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INFLATION AND RETURNS OF ASSET CLASSES

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Abstract

Purpose of the research is to get evidence how returns on assets are related against inflation. In other words, idea is to find out if some assets can offer hedge against inflation. More specifically, aim of the study is to get global evidence of hedging ability of assets against inflation in the long run. Moreover, this research presents findings how assets are related with inflation in different time periods. Additionally, this study shows how returns on assets react against inflation shocks.

First of all, this study points out how nominal and real returns differ from each other between different asset classes. Then, autocorrelation is tested for nominal and real returns. Existence of unit-roots is tested by using ADF-, PP- and KPSS-test. Basic OLS estimation is used to get evidence how returns on assets are related against inflation. More deeply, ARIMA model shows how returns on assets are related against expected and unexpected inflation. Quantile regression presents how returns on assets behave against inflation in different quantiles. Finally, VAR analysis is used to get information of Granger causality, impulse-response function and cointegration.

The results show clearly that Goldman Sachs Commodity Index offers the best hedge against inflation. In fact, Goldman Sachs Commodity Index offers hedge against both, expected and unexpected inflation in the long run. However, quantile regression and periodic analysis show that even Goldman Sachs Commodity Index cannot offer hedge against inflation during extremely high inflation periods. On the other hand, gold seems to offer at least partial hedge against inflation during high inflation periods. REITs can offer partial hedge against inflation, but the hedge does not hold when the rate of inflation is high. Interestingly, stocks cannot offer hedge against inflation in the long run. However, in the case when the rate of inflation is low, stocks seems to offer at least partial hedge against inflation. Interest rates are positively related with inflation, but cannot offer any hedge against it. Finally, bonds are the worst assets against inflation, but U.S TIPS can offer some hedge.

Generally speaking, these results show clearly that when investment decisions are done between different asset classes, the rate of inflation should be taken into consideration with high importance. More specifically, the rate of inflation can be extremely harmful for the returns on assets. Finally, it should be noted that the results show that different asset classes react completely differently against inflation.

Keywords
OLS, ARIMA, Quantile Regression, VAR

Additional information

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1 INTRODUCTION

Purpose of this research is to investigate the relationship between inflation and returns of asset classes. The idea is to find out, how inflation affects nominal returns across assets classes. Historically, almost all asset classes have offered positive nominal return in the long run, but real returns have behaved differently. In fact, real returns have even been negative for some assets. More specifically, one of the key objectives is to find out how returns on assets are related with inflation.

Prior articles on this topic have focused mainly on the evidence of U.S. Inflation has been low for decades, thus previous evidence is quite old. The purpose of this research is to use global data and investigate how assets behave globally against inflation. However, there are no sufficiently long global time series for all assets hence U.S data is used in these situations. This research presents how stocks, bonds, interest rates, commodities, gold and REITs behave against inflation.

In general, prior evidence shows that some commodities, real estate and inflation-linked bonds are good hedges against inflation in the long run. Gold is a good hedge against financial crises and uncertainty, but its role as a hedge against inflation is not clear. Stocks are negatively related with inflation in the short run, but the relation is positive in the long run. (Ilmanen 2011: 350–355.) Dimson *et al.* (2012: 5–15.) complement Ilmanen's evidence by using data over 112 years and in 19 different countries that stocks offer limited shield against inflation. Moreover, bonds behave poorly against inflation, but have a special role against deflation.

Historically, inflation has varied much over decades. In the 70s inflation was high, but after early 80s inflation has fallen and stabled. Interestingly, after early 90s global inflation has yearly been less than 4 percentages. In this research one of the research hypotheses is to find out how different inflation levels have affected differently on returns on assets.

In the beginning this research follows methods of Fama and Schwert (1977) for getting evidence of inflation hedging possibilities on assets. First, is analysed how nominal and real returns on asset varies. Then, autocorrelation is analysed for nominal and real returns on assets. In order to avoid spurious regression stationary is tested by using ADF-, PP- and KPSS- tests.

In regression analysis the idea is to find out how nominal returns are related against inflation. In fact, basic OLS estimation gives long run evidence that can some assets offer hedge against inflation. Previous articles, especially Fama and Schwert (1977), analyse how returns on assets are related with both, expected and unexpected inflation in U.S. Fama and Schwert use U.S treasury bills as an indicator of expected inflation. Then unexpected inflation is actual inflation minus expected inflation. In this research main focus is to use global data. Thus, it is not appropriate to use U.S treasury bills as indicators of expected inflation. Hence inflation has to decompose for expected und unexpected components differently than Fama Schwert have done. In this case, research follows Gultekin (1983) method where inflation is decomposed for expected and unexpected component by using ARIMA model. Estimates of ARIMA model are used to predict expected inflation and forecast errors of ARIMA are used as components of unexpected inflation. Thus, it is analysed how nominal returns are related with both, expected and unexpected inflation.

