12.81	9.90	23.81	2.25
2007	251	17.54	9.89	31.09	5.36
2008	253	32.69	16.30	80.86	16.38
2009	252	31.48	19.47	56.65	9.08
2010	252	22.55	15.45	45.79	5.27
2011	252	24.20	14.62	48.00	8.14
2012	250	17.80	13.45	26.66	2.54
2013	252	14.23	11.30	20.49	1.74

4. UNCERTAINTY AND FLIGHT-TO-QUALITY PHENOMENON

Investors are constantly seeking gains from diversification to reduce the risk for major losses, which is made possible by imperfect integration of international equity markets (Bai & Green 2010; Chandara, Patrob & Yezegel 2009; Francis, Hasan & Sun 2008). The contagious nature of information aftershocks, accompanied with stock market declines, increase the perceived risk in world's stock markets. This has led investors flee to from troubled market to safer assets. (Brocato & Smith 2012.) Recent developments in world economy, naming especially problems related to sovereign debts in Eurozone, have further highlighted the need of these safer assets (Gorton, Lewellen & Andrew 2012; IMF 2013).

Financial decision-making often involves a trade-off between future risks and asset returns. When defining risks, the emphasis is often on asset volatilities and correlations between securities. These risk measures are however constantly evolving as the economy changes and new information is released. Thus the historical data may not always produce best estimates for future risks. (Capiello, Engle & Sheppard 2006.) Option implied volatility is however seen to be able to predict future volatility, and it has been noticed to be positively related to economic uncertainty (Boscaljon & Clark 2013; Connolly, Stivers & Sun 2005; David & Veronesi 2002).

This chapter focuses on building a theoretical background for the analysis part. The main idea of this chapter is to introduce concepts of flight-to-quality and safe havens. These concepts are tightly related, and arise from the phenomenon of financial contagion, which is presented in the first part of this chapter. The emphasis in contagion part is on adverse market conditions, which threats the financial system equilibrium. This part creates a base for the second part, in which the flight-to-quality phenomenon is introduced. As said, this phenomenon is tied to a concept of safe haven, which is also briefly explained here to ensure the full understanding of the discussed phenomenon. The most famous relationship related to flight-to-quality is between stocks and bonds, which is covered in the third part of this section. This is done to illustrate the whole concept of flight-to-quality.

In remaining part of this chapter, the emphasis is on the studied commodity gold. It is an important asset class, and often considered as markets primary safe haven among United States bonds. Gold's safe haven property is discussed in this section more in detail through previous studies of the area. As for at the very end of this chapter, the relationship between VIX index and stock and gold markets are brought up to build a base for the studied relationship in the analysis part.

4.1. Contagion across markets

Equity market linkages have been observed to increase dramatically during periods of financial turmoil such as stock market crash in 1987, the beginning of the Gulf war, and the Asian financial crisis (Capiello et al. 2006). It is hence common that when stock markets in United States crash, other national stock markets will follow (Gulko 2002). This is due to phenomenon called contagion. It refers to spill-over of financial turbulence from one country to another, and it has been a current topic due to financial market instability in recent years. Contagion can be observed through comovements in exchange rates, stock prices, sovereign spreads and capital flows. (Dornbusch, Park & Claessens 2000).

Stock market crashes are naturally feared by investors and it has been noticed that the frequency of crashes is much higher in emerging markets than in developed countries. This is because of emerging markets are more vulnerable to macroeconomic shocks. The crashes in emerging markets often stay local, but in time to time they evolve first into regional crises, and some even end up to become global crises. This kind of domino effect has been proven to exist, and it is not always the bigger markets that cause disturbance in world's stock markets. This spreading of financial crisis from market to another poses a great threat to financial market equilibrium. To distinct contagion from common interdependence between markets, Markwat, Kole, and van Dijk (2009) define contagion to be the dependence existing after correcting for interdependence. This is because contagion refers only to large or extreme shocks while interdependence exists in all states of the world. (Markwat et al. 2009.)

To put this in other words, crash occurring in market X on a certain day, significantly increases the probability of more severe crash occurring in market Y the following day. Thus the crash in market X can be used as an early warning signal for wider crashes. (Markwat et al. 2009.) Similar findings were made also by Dornbusch et al. (2000), who claimed that financial distress panic spreads contagiously. Local crashes are hence good predictors of upcoming financial turmoil and they should be carefully monitored by investors, even if they are not directly exposed to it (Markwat et al. 2009).

When it comes to transmittance of shocks, in tranquil times they have been seen to transmit through various links, such as financial and trade links. However, during crisis periods the way shocks are transmitted from country to another seem to differ, and the mechanism of transmission has remained partly unknown. Though, some explanations for the increase in risk of sudden spillovers have been suggested. In weaker economies, sudden spillovers are seen to be related to economic fundamentals, macro-similarities, and exposures to certain type of financial agents and associated transmission channels. In addition, the state of international financial system has been seen to affect contagion. (Dornbusch et al. 2000.)

Dornbusch et al. (2000) split contagion into two categories based on the reason of its occurrence. The first category is called fundamentals-based contagion, which explains contagion with real and financial linkages between market economies. Crises can thus transmit through common shocks or global causes, such as commodity price changes or competitive devaluations. An example of this can be a situation, where crisis in one country and devaluates its currency, putting simultaneously pressure to another country's currency, when they are competing in third markets.

In the second category, the behavior of investors and other financial agents is emphasized. Investors can for example act irrationally withdrawing their investments from whole region when crisis occur in one of the region's country, without even considering fundamentals of region's other markets. This irrational behavior can be caused by financial panic, herd behavior, loss of confidence, or an increase in risk aversion. Although, causes can be individually rational, they may still lead to a crisis. (Dornbusch et al. 2000.) Furthermore, it is noticed that investors' behavior is also contagious, and an increased risk aversion might as well transmit from one country to another (Inci, Li & McCarthy 2011). Nevertheless, the presence of contagion is unquestionable and also supported by portfolio investors' actions. Investors such as commercial banks and mutual funds for instance, are noticed to play an important role in contagion by using the so called contagion strategies, in which they utilize contagion by selling assets from one country when crisis hits another. (Dornbusch et al. 2000; Kaminsky, Lyons & Schmukler 2004.)

As a consequence of contagion, the correlations of equity markets are closing unity even if macroeconomic fundamentals would state markets' strong independence. So the existence of contagion greatly diminishes potential benefits of international diversification. (Dornbusch et al. 2010; Gulko 2002; Hasman & Samartin 2008.)

4.2. Flight-to-quality phenomenon

The contagion effect is a great motivation for investors to seek safer assets, which do not suffer from negative effects of contagion. When stock markets are producing negative returns, investors adjust their portfolios by shifting from stocks to assets which would better preserve their value. This transition, from risky to safer assets, is called flight-to-quality phenomenon. (Baur & Lucey 2010; Baur & McDermott 2010; Inci at al. (2011)

Bradley & Taqqu (2005) explain flight-to-quality from statistical point of view, by saying that flight-to-quality from X to Y market exists, when X market's loss tail dependence becomes higher than the dependence at its center. Simply said, it means capital shifting from troubled market to a safer market (Dungey, McKenzie & Tambakis 2009; Inci, et al. 2011). Several academic papers, such as Capiello et al. (2006) and more recently Briére, Chapelle and Szafarz (2012), have found evidence supporting the existence of this phenomenon. These flights are often sudden and they need to be distinguished from a strategic re-allocation of assets, since flight is more tactical and motivated by fear of sudden and permanent capital losses, regardless of portfolios long-run imbalance (Brocato & Smith 2012).

It is suggested that investors make changes to their portfolios, when their funds' performance falls below a certain level. Additionally, investors' liquidity premiums are observed to increase with volatility, indicating heightened risk aversion. Therefore, in extreme market episodes when volatility increases, investors' liquidity premiums required from assets widen and investors face a sudden extreme preference for holding liquid assets. So as poor portfolio performance becomes more likely with increased volatility, investors tend to make withdrawals in their portfolios. (Vayanos 2004.)

Events like financial crisis are often associated with high volatility, accompanied with investors' risk aversion increase (Vayanos 2004). This means that risk premiums per volatility unit increase and investors require greater returns on their investments (Boscaljon & Clark 2013; Inci et al. 2011; Vayanos 2004). During these unusually adverse times, the effect of volatility on liquidity premium can be even convex. This indicates that as volatility increases, assets become increasingly correlated with each other and more negatively correlated with volatility itself. Illiquid assets' prices are thus more sensitive to volatility, and volatility shocks are major drivers behind asset prices in times of inclined uncertainty. Convexity causes probability for withdrawals to grow rapidly when volatility increases, leading to flight-to-quality phenomenon and investors to prefer safer assets. (Vayanos 2004.)

Taking a broader perspective, Caballero and Krishnamurthy (2008) state flight-to-quality episodes to be signs of financial and macroeconomic instabilities, and they can be triggered by unusual events which lead agents to question their world view. These episodes are not only caused by sudden information void concerning future prices and returns, but also uncertainty concerning the whole environment, which in turn increases investors risk aversion (Brocato & Smith 2012; Inci et al. 2011; Caballero & Krishnamurthy 2008). One relatively new example of this could be the terrorist attacks of 9/11, which caused uncertainty to grow rapidly among people, leading regulators to fear that investors would hoard liquidity gridlocking the payment system (Caballero & Krishnamurthy 2008). In these kinds of events, investors' behavior, such as revaluation models, conservatism, and avoiding risky activities, is often due to Knightian uncertainty and not only an increase in risk exposure. The term Knightian uncertainty refers to worst-case scenario which emphasizes tail outcomes and immeasurable risk, causing investors to become more risk averse and to favor safer assets. So uncertainty shocks are often seen to cause flights from risky assets to safer assets. (Caballero & Krishnamurthy 2008.)

4.2.1. Safe havens

As discussed, the correlations between markets are not stabile but instead time varying (Erb, Harvey & Viskanta 1994; Longin & Solnik 2001; Solnik, Boucrelle & Fur 1996). In Europe for instance, the equity markets' correlations have been increasing since the introduction of the euro (Capiello et al. 2006). This poses a problem for investors in times when stock markets' volatility increases and negative returns are to be expected (Boscaljon & Clark 2013). The turn from tranquil to more volatile period can also be very sudden, which requires immediate reactions from investors (Starica & Granger 2005).

This grown interdependence has increased the need for safe havens, especially since the financial market upheaval of 2007. (Baur & Lucey 2010; Baur & McDermott 2010.) Safe haven is an ideal investment in times when uncertainty has cornered the markets (Kaul & Sapp 2006). It is as place for refuge and safety, holding its value even in "stormy weathers" or adverse market conditions. Safe havens are noticed to be sought especially when markets face a number of severe negative shocks in a short period of time. (Baur & McDermott 2010.)

Safe havens increase investors' utility, because they do not lose their value even in most extreme crisis, but instead, they are meant to cover the losses suffered from other asset classes. This means that they are uncorrelated or negatively correlated with stock markets during specific time periods, for example during financial crisis. For clarification, this does not mean that safe havens are uncorrelated or negatively correlated with stock markets on average, but only during certain periods. It is hence possible that in normal times or bullish stock markets, correlation turns positive. Safe havens are often compared to hedges, which in turn are uncorrelated or negatively correlated with stock markets on average, but not necessarily during specific periods of negative stock market returns. So in case like financial crisis, hedges may also decrease in value along with other assets. (Baur & Lucey 2010; Baur & McDermott 2010.)

Both safe havens and hedges can be divided further into categories of strong and weak. Weak safe havens or hedges are uncorrelated with stock markets, as for the strong ones are negatively correlated. The difference is highly significant especially when safe haven's performance during stock market crisis is analyzed. (Baur & McDermott 2010.) By serving as a refuge against adverse market conditions, safe havens increase the stability of capital markets and alleviate the severity and duration of the most extreme market conditions (Baur & Lucey 2010).

4.3. Stock-bond correlation

US bonds have a central role in global capital markets being a reference point for valuation, portfolio design, and financial security in times of tranquility as well as a global safe haven during financial crisis (Gulko 2002). Due to asset allocation and risk management strategies, co-movements of stock and bond markets are often of interest of investors (Andersson et al. 2008).

The linkage between these two asset classes is indeed found to be very strong (Fleming, Kirby & Ostdiek 1998). Earlier, the correlation between stocks and bonds was assumed to be rather constant (Campbell & Ammer 1993; Shiller & Beltratti 1992). However, later numerous academics have noticed this correlation to vary with time, and to be slightly positive in the long run but also to contain periods of negative correlation

(Andersson et al. 2008; Brocato & Smith 2012; Capiello et al. 2006; Connolly et al. 2005; Gulko 2002; Hartmann et al. 2004; Yang, Zhou & Wang 2009). The correlations can also turn from positive to negative very suddenly and this has been observed in several markets. (Andersson et al. 2008).

Before the crash in year 1987, bonds reacted anemically to stock market crashes while gold rallied sharply acting as markets primary safe haven. Afterwards United States' bonds have become markets safe haven of choice, and as financial crises have struck the markets, investors have fled to bonds bidding their prices up. It is thus noticed, that a crash in a stock market is often accompanied with a boom in a bond market, supporting the pre-mentioned flight-to-quality phenomenon (Gulko 2002; Hartmann et al. 2004). This phenomenon is also supported by empirical evidence which suggests that United States bonds have asymmetric volatility responses to price shocks, and that bond markets often react to opposite direction compared to other asset markets. For instance, as emerging stocks are facing negative returns accompanied with heightened volatility, it is often reflected in bond markets by increasing bonds volatility, but their prices as well. (Dungey et al. 2009.) In addition, Hartmann et al. (2004) observed that cross-border flights from stocks to United States bonds are as common as flights within borders, which indicates that United States bonds are also a global safe haven.

A study by Inci et al. (2011), suggest that flight from stocks to United States bonds does indeed exist when returns of stock markets are heading towards their lowest percentiles, but they also made a notion that when stock returns are at their extreme lowest, that being under 1 percentile, flight from stocks to bonds tend to vanish. One possible explanation for this could be the fact that investors may speculate stock markets to correct themselves soon, and hence investors even increase their equity holdings at these times waiting for a recoil. One percentile thus acts as the "*threshold of fear*" after which investors are with less to lose.

In United states, the negative correlations between stocks and bonds have noticed to take place in business cycle turning points, which often refer to crisis times (Brocato & Smith 2012; Schwert 1990). In United Kingdom however, negative correlations are seen during recession while positive correlation prevails during periods of expansion (Guidolin & Timmermann 2005). The relationship between business cycles and stock-bond correlation has also been questioned (e.g. see Jensen & Mercer 2003), but the general opinion is that business cycles are closely related with stock-bond correlation, and in most markets, correlations are proved to be higher during times of expansion compared to those of recession. (Yang et al. 2009).

Relating to adverse market conditions, Gulko (2002) noticed that during high stock market volatilities high excess bond returns are observed, again referring to flight-to-quality. Apart from observed volatility in stock markets, the prevailing uncertainty, measured with VIX, has been proved to affect negatively to stock-bond correlation. This means that as high VIX values are observed in the markets, the returns of stocks and bonds are diverging. (Andersson et al. 2008; Connolly et al. 2005; Li 2002.) To explain this, Andersson et al. (2008) suggest financial market uncertainty and risk assessment to cause risk premiums demanded for stocks to increase greater compared to premiums demanded for bonds, causing flight from stocks to bonds and the divergence of their returns. Similar findings were made by Chordia, Sarkar and Subrahmanyam (2001), who found stock and bond spreads and volume changes to increase during crises, which they explained to be caused by elevated uncertainty leading investors to reallocate their assets. So in other words, due to uncertainty of crises periods, correlations often start to decline supporting flight-to-quality phenomenon, and bad news are seen to have greater effect on stocks than bonds (Brocato and Smith 2012; Capiello et al. 2006; Gulko 2002).

Additionally Connolly et al. (2005) proved stock-bond diversification to be beneficial during times of high stock market uncertainty, due to the aforementioned relation between VIX and stock-bond correlation. They found correlation to have two regimes which vary with VIX, first of them being substantially positive and the other slightly negative. Gulko (2002) also noticed bond prices to increase relative to stock prices after high VIX values. However when stock markets crash, correlation between these assets reverts close to its pre-crash values, while VIX remains at high levels indicating uncertainty still to prevail in the markets (Gulko 2002).

Apart from uncertainty, there is still one major factor behind changes in stock-bond correlation which is related to business cycles, and that is inflation. Conventionally asset prices are assumed to be positively correlated, which is indeed correct in the long run also for stocks and bonds. The comovement is explained by their common component of real interest rate but also news about future excess returns is seen to affect positively to their correlation. (Campbell & Ammer 1993; Fama & French 1989; Shiller & Beltratti 1992.) However, stocks are relatively stable in real terms while long-term bonds are in nominal terms (Andersson et al. 2008; Connolly et al. 2005; Li 2002; Shiller & Beltratti 1992). Therefore, as nominal yields of long-term bonds are often considered to reflect primarily inflation expectations, and as inflation rises, these two income streams can correlate rather differently with nominal discount rates. On the other hand, as stock markets crashed in 1987 in United States, long-term bond prices rose meaning long-term interest rates to decline. This was interpreted to be due to adverse outlook of future corporate profits. So the information carried by interest rates might sometimes offset the negative tendency between stocks and bonds. (Shiller & Beltratti 1992.) The decoupling of stock and bond returns has also been observed in touch with subdued inflation expectations as noticed by Campbell & Ammer (1993) and later by Andersson et al. (2008).