Quantile regression is utilized for getting evidence, how inflation is related with returns on assets in different deciles. Quantile regression shows, how returns on assets react distinctly against low or high inflation.

Moreover, inflation is divided for three different time periods in order to compare how assets behave in high and low inflation periods. Interestingly, there is not much previous evidence on inflation periods' influence on returns on assets. Finally, VAR analysis is done for the data. VAR analysis includes Granger causality test, impulse-response functions and cointegration estimation.

The results of this research indicate that GSCI (Goldman Sachs Commodity Index) offers the best hedge against inflation in the long run. In fact, GSCI seems to offer hedge against both, expected and unexpected inflation. However, the results show that even GSCI cannot offer hedge against high rate of inflation. Interestingly, gold can be used as a hedge against high rate of inflation which support the general idea that gold is a safe haven of assets during times of uncertainly. REITs and U.S TIPS are positively related with inflation and they offer at least partial hedge in the long run. On the opposite, stocks perform poorly against inflation and cannot be used as a hedge. Interest rates are positively related against inflation, but the the positive relation is weak and cannot offer hedge. Bonds are the worst assets against inflation. However, during times of low inflation almost all assets are positively related with inflation and can offer at least partial hedges. In the short-term, the evidence of impulse-response function shows that GSCI and interest rates react positively and statistically significantly against inflation shock.

This research is organized as follows. Chapter 2 reviews prior evidence of the relation between assets return and inflation. Basically, Chapter two points out the main prior findings of how inflation is related with returns on stocks, bonds, interest rates, commodities, gold and REITs. Chapter 3 reviews the research hypothesis, data and research methods used in this research. Chapter 4 presents the results of this research. Finally Chapter 5 concludes the main points.

2 INFLATION HEDGING AMONG ASSET CLASSES

2.1 Hedging against inflation

Globally, inflation has not been on the news for many years, because inflation has been quite low for decades. In fact, for the last 15 years inflation has been less than 4 percent annually. Hence, at the moment inflation is at a decent level globally, but what is the future? Figure 1 presents global inflation. Inflation is calculated by taking logarithmic difference of global Consumer Price Index from OECD's database. Global inflation shows how dramatically inflation has varied over 40 years. During 1970s and early 80s inflation was rallying and it was one of the dominant financial concerns. Since early 1980s, inflation has stabilized and slowed down. Especially during 21th century, global inflation has been very low and stable.

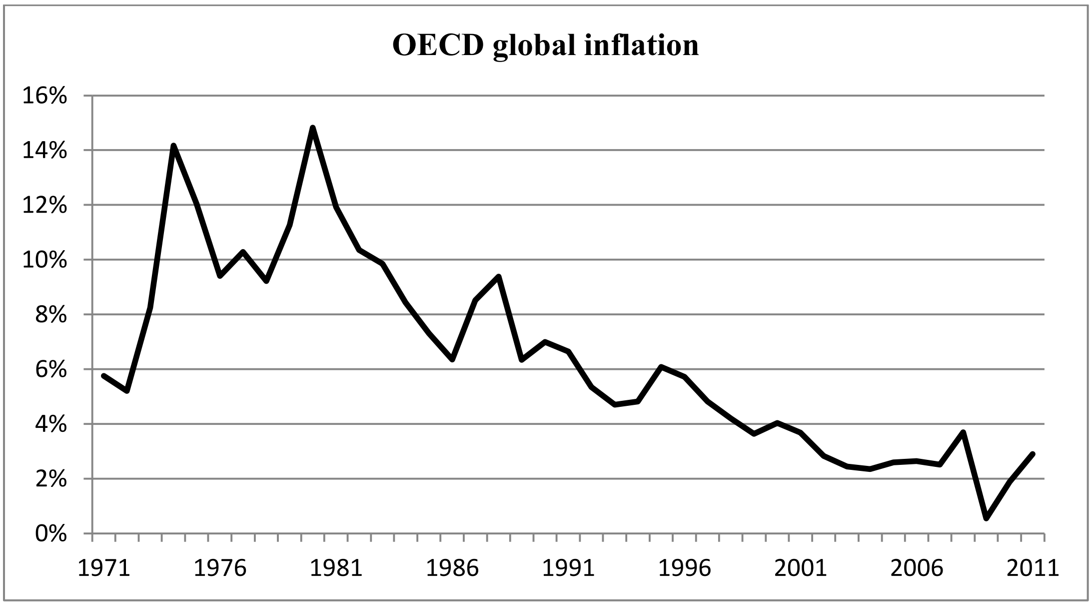

Figure 1. Global inflation

Interestingly, the global financial recession of 2008 brought deflation concern back on the table. In general, deflation seems to be much scarier for assets returns than inflation. However, as Figure 1 shows, global data does not contain deflationary periods. Basically the only data available of deflation is from U.S in the 1930s and Japan in the 1990s. Overall, inflation is bad for assets, but disinflation can actually help risky assets. However, deflation can be destructive for asset's return. (Ilmanen 2011: 355.)