4.4. Gold as a safe haven

Apart from United States bonds, gold is often believed to act as one of the primary safe haven for stock markets, preserving its value in every market condition (Baur & Lucey 2010; Baur & McDermott 2010; Cohen & Qadan 2010). Gold's safe haven property is often explained by its historic linkage to money, and its use as a conventional hedging vehicle against inflation (Baur & Lucey 2010; Baur & McDermott 2010). It may as well be explained by the simple nature of gold market, and investors may consider gold's price components to be more understandable and easier to evaluate (Baur & McDermott 2010; Cohen & Qadan 2010). Gold's intrinsic value as a precious metal, relatively stable supply, and more importantly, the counter-cyclical elements of its demand, are all supporting gold's alleged safe haven status against financial market turbulence (Baur & McDermott 2010).

Few major reasons to prefer gold to bonds these days are the high debt ratios in Europe and United State, growing fear about world economy's negative future development, and the inflation in developing markets. These factors are causing investors to shift to precious metals also in the future. The demand for gold has kept on increasing since the United States decided to keep federal funds rate close to zero, which in comparison, makes gold's possible returns tempting. In addition, the downgrading of the United States credit rating made investors more nervous, and they are desperately seeking for alternative safe havens to park their money into. (Shumsky 2011.)

It is indeed noticed, that as uncertainty rises, investors become unwilling to trade equities causing ambiguousness in asset values. In a similar vein, finance theory suggests that as financial markets are in trouble, investors are in search for substitutes that would better hold their value. (Baur & McDermott 2010; Cohen & Qadan 2010.) Like bonds, gold’s beta is also time varying and positive in the long run. Like bonds, it also contains periods of negative correlations. (Baur 2013; Baur & McDermott 2010.) Similar finding were also made by Baur & Lucey (2010) and Ciner, Gurdgiev & Lucey (2010), who found gold to act as a hedge or a safe haven during periods of stock market declines, as for in bull markets gold is found to be positively correlated with stocks. So gold’s counter-cyclical elements make it an important asset class during stock market downturns (Hiller, Draper & Faff 2006; Sumner, Johnson & Soenen 2010).

As said, gold seems to react positively to negative stock market shocks. Historically gold’s real price was at its highest on year 1980, when its value exceeded 2,000 USD measured with 2008 dollars value. This is said to be an outgrowth of the high inflation levels and growing fear about global recession, caused by oil crises in the 1970’s. The gold price has also increased around the turn of the past decade, as a result of the 2008 financial crises. (Baur & McDermott 2010.) As the uncertainty about the future economic development grows, and negative signals from stock and bond markets have been received, investors have rushed into gold markets in order to protect their wealth (Shumsky 2011).

Baur and Lucey (2010) studied gold’s price reactions to stock market declines of the early 2000’s, and found gold returns to be positive in accompanied with the most extreme stock market declines. The negative stock-gold correlation was even stronger when one day lag was applied on stocks. The safe haven role did not apply in all conditions, but only when the most extreme negative shocks were faced in stock markets. They also noticed gold returns to revert back their pre-crash values within the following 15 days of the crash. In a similar vein Baur and McDermott (2010) studied gold’s price development during specific crisis periods in different markets. They found gold to be a strong hedge for stock markets in Europe and United States, and in most extreme market conditions it also acted as a strong safe haven. A recent study by Hood & Malik (2013) also supported these findings. Results of these studies are also in line with findings of Baur & Lucey (2010) and the flight-to-quality phenomenon.

Again, much like United States bonds, gold return volatility forms an asymmetric reaction between positive and negative returns. This asymmetry can be described to be exceptional compared to volatilities seen in other markets, which is an outgrowth of gold's unique role as a safe haven. It is argued, that investors interpret gold price increases as signals for future uncertainty and negative development in other asset classes, which further increases gold market volatility. Increased volatility in the gold markets is also noticed to further decouple gold and stock prices, and to strengthen their negative correlation during crises. (Baur 2012.)

Additionally, gold has alleged to be safe haven, not only against negative stock market returns, but the volatility as well (Baur & Lucey 2010; Baur & McDermott 2010; Dicle et al. 2011). Since the break of the financial crisis in 2007, gold rallied when stock markets were highly volatile (Baur & McDermott 2010; Dicle et al. 2011). Consequently, the increased stock market volatilities' effect on gold price has been studied recently in a number of papers (e.g. see Baur & Lucey 2010; Baur & McDermott 2010; Dicle et al. 2011; Hood & Malik 2013). Here gold is noticed to co-move with stock markets in times of low stock market volatility, like observed between years 2004 and 2007. As for in times of high stock market volatility, observed for example around millennium, the returns of these two asset classes decouple. (Baur & McDermott 2010.)

More specifically, Baur and McDermott (2010) found that in most markets, gold acts as safe haven when volatility is over 95 percentile, measured with GARCH (1,1) model from world stock market index, but when it reaches the 99th percentile gold's safe haven property applies only in United States and China. In addition, instantaneous feedback between changes in stock market volatility and gold returns was observed and the results suggested that during crisis the lag diminishes totally (Dicle et al. 2011). Baur & McDermott (2010) also noticed stock market volatilities to cluster, which causes that gold's safe haven property is not confined only to specific days of extreme volatilities. However, since high volatility periods include also crisis periods, and after crisis gold is noticed to produce negative returns, gold thus acts as a safe haven for a very specific time period. (Baur & McDermott 2010.) The results found indicate that investors begin to sell gold as market participants regain confidence and volatility is lower. It is thus crucial weather investors hold gold in their portfolios all the time, or do they buy it after stock markets have already faced a negative shock. For the latter case investor's portfolio will lose in value. Gold therefore is a safe haven only when it is needed the most and in bullish stock markets its safe haven property disappears. (Baur & Lucey 2010.)

4.3. The effect of VIX on stocks and gold

In the following, stock and gold market behaviors are introduced in relation to VIX index. This is to create a link between these two assets via common driver. The emphasis is here set on crisis periods, when VIX is at its highest indicating panic in the markets.

4.3.1. VIX driving the stock markets

As noted earlier, Equity market linkages are observed to be significantly stronger in times of financial market turmoil (Capiello et al. 2006). This turmoil is often measured with VIX, which is considered to be markets fear gauge and a good indicator for stock market uncertainty (Connolly et al. 2005). When dramatic increases or decreases are seen in stock markets, investors tend to either buy or sell large amounts of stocks, which will cause fluctuation also in option prices, upon which VIX values are created on (Cohen & Qadan 2010). Therefore, high VIX levels are often observed in touch with strong stock market declines increasing risk premiums required for stocks (Psychoyios et al. 2010). One suggested factor increasing risk premiums is liquidity requirements affecting stock prices, which are further reflected to assets' volatilities. It has also been proven that the diminishing liquidity highly correlates with stock price declines. (Amihud & Mendelson 1987.) For instance, the liquidity risk perceived in the markets is one explanation for the most recent high VIX levels observed during current European sovereign-debt crisis (Christner 2009).

Apart from academics, VIX is used for timing purposes by practitioners. This is because high VIX levels tend to coincide with market bottoms, and seem to indicate "oversold" markets. Thus investors take long positions assuming markets to correct themselves and stocks gain in value. (Banerjee, Doran & Peterson 2007; Giot 2005.) One example of this occurred in 2008 when markets experienced an unparalleled upheaval and fluctuations, which was comparable only to years 1987, 2000–2003 and 1929–1933 (Christner 2009). In October 2008 VIX rocketed and crossed 80, when its normal level is around 20, indicating panic in the markets. These sudden changes in VIX values are indeed seen to be linked with stock market crisis and investors overall sentiment. (Cohen & Qadan 2010.) Furthermore, Christner (2009) claims that VIX could have been used an efficient hedging tool in financial crisis of 2008. This result is also supported by findings of Hood and Malik (2013). In consequence, VIX has fairly become a directional indicator for stocks within past decade, and between years 1990 and 2007 the weekly correlation between VIX and S&P 500 was -0.67, after which the correlation has grown to be even more negative. (Pollard 2012.)

4.3.2. VIX driving the price of gold

Copeland and Copeland (1999) illustrate how investors shift to safer portfolios when uncertainty in stock markets is high. Boscaljon and Clark (2013) proved this to be the case also in gold markets. During crisis periods, when uncertainty prevails, investors tactically shift their portfolios towards gold. Additionally, during the post financial crisis period, large increases in VIX index have triggered investors to shift back to gold markets. (Boscaljon & Clark 2013.)

Uncertainty’s effect on gold markets has caught interest also among other academics, and the causal relation between VIX and gold changes has been studied by Cohen and Qadan (2010). In their whole sample period running from November, 2004 to July, 2009, gold’s price changes cannot be said to be caused by changes in VIX values, but instead the relationship was the opposite way. However, when dividing the sample into two sub periods, by the relative stability of the markets, they noticed that in times of stable market conditions there was a significant bi-directional causality between VIX and gold. In periods with more uncertainty and higher VIX values, as for example during financial crisis in 2008, gold’s price changes were not affected by changes in VIX values, but the relation was again the opposite way. This means that changes in gold price today is affecting tomorrows VIX value. The results however imply that investors still consider gold to be a safe haven in times of high uncertainty. (Cohen & Qadan 2010.) Later Qadan and Yagil (2012) studied the relationship between VIX and gold further, and found them to have a lagged causal relation which means that VIX drives the price changes of gold futures.

As for in paper by Dicle et al. (2011), the financial crisis of 2008 was studied more in detail, and very high VIX values were observed with simultaneous dramatic increases in the price of gold. Therefore, the causal relation of gold and VIX was studied during these specific periods of stock market crisis. Departed from study by Cohen and Qadan (2010), they found VIX and gold to drive one another’s price changes also during stock market crisis periods. During tranquil times however, VIX was found to be driven by changes in gold price. Interestingly, Dicle et al. (2011) also found volatilities in US stocks and gold to have instantaneous correlation comovement. This means that the lag between changes in gold returns and stock market returns vanished. Another interesting notion of the study was that, the correlation between VIX index and gold returns was less negative for stock market crisis subsample, than the correlation calculated using the whole sample. (Dicle et al. 2011.) The found negative correlation is also supported by Baur (2013), who found that VIX and gold are inversely related to each other. However the analysis does not include the most recent years and is referring only to period prior commence of the US subprime crisis in 2007.

Similar to this paper, a recent study by Hood and Malik (2013) examined the stock-gold correlation emphasizing different volatility regimes based on VIX. They found that, during high volatility period between September 12, 2008 and December 2, 2008, gold did not serve as hedge or a safe haven, but instead it had parallel movements with stocks. Therefore, as high volatility regime prevailed in stock markets, they noticed gold’s price to decline along with stock markets. They also found gold and stocks to have a positive correlation during low volatility regimes. In between these extreme volatility periods, gold and stock returns were thus moving to opposite directions. (Hood & Malik 2013.)

5. THE EFFECT OF VIX ON STOCK-GOLD CORRELATION

This chapter is to study the effect of VIX index on stock-gold correlation, and the motivation to study this relation lies on the theoretical background introduced in chapter 4. In short, the study is built on the idea that investors prefer safer assets during times of heightened uncertainty. This is because poor stock market performance becomes more likely during volatile times, and high uncertainty is proved to be linked with great stock market declines (Vayanos 2004; Psychoyios et al. 2010). Stock market crashes are also seen to be contagious by nature, making international diversification between equity markets inefficient (Capiello et al. 2006). Consequently, assets that are often favored by investors during these adverse times are United States bonds and gold, which are acting as markets primary safe havens.

The previous literature concerning these safe havens has mainly concentrated on the relationship between stocks and United States bonds. It is not until after the millennium that gold has gained interest among academics, and more papers concerning the relationship between stock and gold returns have been published. These papers however often concentrate on the causality between stock and gold returns during certain periods of time, leaving their simultaneous comovements in relation to other factors relatively untouched. Therefore, the research of this area is still vastly incomplete. This study is concentrating on the causal relationship between VIX index and stock-gold correlation, paying particular attention on the effect of VIX on stock-gold correlation when VIX is at its highest levels.

This chapter is structured as follows. First the underlying data and sample period used in the analysis are justified, and the most important descriptive statistics are given. This is followed methodology and results parts, in which two stock-gold correlation time series are constructed. These series are categorized under five subgroups based on the prevailing VIX index level, to allow comparison between stock-gold correlations at different states of market uncertainty. After going through the subgroup statistics, two sets of regression analysis are performed to study the effect of VIX index on subsequent stock-gold correlation. First of these regressions is concentrating on the overall effect of VIX on stock-gold correlation, whilst the latter pays particular attention to the effect on periods when uncertainty is at its highest. Finally, stock and gold weekly return correlations are studied in relation to contemporaneous VIX changes by dividing the observations into subgroups based on weekly VIX changes.

5.1. Data and descriptive statistics

To study the effect of VIX index on stock-gold correlation, three time series are needed. First of these time series is S&P 500 index representing stock markets in United States. Second of the studied series is S&P GSCI Gold Spot - price index which follows the price of gold. The final time series is the VIX index, which is a measure for stock market uncertainty. The time span chosen for this study runs from 2.1.1990 until 18.3.2014. This is because VIX values are retrospectively calculated until the beginning of year 1990. All data is obtained from Datastream. Below short descriptions of the indexes are provided to justify the use of these measures.

The emphasis of this study is set on markets of United States, and thus the Standard & Poor's 500 Composite Stock Price Index is used as a measure of stock market performance. For the intelligibility of this paper the index is referred here as S&P 500, by the name more commonly known among general public. This index is a capitalization-weighted index of 500 stocks, intended to be a representative sample of leading companies in leading industries within the United States' economy. Although it focuses on large-cap companies within United States, S&P 500 covers approximately 75 % of United States equities and is thus considered as a good proxy for total markets of the United States. Stocks included in the Index are chosen by the criteria of market size, liquidity, and industry group representation. (S&P Dow Jones Indices 2013a.)

The other asset used in this paper is S&P GSCI Gold Spot Price Index which follows the price of gold. S&P GSCI is widely considered as the leading measure for investable commodity price movements, and its gold spot sub-index provides a publicly available benchmark for COMEX gold future. It is designed to be easy to trade, readily accessible, and a cost efficient tool for gold investing. (S&P Dow Jones Indices 2013b.) In this study, the full name of S&P GCSI Gold Spot Price Index is not used and it is only referred shortly as the price of gold.

The third time series used in the analysis part is the VIX index, which is the measure for market uncertainty. It is introduced more in detail earlier in this paper in chapter 3. In figure 5, the evolutions of S&P 500 and gold price are portrayed accompanied with VIX index development. Descriptive statistics of assets' daily returns and VIX changes are seen in table 2 below the figure.

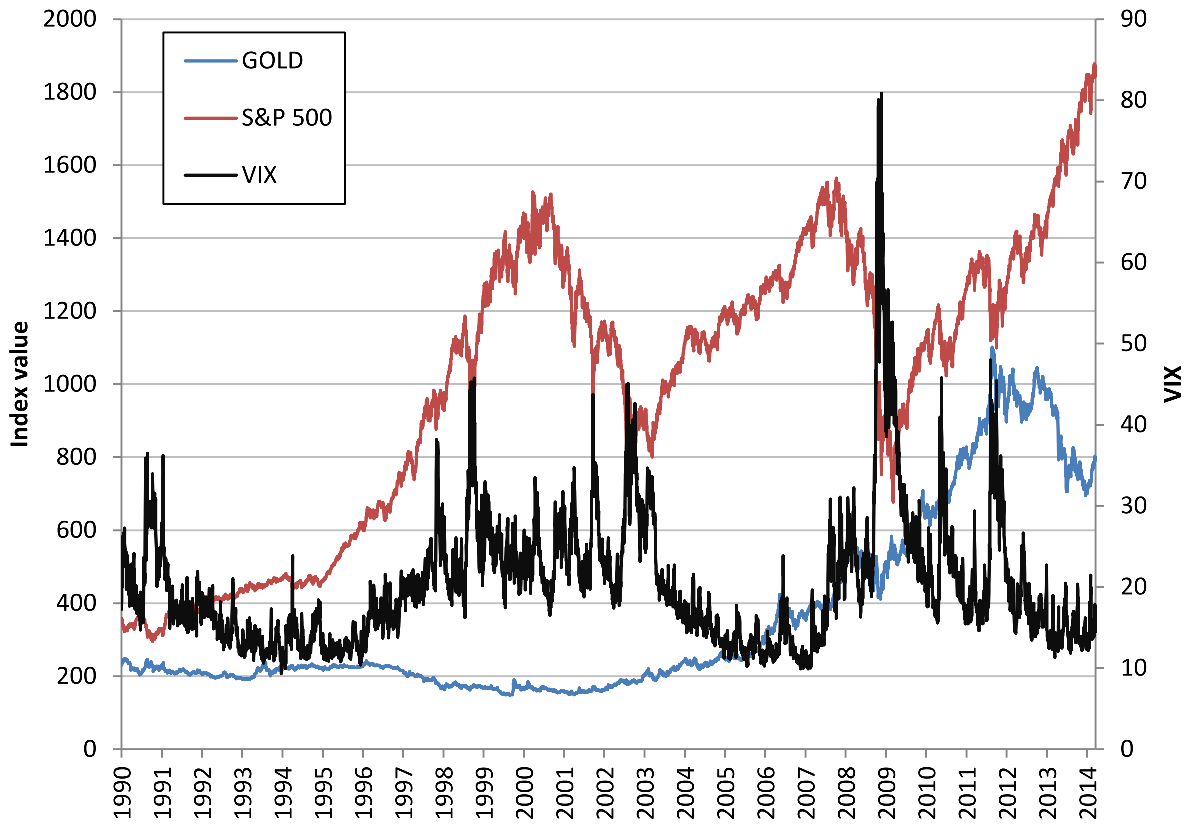

Figure 5. Performance of S&P 500 and Gold prices (measured on left axis) in relation to VIX index development (right axis).