Conditions of deflation are related with recession. Overall, deflation is bad for risky assets, because the whole economy suffers from it. In conditions of deflation consumer price level falls and the real value of money rises. In fact, deflation can even lead to a deflationary spiral. Deflationary spiral means decline in consumer prices, high real interest rates, recession and even depression. (Dimson *et al.* 2012: 5–7.)

Dimson *et al.* (2012: 5–7.) explain that recent global turmoil, unconventional monetary policy of euro crisis can lead to inflation pressures. Eurozone and U.S are in recession, but some emerging economies may be overheated. Especially, central bank's stimulating monetary policy has raised concerns about future inflation levels.

Fed's printing money policy (quantitative easing) and ECB's monetary tools that lead to growth of money supply can change our inflation rates very quickly and unexpectedly. Moreover, for pension funds, large institutions and other long-term investors' one of the biggest threats and fears of profitable investing is future inflation. Also, pension funds' main focus is to maintain purchasing power of their assets over time. Nominal returns can be positive, but after inflation correction, real returns can be much lower or even negative. Thus, inflation hedging is an important aspect of long-term portfolio management.

Bodie (1976) determines when asset is inflation hedged by giving two alternatives definitions. First, an asset is an inflation hedge if asset's return is above inflation level. Second, an asset is an inflation hedge if asset's return is independent of the inflation level. The first definition is inadequate, because it does not take into a count the role of nominal and real returns. In fact, Bodie's second definition is the only possible way to determine, when asset offers full hedge against inflation. It can be concluded that, asset class is fully inflation hedged if and only if assets real returns are completely independent of inflation movements. Nominal returns should be above real returns by the amount of inflation.

Generally speaking, before analyzing the relationship between returns on different asset classes and inflation, it is appropriate to determine what inflation is. Precisely, inflation is a increase in the price level. This means that its purchasing power falls. According to Milton Friedman (1963) famous speech:

"Inflation is always and everywhere a monetary phenomenon, in the sense that it cannot occur without a more rapid increase in the quantity of money than in output"

2.1.1 Quantitative theory of money

Quantitative theory of money (1) is an economic theory, which has been used widely to explain inflation movements. According to this economic theory, money supply determines inflation level. M / P is the real money supply and Y / V is the real money demand. Given constant velocity (V), an increase in nominal money supply leads to an equivalent increase in prices (P). (Mishkin 2012: 536.)

$$MV = PY \tag{1}$$

where V = velocity of circulation,
Y = potential level of real GDP,
P = price level and
M = nominal money supply.

2.1.2 Fisher hypothesis

Fisher (1930) proposes the famous and largely used Fisher hypothesis. Fisher hypothesis (2) predicts a positive relation between expected nominal returns and expected inflation. The Fisher effect states that the real interest rate equals the nominal interest rate minus the expected inflation rate. The main idea of Fisher's hypothesis is that when expected inflation rises, nominal interest rates will rise at the same amount. For example, according to the Fisher hypothesis a 1 % rise in inflation leads to a similar rise in nominal interest rates, so real interest rates are constant.

$$i = r + \pi \tag{2}$$

where i = nominal interest rate,
r = real interest rate and
π = expected inflation.

Fisher effect means that every country has their own nominal interest rates, which describe investors' demand of real interest rate and expected inflation. Real interest rate should be equal across countries. Thus countries which have high inflation have higher nominal interest rates than countries which have low inflation. Moreover, when nominal interest rates are different, investors will invest in countries which have high interest rates until the interest rate will be equal due to arbitrage. The relationship means that if inflation rises, the interest rates have to raise an equal amount.

Academic research tries to define the relation between inflation and asset returns by using Fisher effect. Basically, if Fisher effect holds, asset values should be positively related with expected inflation, providing a hedge against rising prices.