Table 2. Descriptive statistics of S&P 500 and gold daily returns and VIX daily changes during the sample period between 3.1.1990 and 18.3.2014.

	VIX	**S&P 500**	**GOLD**
Mean	0.00%	0.03%	0.02%
Median	– 0.08%	0.02%	0.00%
Maximum	49.60%	10.96%	8.83%
Minimum	– 35.06%	– 9.47%	– 9.81%
Std. Dev.	6.02%	1.13%	1.03%
Skewness	0.67	– 0.24	– 0.30
Kurtosis	7.56	12.04	11.60
Observations	6315	6315	6315

To briefly describe the studied series based on figure 5 and table 2, it can be said that both stocks and gold have increased in value during the sample period. VIX has however kept its level, which is not surprising due to its mean reverting nature. The return series of gold and stocks are negatively skewed, implying that positive returns are more common for both assets. Their standard deviations are also close to each other, staying slightly above 1 %. However, when it comes to VIX index, it is easy to notice that VIX portrays greatest dispersion around its mean. Unlike stocks and gold, it is also positively skewed. The figure 5 also illustrates that VIX can spike very rapidly and its maximum and minimum daily changes are by far the greatest compared to stocks and gold.

5.2. Methodology

Below the methodology used in the analysis of stock-gold correlation in relation to VIX index is presented. Methods are following studies by Andersson et al. (2008) and Connolly et al. (2005), which both studied stock-bond correlation movements in relation to VIX index. Firstly, the following part introduces the formation of time-varying stock-gold correlation series upon which the subgroup analysis is created. After this, descriptions of regression analyses are given. Finally the examination of the magnitude of VIX changes on stock-gold correlation is described.

5.2.1. Time varying stock-gold correlation

In order to test the effect of VIX index on correlation between stock and gold returns, two series of time-varying stock-gold correlations are calculated. The methods chosen for the analysis are following the study by Andersson et al. (2008). First of these methods is 22-day rolling window correlation (RWC). It is calculated according to equation 10, in which the equally weighted covariance estimate over the past 22 trading days is divided by the square root of the product of two assets' 22-day variance estimates. Even if it is fairly simple method, it enables to capture at least some of the time variation and clustering of the stock-gold correlation. Although, this method suffers from the inability to adequately measure the cross-return linkage dynamics, and it adjusts rather slowly to changes in correlation due to equal weighting of the observations. (Andersson et al. 2008.) It is also to be noted, that as correlation estimates are depending on market volatility, an upward bias may occur over periods of market stress (Forbes & Rigobon 2002).

(10) $$\hat{\rho}_t = \frac{\sum_{i=1}^{22} r_{S,t-i}, r_{G,t-i}}{\sqrt{\sum_{i=1}^{22} r^2{}_{S,t-i} \sum_{i=1}^{22} r^2{}_{G,t-i}}},$$

where

$r_{S,t}$ = Stock return on day t

$r_{G,t}$ = Gold return on day t.

The second method to measure the time-varying relationship between two return streams is a simplified multivariate generalized autoregressive conditional heteroskedasticity (GARCH) model proposed by Engle (2002), which is named as dynamic conditional correlation (DCC) model. The benefits of this model are the flexibility of univariate GARCH models and the ability still to provide parsimonious correlation specifications without the computational difficulties that multivariate GARCH models suffer from. (Andersson et al. 2008.) In this study, DCC(1,1) model is used as follows in equation 11, to portray the covariance between stock and gold returns.

(11) $$r_{i,t} = \gamma_i + \emptyset_i r_{i,t-1} + \varepsilon_{i,t}$$

$$\sigma^2{}_{i,t} = \omega_i + \alpha_i \varepsilon^2{}_{i,t-1} + \beta_i \sigma^2{}_{i,t-1}$$

$$\sigma_{ij,t} = \bar{\sigma}_{ij} + \alpha(z_{i,t-1} z_{j,t-1} - \bar{\sigma}_{ij}) + \beta(\sigma_{ij,t-1} - \bar{\sigma}_{ij}),$$

where

$r_{i,t}$ = Asset i's return at time t

$\sigma_{i,t}$ = Conditional volatility of asset i at time t

$\sigma_{ij,t}$ = Covariance between assets i and j at time t

$z_{i,t}$ = $r_{i,t}/\sigma_{i,t}$

$\bar{\sigma}_{ij}$ = Unconditional expectation of the cross product $z_{i,t}\, z_{j,t}$.

First one of the three equations above, is filtering the return series and is specified in the form of an AR(1) process, where the constant is capturing the possible nonzero mean in the time series and the lagged return term is capturing the potential autocorrelation property of returns. The following two equations are the likelihood functions of the DCC model. First of these is the volatility part which is followed by the correlation part. This enables two-stepped estimation process. In the first step, univariate GARCH (1,1) model is estimated for both assets based on the filtered returns received from the first equation. In the second step these variance series received from the first step are used to estimate the last equation. (Andersson et al. 2008.)

5.2.2. Bootstrapped subgroup correlations

Following the study by Connolly et al. (2005), the obtained DCC and RWC series are grouped under five subgroups based on the prevailing VIX index level. The sample observations are thus forming quantiles starting from the lowest 20 % of VIX values and ending into group of highest 20 %. In each group the proportion of observations containing negative stock-gold correlations, mean values with 95 % confidence intervals, and values in 25th, 50th, and 75th percentiles are calculated. This allows the comparison of stock-gold correlations under different uncertainty levels. The data used is weekly data and it is collected on Fridays. The statistical values are bootstrapped, meaning that a number of independent bootstrapping samples are generated from sample observations by random picking, obtaining the same amount of observations as in original sample. Each generated sample will in turn provide individual statistics, upon which bootstrapped sample statistics are calculated on. (Efron & Tibshirai 1993,12–14.) In this study values are based on 1,000 draws with replacement from each respective group.

5.2.3. Regression analyses

In order to study the effect of VIX index on stock-gold correlation more in detail, ordinary least square regressions are performed for both correlation series. However since correlations are naturally restricted to open range between -1 and +1, the correlations cannot be regressed as such and logit transformation needs to be applied in order to allow regressed values to be unrestricted. This method was first introduced by Sir Ronald Fisher (1915), and is also known as the Fisher transformation. It is been proven to be remarkably robust in large sample sizes. In equation 12, the transformation used in regressions is displayed in mathematical form.

(12) $$z = \log\left(\frac{1+\rho_t}{1-\rho_t}\right),$$

where

z = Transformed unrestricted correlation

ρ_t = Correlation at time t.

The data used in all regressions is weekly data obtained on Fridays. Additionally, in all regressions, residual autocorrelations are checked to ensure that the received ordinary least square estimates are really best linear unbiased estimates. The residual autocorrelations are tested with Breusch–Godfrey serial correlation Lagrange multiplier test (Breusch 1978; Godfrey 1978). If test results indicate that regression's error terms are autocorrelated causing estimates' efficiency to become violated, an AR(1) term is added into regression's explanatory variables. This ensures that regression gains smallest possible variance and thus more efficient estimates

First regression analysis is performed following model by Andersson et al. (2008). The lagged VIX variable of the model is however in logarithmic form as suggested by Connolly et al. (2005), to reduce the skewness of the VIX series. The estimated model is as follows in equation 13.

$$(13) \qquad z = \alpha + \beta_1 \ln(VIX_{t-1}) + \varepsilon_t,$$

Based on theoretical background it can be assumed that correlation between stocks and gold becomes increasingly negative in times of high uncertainty, as investors flee from stocks to gold according to flight-to-quality phenomenon. The effect of VIX on stock-gold correlation during times of extreme VIX values is here studied according to regression equation 14. Compared to regression equation 13, here quantile dummies are added in order to extract the effect of most extreme VIX values from the common effect. This equation is following method used by Conolly et al. (2005) with the exception of adding quantile dummies according to study by Hood & Malik (2003).

$$(14) \qquad z = \alpha + (c_1 + c_2 D_{VIX\ 0.90} + c_3 D_{VIX\ 0.95} + c_4 D_{VIX\ 0.99}) \ln(VIX_{t-1}) + \varepsilon_t,$$

5.2.4. VIX changes and the stock-gold return relation

Previous studies suggest that stock returns are negatively related with contemporaneous VIX changes (Fleming, Ostdiek & Whaley 1995). Later Connolly et al. (2005) showed that stock-bond correlation decreases during periods of substantial VIX increases. Following the study of Connolly et al. (2005), a similar analysis is performed with weekly stock and gold returns. Here weekly returns in stocks and gold are categorized under subgroups based on the contemporaneous VIX changes. First of these groups is the lowest 5th percentile of VIX changes referring to greatest declines, while the last group represents the greatest 5 % of VIX increases. Other four groups are formed by VIX change quartiles. Each subgroup statistics consists of stock and gold mean returns, standard deviations, and the stock-gold correlation within a group.

5.3. Results

The following part consists of results of the foregoing methodology part, starting from the resulted stock-gold correlation time series which are first categorized into subgroups to provide an outlook on VIX index levels' effect on stock-gold correlation. This is followed by regression analyses, in which the upcoming stock-gold correlation is regressed with VIX index. Finally subgroups are based on the magnitude of VIX changes and contemporaneous stock gold return correlations are formed.

5.3.1. Time varying correlations

The maximum likelihood estimates for the given DCC model are portrayed in table 3. The estimates found are highly significant and both α and β are positive. The sum of these two estimates remains below unity, which enables model to be mean reverting. Figure 6 illustrates the received conditional correlation series in graphical terms. The graph depicts weekly values for conditional correlation values obtained Fridays. As can be observed, the correlation is not stabile but evolving through time. It often revolves between 0.2 and -0.2, but may also experience rapid and extensive changes as observed for example between years 2010 and 2012. Relatively long periods of sustained negative correlations are also observed, such as the period after April 2002.

Table 3. Maximum likelihood estimates of DCC(1,1) for stocks and gold.

DCC (1,1)						
	γ_S	γ_G	$\emptyset_S$	$\emptyset_G$		
Estimate	0.000 **	0.000	– 0.060 ***	0.002		
t-statistic	2.012	1.542	– 4.776	0.158		
	ω_S	ω_G	α_S	α_G	β_S	β_G
Estimate	0.000 ***	0.000 **	0.070 ***	0.041 ***	0.922 ***	0.960 ***
z-statistic	5.078	2.136	8.512	4.297	119.966	122.230
	α	β				
Estimate	0.029 ***	0.950 ***				
z-statistic	15.482	460.082				

Significance at 10 %, 5 % and 1 % levels are marked *, ** and *** respectively.

In figure 7 the time varying correlation between stocks and gold is portrayed with rolling window correlation results. Trends in both correlations are relatively similar, but rolling window correlation proves to be more volatile and ranges often between 0.6 and -0.6. Changes are even more rapid and drastic compared to dynamic conditional correlation. These notions are also supported by descriptive statistics (table 4). Both series have similar means and medians, which are slightly negative. However, the standard deviation of rolling window correlation is over twice the size of dynamic conditional correlation's.

Table 4. Descriptive statistics of correlations (weekly data).

	DCC	**RWC**
Mean	– 0.045	– 0.048
Median	– 0.053	– 0.068
Maximum	0.503	0.792
Minimum	– 0.538	– 0.799
Std. Dev.	0.143	0.301
Skewness	0.244	0.292
Kurtosis	3.355	2.754
Observations	1263	1263

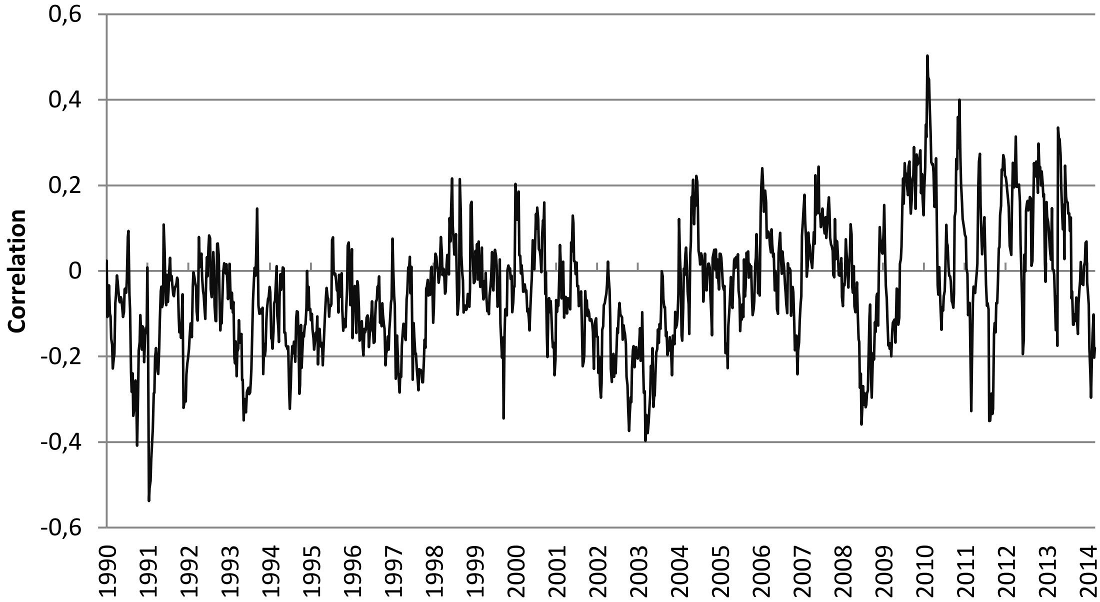

Figure 6. Dynamic conditional correlation between stocks and gold with weekly observations

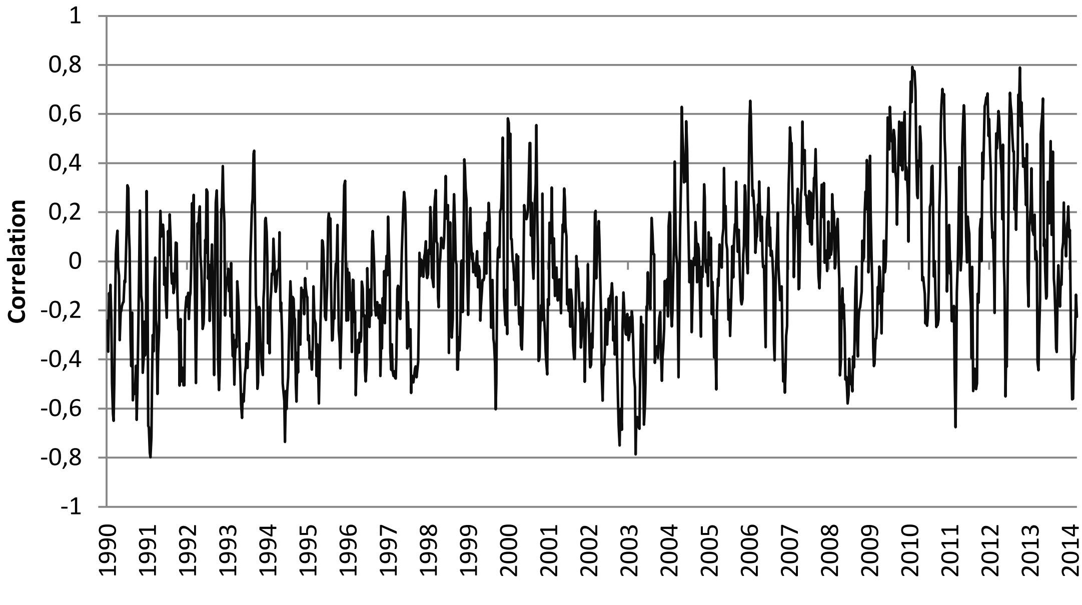

Figure 7. Rolling window correlation between stocks and gold with weekly observations.

5.3.2. Stock-gold correlations in VIX index quantiles

The resulted values of the subgroup analysis seen in table 5 show, that the correlation is negative on average for the whole sample period. Both series' bootstrapped 95 % confidence intervals for the mean are also below zero. When observing the created sub-groups, it can be noticed that the probability for positive correlation becomes more likely when moving from lowest VIX values towards higher VIX percentile groups. This contradicts with the hypothesis 1 stated in section 1.2. The tendency however changes after the subgroup of VIX values between 40th and 60th percentile, where mean correlation for DCC is -0.019 and 0.008 for RWC. In subgroups of higher VIX percentiles, stock-gold correlation depicts a downward sloping trend. The lowest correlations are observed in subgroup of highest VIX values, when correlation mean for DCC is -0.080 and for RWC the value stands at -0.096. Especially for DCC this mean value differs significantly from the mean of the whole sample. This partly supports the first hypothesis. The resulted average correlations with 95 % confidence intervals are also illustrated in graphical terms in figures 8 and 9.

Thus the results in table 5 imply that stock and gold returns are negatively related with each other in general, and in periods of especially low and high VIX values the correlation is even more negative. This supports the notion that gold serves as a strong hedge for stocks, gaining in value as stocks provide negative returns. The results also suggest that the decoupling of returns is strongest as uncertainty is at its highest levels. Furthermore, decoupling is relatively strong in times when VIX reaches its lowest values, which could be due to strong stock market performance. Therefore, it can be said that gold serves as a safe haven for stocks in times preceding the most uncertain times, but stock-gold correlation cannot however be said to continuously decrease with uncertainty.

Table 5. VIX level subgroups and stock-gold return correlation statistics for DCC and RWC methods.