2.2 Stocks

In 1960s academic evidence implied that stocks are moving directly with inflation. Traditional assumption argues that stocks are claim to real assets and should offer full hedge against inflation. Traditional assumption is based on Fisher's hypothesis. Thus, if Fisher's hypothesis holds, stocks should move directly with inflation rate because of their positive relation. However, according to Lintner (1975), Jaffe & Mandelker (1976), Nelson (1976) and Fama & Schwert (1977) among others, stocks returns have negative correlations between expected, unexpected and changes in unexpected inflation, at least in the short run. Unexpected inflation is the difference between actual (realized) inflation and expected inflation. Actually, stocks tend to perform very poorly during inflationary periods. Bodie (1976) finds similar results and goes even further. Bodie explains this negative correlation that stocks should sell even sort for getting hedges against inflation. Fama and Schwert (1977) find that stock returns can offer hedges against expected inflation but not against unexpected inflation.

The academic research of the relationship between stock returns and inflation is mixed. It is quite obvious that stocks cannot offer full hedge in the short run because prices of raw materials and salaries are sticky. This has an affect for earnings and thus stock returns and inflation cannot be completely correlated all the time. Boudoukh and Richardson (1993) article supports for a positive relationship between stock returns and inflation in the long run. They find strong evidence that stock returns are hedges against both ex ante and ex post inflation in the long run. Ely and Robinson (1997) argue that common stocks keep their values against price indexes in statistically significant level. Moreover, they extent this assumption and show that stock returns are hedges against inflation whether the source of inflation comes from monetary or real sector.

Lintner, Bodie, Jaffe and Mandelker, Fama and Schwert, and Nelson research is based on U.S data. Firth (1979) implies that the relationship between inflation and stock returns has been positive in UK. Because of this Firth's evidence, Gultekin (1983) has done research between the relation of stocks returns and inflation for different countries and environments. Gultekin's evidence shows that stocks returns and inflation are not negatively correlated in every country. Moreover, he identifies countries which have higher inflation also have higher nominal stock returns. Barnes *et al.* (1999) extent this conclusion by showing that an increase in inflation rate has smaller effect on real returns in countries whose current inflation level is high compared to countries whose current inflation level is low. In other words, high inflation countries can provide some hedge against inflation.

Choudhry's (1999) evidence in Latin America during 80s and 90s implies that stock returns and inflation are positively correlated in high inflation countries. This statistically significant investigation points out that stock returns can be used as hedges against inflation in Argentina, Chile, Mexico and Venezuela. Spyrou (2004) finds statistically significant evidence that stock returns and inflation are positively related in Argentina, Malaysia and Philippines. In Mexico, Brazil and South-Korea the relationship between inflation and stock returns is positive, but insignificant. In a nutshell, Spyrou argues that stock returns are hedges against inflation in emerging economies expect in Thailand. The findings suggest that equity markets are different in emerging economies than in developed economies.

The most recent studies have found mixed conclusions that stock can offer a hedge against inflation at least in the long run. According to Schotman and Schweitzer (2000) stock returns can give hedges against inflation when stock returns are negatively related with unexpected inflation. The reason for the hedge is that stock returns can be at the same time positively related with expected inflation. One of their key implications is that investment horizon determines, if the hedge ratio is positive or negative. It should be noted that hedging performance is reliant to the inflation persistence. Ahmed and Cardinale (2005) find evidence for asymmetric behavior of investors during inflationary periods in the short term. Long run results show that short-term dynamic movements cannot be ignored when investors analyze long run inflation hedges. Findings argue that stock returns fail to be hedge against inflation when it is most needed. Ahmed and Cardinale incorporate to their findings that during inflationary periods stock returns are strongly negatively related with inflation. In general, equity returns are good hedges against inflation during inflation up to 3 percent, in the short run. However, the relationship between inflation and stock returns during deflationary periods has been negative. On the other hand, Luintel and Paudyal (2006) give evidence from U.K that stocks are hedges against inflation in the long run.

Fama and Schwert (1976) try to explain the negative relation between stock returns and inflation by giving two different possibilities. They argue that some phenomenon can cause expected real returns and expected inflation to be negatively related to stocks. According to their findings, market can be inefficient and information of consumer price levels is not incorporated to stock prices. Fama (1981) explains negative paradox between inflation and stock returns by using proxy effect. Proxy effect means that stock returns are positively correlated with real activity of economy. At the same time, there is a negative correlation between inflation and real activity because of the quantity theory of money and the money demand theory. However, Fama ignores the role of monetary policy for explaining real economic shocks. When economy is growing, real output is associated with lower inflation rates. Also, stock returns and inflation are both strongly connected with future economic activity. One of the easiest examples of this phenomenon is stagflation.