Dynamic Condtitional Correlation (DCC)

VIX Criterion	Obs.	Proportion of Corr. < 0	Correlation Avg.	95 % confidence interval		Median	25th Pctl.	75th Pctl.
All	1263	65.40%	– 0.045	(– 0.053	– 0.037)	– 0.053	– 0.138	0.036
$0-20^{th}$	252	67.38%	– 0.049	(– 0.063	– 0.035)	– 0.056	– 0.127	0.025
$20^{th}-40^{th}$	253	60.43%	– 0.025	(– 0.040	– 0.009)	– 0.032	– 0.115	0.042
$40^{th}-60^{th}$	253	58.51%	– 0.019	(– 0.037	– 0.001)	– 0.027	– 0.131	0.072
$60^{th}-80^{th}$	252	68.00%	– 0.053	(– 0.073	– 0.033)	– 0.053	– 0.161	0.022
$80^{th}-100^{th}$	253	72.60%	– 0.080	(– 0.098	– 0.061)	– 0.088	– 0.170	0.009

Rolling Window Correlation (RWC)

VIX Criterion	Obs.	Proportion of Corr. < 0	Correlation Avg.	95 % confidence interval		Median	25th Pctl.	75th Pctl.
All	1263	59.10%	– 0.048	(– 0.064	– 0.033)	– 0.068	– 0.251	0.148
$0-20^{th}$	252	60.27%	– 0.057	(– 0.091	– 0.023)	– 0.084	– 0.253	0.140
$20^{th}-40^{th}$	253	56.20%	– 0.025	(– 0.060	0.007)	– 0.034	– 0.212	0.138
$40^{th}-60^{th}$	253	52.10%	0.008	(– 0.028	0.044)	– 0.020	– 0.205	0.217
$60^{th}-80^{th}$	252	59.04%	– 0.067	(– 0.108	– 0.026)	– 0.081	– 0.296	0.130
$80^{th}-100^{th}$	253	67.48%	– 0.096	(– 0.133	– 0.061)	– 0.120	– 0.301	0.070

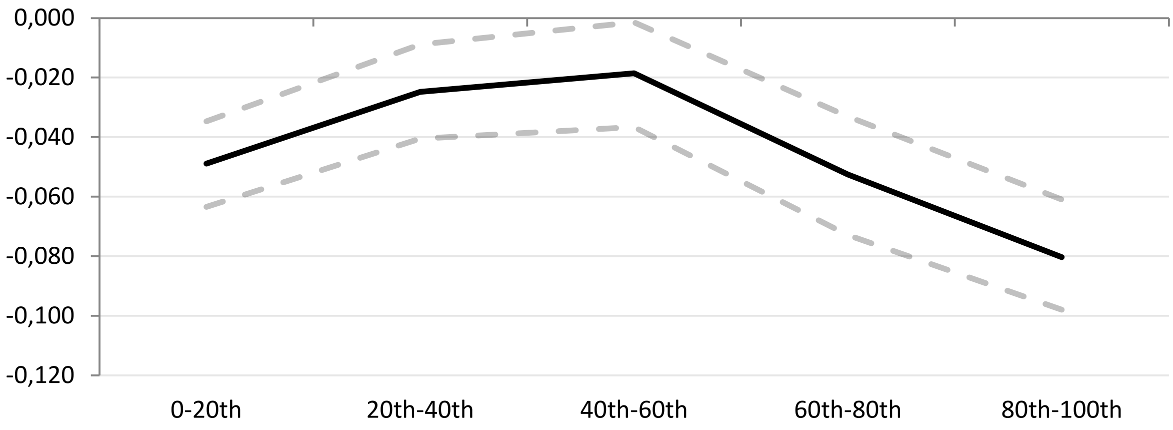

Figure 8. DCC average correlation with 95 % confidence intervals in relation to VIX levels.

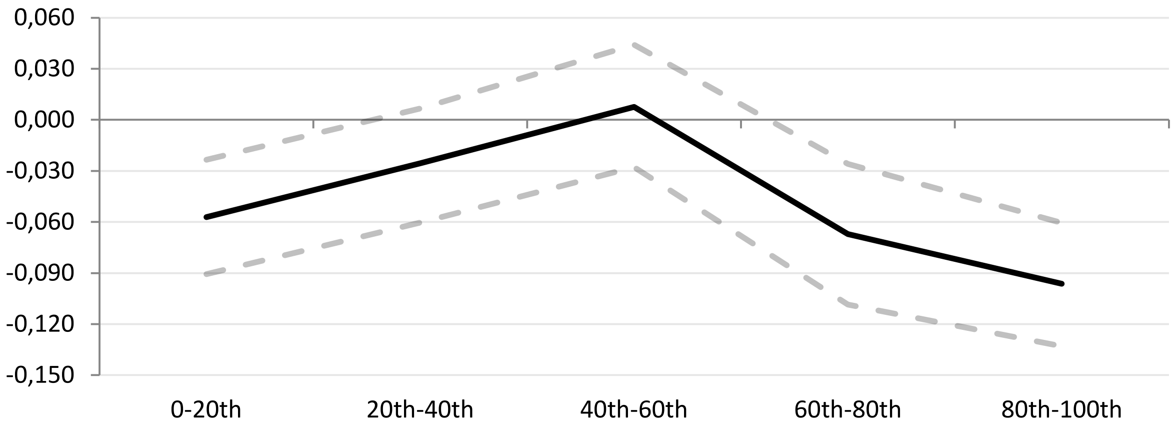

Figure 9. RWC average correlation with 95 % confidence intervals in relation to VIX levels.

5.3.3. VIX effect on subsequent stock-gold correlation

The estimation is performed according to regression equation 13 and the obtained results are seen in table 6. These results imply that an increase in VIX causes decoupling of stock and gold returns the following week. The obtained estimates are significant and similar in sign for both correlation series, although the effect is much stronger when RWC is used as the explained variable. Based on these results, hypothesis 2 can be affirmed. The results are also consistent with the flight-to-quality phenomenon.

Table 6. The impact of VIX on subsequent stock-gold correlation.

	DCC			RWC		
	Estimate		t-statistic	Estimate		t-statistic
Constant	0.178	*	1.778	0.330		1.287
$\ln(VIX_{t-1})$	– 0.090	***	– 2.823	– 0.143	*	– 1.685
AR(1)	0.898	***	70.966	0.850	***	56.105
Adjusted R^2	0.807			0.722		
F-statistics	2541.018			1578.386		
No. of Observations	1216			1216		

The estimation results for the regression equation 14 are in turn seen in table 7. The obtained estimation coefficients, for the common effect of VIX on subsequent stock-gold correlation, are close to identical compared to regression results obtained with equation 13. The negative effect of VIX on following week's stock-gold correlation is statistically significant for both series, and thus reinforces the perception that VIX is negatively related to stock-gold correlation in general.

The primary interest of this regression though lies on the information captured by dummy variables. These are to describe VIX index effect on stock-gold correlation during times when extreme uncertainty prevails in the markets. However, only one of the obtained dummy estimates is statistically significant. This is the dummy for highest 1 percent of VIX values, when RWC was used as the measure of stock-gold correlation. The resulted dummy estimate is positive (0.079), but not large enough to turn whole effect of VIX to positive, since the common effect of VIX is -0.146. This implies that when market uncertainty is at its highest, a further increase in VIX causes decoupling of stock and gold returns to diminish. Other dummy variables remained statistically insignificant and thus no conclusions of these effects can be drawn.

Thereby, based on the results seen in table 7, it cannot be said that during extreme uncertainty the decoupling of stock and gold returns would intensify. Therefore, hypothesis 3 is rejected. Regardless of this, stock and gold returns are seen to move to opposite directions even after VIX increases during the most uncertain times. However the results provide indications that this decoupling of returns weakens right after the most uncertain weeks, which was not expected. The negative correlations are still in line with the flight-to-quality phenomenon and supporting the claim that gold is not only a hedge for stock markets, but also a safe haven during times of extreme uncertainty.

Table 7. The impact of VIX on subsequent stock-gold correlation during most uncertain times.

	DCC			**RWC**		
	Estimate		t-statistic	Estimate		t-statistic
Constant	0.179	*	1.781	0.342		1.331
$\ln(VIX_{t-1})$						
Common effect	– 0.091	***	– 2.821	– 0.146	*	– 1.710
$D_{VIX\ 0.90}$	– 0.008		– 1.450	– 0.014		– 0.928
$D_{VIX\ 0.95}$	0.011		1.501	– 0.011		– 0.524
$D_{VIX\ 0.99}$	0.017		1.200	0.079	**	1.987
AR(1)	0.898	***	70.930	0.849	***	55.924
Adjusted R2	0.807			0.722		
F-statistics	1019.434			633.511		
No. of Observations	1216			1216		

5.3.4. VIX changes and contemporaneous stock-gold comovements

The results obtained when dividing weekly observations by the magnitude of VIX change are seen in table 8 and group correlations are illustrated in graphical terms in figure 10. These results indicate that stock and gold returns are portraying positive correlations during weeks when VIX increases the most. The correlation obtained for the group of biggest five percent of VIX increases is also appear to be far greater compared to other groups. During these weeks the mean stock return dropped to -3.9 %, which is considerably lower than the unconditional mean stock return. The effect of VIX changes' magnitude on gold returns is in turn relatively modest, as the dispersion in mean returns is only 0.752 % between groups. All in all, the results imply that stock and gold returns are diverging when VIX changes are between 25th and 75th percentile, or below 5th percentile. As for in case of greatest 25 % of increases or decreases in VIX, the correlation between stock and gold returns is positive, and even increasing when the most extreme increases in VIX are observed. The more positive correlation observed in weeks of most extreme increases in VIX, may be due to fact that the greatest percentual increases in VIX are observed in times when VIX is at its lowest and the increase in VIX cannot be considered as a panic signal causing flights. The greatest VIX declines accompanied with negative stock and gold return correlation, can in turn be caused by the regained confidence of investors, as they shift from other asset classes back to stock markets. Nonetheless, the obtained results are not in line with the assumption that greatest increases in uncertainty causes flights from stocks to gold. Therefore the hypothesis 4 can be rejected.

Table 8. Weekly change in VIX in relation to stock-gold returns over the sample period.

VIX Change Criteria	Obs	μ_{GLD}	σ_{GLD}	$\mu_{S\&P\ 500}$	$\sigma_{S\&P\ 500}$	$\rho_{GLD,S\&P\ 500}$
All	1262	0.096	2.290	0.131	2.338	– 0.009
$0–5^{th}$	64	0.693	2.642	3.518	2.187	– 0.025
$0–25^{th}$	316	0.044	2.500	2.035	1.897	0.045
$25^{th}–50^{th}$	315	– 0.059	2.028	0.605	1.360	– 0.011
$50^{th}–75^{th}$	315	0.133	2.047	– 0.117	1.536	– 0.030
$75^{th}–100^{th}$	316	0.267	2.533	– 1.999	2.370	0.044
$95^{th}–100^{th}$	64	0.206	3.384	– 3.929	3.053	0.176

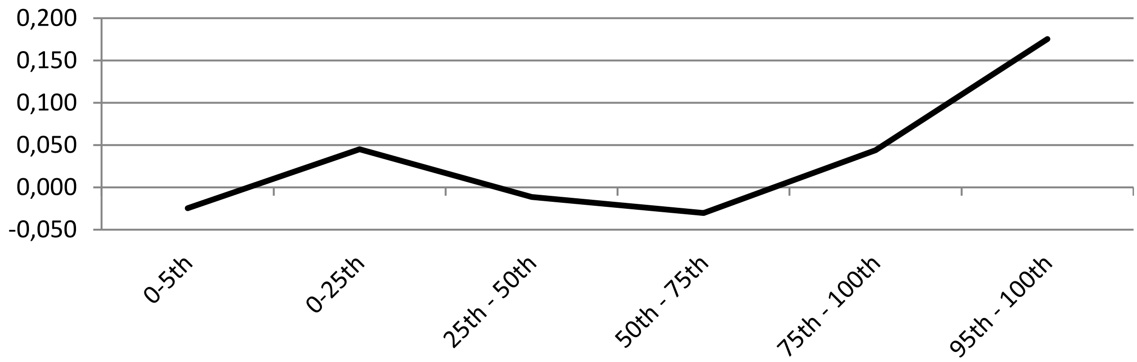

Figure 10. VIX changes and the contemporaneous stock-gold correlation.

6. CONCLUSION

This study is to examine the relationship between stock-gold correlation and VIX index. The motivation relies on previous studies concerning stock-bond correlation, and on concepts of contagion, flight-to-quality, and safe havens. The aim is to identify, whether uncertainty can alter the relationship between stocks and gold.

Since stock markets have been extremely volatile during the past decade and a number of stock market crashes have been faced, investors have grown cautious and uncertain about the future stock market development. Great VIX values are also often observed in touch with stock market crashes. During these adverse market conditions, substitute investments such as gold are seen to increase in value. This is because investors often consider gold as a safe choice, which will keep its value regardless of the state of the economy. Therefore, as stock markets decline and investors are uncertain about the future development, they will shift from stocks to gold according to flight-to-quality phenomenon. That is why it can be assumed that an increased uncertainty is causing decoupling of stock and gold returns.

The effect of VIX index, as a measure of market uncertainty, on stock-gold correlation is here studied with United States data running from the turn of 90's until the early 2014. The compared indexes are S&P 500, S&P GSCI Gold Spot Price, and VIX, which can be considered as leading measures of each represented group. The timespan chosen also favors the analysis as it contains different economic regimes and rapid changes in market environment.

In the analysis part, first two sets of time varying stock-gold correlation series are constructed, following study by Andersson et al. (2008). These two series are rolling window correlation (RWC) and dynamic conditional correlation (DCC), which enable capturing of changes in stock-gold return relation. These obtained series are portraying similar movements, RWC being however more volatile. Furthermore, both series indicate that, stock-gold correlation can go under rapid changes and it contains sustained periods of both positive and negative correlations.

These correlation series are in turn studied first by dividing them into subgroups based on the prevailing VIX index levels. This is done to extract the differences in stock-gold correlation in varying VIX index levels, making a hypothesis that stock-gold correlation is negative and decreasing towards the highest VIX level quantiles. The results suggest that stock-gold correlations are negative on average and at their lowest in group of highest VIX index values, but yet they are not monotonically decreasing with VIX. The negative correlation first weakens towards the group of VIX quantile 40^{th} – 60^{th} after which the correlation becomes more negative as VIX increases. Results imply that gold acts as a hedge for stocks, as well as a safe haven in times when VIX reaches its greatest values.

To study the relation of stock-gold correlation and VIX index further, two sets of regression analysis are performed. Firstly, the effect of VIX on subsequent week's stock-gold correlation is estimated, finding it to be negative and statistically significant for both correlation series. This is in line with the hypothesis of VIX being negatively related with stock-gold correlation, as well as the flight-to-quality phenomenon. In second regression, the effect of VIX is hypothesized to intensify as VIX is at its highest levels. The common effect of VIX still remains negative and statistically significant, whereas quantile level effects are insignificant for the most parts. Only when RWC is used as a measure of stock-gold correlation, the coefficient for highest 5 % of VIX values is significant and positive, contradicting with the hypothesis. Despite this positive coefficient, the overall effect of VIX remains negative even in the quantile of highest 5 % of VIX values, since the negative common effect is nearly twice the magnitude of the obtained positive quantile effect. Therefore, it can be said that VIX is negatively related with subsequent stock-gold correlation in general. Additionally, second RWC regression indicate that gold also acts as a safe haven during the most uncertain times, even though the negative relation between VIX and stock-gold correlation is not as strong as it is on average.

In the last part of the study, the comovements of stocks and gold are studied in relation to contemporaneous VIX changes. The hypothesis is that during weeks of greatest VIX changes, stock and gold returns are most negatively correlated, since sudden increases in uncertainty are assumed to trigger flights from stocks to safe havens. Weekly evolutions of the series are divided into groups based on VIX changes for the closer analysis, and the obtained results strongly contradict with the hypothesis. The results indicate that the greatest 5 % of VIX increases are accompanied with significantly positive correlation between stock and gold returns. Negative correlations are in turn observed during weeks when VIX changes are between 25^{th} and 75^{th} percentile, or when VIX is facing its greatest declines. The great positive correlation in weeks of greatest VIX increases can be explained by the notion, that these increases are observed in times of very low VIX levels, and thus the increase in VIX cannot be interpreted as a panic signal triggering flights from stocks to gold. The greatest declines in VIX are in turn accompanied with strong positive returns in stocks, and at the same time gold returns are mainly negative. This could be interpreted as stock markets regaining confidence of investors who are shifting back to stock markets.

To summarize the results, stock-gold correlation is negative on average implying that gold serves as a hedge for stocks. Stock-gold correlations are also at their most negative when VIX index is at its highest, indicating that investors shift from stocks to gold as uncertainty rises. The further studies of VIX index effect on stock-gold correlation also suggest that VIX is negatively related with upcoming stock-gold correlation, but the effect cannot be said to intensify at the higher VIX quantiles. The study of magnitude of VIX changes on stock-gold correlation however suggests that greatest increases in VIX are accompanied with contemporaneous positive stock-gold correlation, and vice versa. This contradicts with the assumption that sudden increases in uncertainty would trigger flights from stocks to gold.

One major defect of this study is the simplified assumptions of the relations and the lack of consideration of other explanatory factors behind stock-gold correlation, such as inflation or GDP growth. These factors could have even greater effects on stock-gold correlation than implied volatilities used in this paper. The effects of these other factors' should be restricted in order to be able to extract the effect of VIX index on stock-gold correlation. In addition, subsamples could have provided better information about the current relationship of stocks and gold, as the recent debt crisis may have altered investors' preferences making gold more desirable safe haven as it used to be in earlier years of the sample period, when comparing to bonds.

For future studies concerning stock-gold correlation, the use of subsamples is suggested. Also event studies around VIX thresholds and sustained periods of high uncertainty could be performed to extract flight events caused by uncertainty. Apart from gold price movements around VIX values, the volume of trade in stock and gold markets should also be taken into consideration for more adequate analysis of flight events and their intensity.

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