Geske and Roll (1983) argue that negative correlation between stock returns and inflation exists because of the chain of events. This finding ignores causality and exogenous shocks in real output as causing this negative relation. Geske and Roll's findings challenge Fama's proxy hypothesis. For example, the chain of events, like decrease in economy, will increase government budget deficit and thus stimulating monetary policy. Stimulating monetary policy leads to a growth of the amount of money. Then, money growth will lead to a higher inflation. Geske and Roll imply that rational investors realize these causal chains of events and add these changes to prices. Moreover, Geske and Roll explain that the role of central bank counter-cyclical monetary policy leads to negative correlation between stock returns and expected inflation. Also, Solnik (1983) finds supportive evidence for Geske and Roll's hypothesis that stock prices are negatively correlated with expected inflation.

Kaul (1987) extends Geske and Roll's idea of the role of monetary policy by explaining the negative correlation between stock returns and inflation showing that this negative relationship varies in time. Main implication of Kaul's article is that negative correlation between stock returns and inflation exists because of money demand and counter-cyclical monetary policy. Kaul (1990) shows that pro-cyclical monetary policy can lead to even more positive relationship between stock returns and inflation. Kaul finds that central bank's operating targets affect strongly the relationship between inflation and stock returns. Evidence shows that the relation between inflation and stock returns is noticeably stronger during counter cyclical interest rate policy than during money supply policy.

Marshall (1992) argues by using postwar U.S data that there is a negative correlation between stock returns and inflation, and a positive correlation between stock returns and money growth. Marshall implies that because of the difference between stock returns - inflation and stock returns - money growth, correlation results will challenge the general idea that inflation is just a monetary phenomenon.

Previous literature of the relation between stock returns and inflation can be extended by dividing stock returns for two components: dividend yields and capital gains returns. Evidence shows that dividend yields and capital gains behave differently compared to expected inflation. Results support Fama's proxy hypothesis by confirming negative relation between inflation and excess return. Main finding argues a positive relationship between inflation and dividend yields and a negative relationship between inflation and total returns. Moreover results show a negative relationship between inflation and capital gains returns. (Pilotte 2003.)

Graham (1996) finds a negative relation between inflation and stock returns before 1976 and after 1982. However, between 1976 and 1982 the relation has been positive. Graham explains this phenomenon by using counter-cyclical and pro-cyclical monetary policy. According to Graham's findings positive relationship between inflation and stock returns exists because of pro-cyclical monetary policy. These results indicate that stock returns are negatively correlated with inflation during neutral or counter-cyclical monetary policy. Spyrou's (2004) evidence of the positive relationship between stock returns and inflation from emerging economies tries to explain this relation by the role of money. Moreover, for many emerging economies inflation may not be negatively correlated with future economic activity.

It could be possible that monetary sector and real economy are not independent of each other's.

In many time periods and markets is shown that stock offer hedge against inflation, because long run returns are above inflation. However, Dimson et al. (2012: 9.) argue that, high ex-post return is explained by using equity risk premium. In fact, the level of the equity risk premium explains nothing of the relation between equity returns and inflation.

In conclusion, stocks are not hedges against inflation in the short run. However, it can be concluded that stocks can offer at least a partial hedge against inflation in the long-term periods. However, investors should keep in mind that long-term evidence is mixed and the rate of inflation affects strongly to the results. Especially results from emerging economies and high inflation countries indicate that stocks can offer a hedge against inflation. However, data from developed economies gives statistically significant evidence that stock returns and inflation are negatively correlated at least in short-term.

2.3 Bonds and Treasury bills

One of the major objectives of central bank's monetary policy is to control inflation target. During high (low) inflation periods central bank raises (reduces) interest rates *ceteris paribus*. Fixed income securities such as bonds move inversely with interest rates. Prices of bonds decrease (increase) when interest rates rise (fall). In other words, bond yields go up and prices go down because of inflation expectations. Thus bonds behave well in deflationary or declining inflation environment.

Fisher's hypothesis point out that nominal interest rate is equal to the real interest rate plus expected inflation. The key idea of Fisher's hypothesis is that nominal interest rates and expected inflation move one-for-one in the long run. However, Fisher's hypothesis is inconsistent with Fama's efficient market hypothesis. Fama's

(1975) evidence is consistent with efficient market hypothesis because treasury bills nominal interest rate incorporates all information of the change in expected future rates. Moreover Fama argues that treasury bills' variation comes from expected inflation rates. This indicates that the real rates of interest are constant through time. Fama (1976) extends prior evidence of treasure bills expected real returns relation to inflation uncertainty by arguing that this uncertainty does not change much through time. Nelson and Schwert (1977) challenge Fama's findings by pointing out that these prior results are not enough powerful to reject Fisher hypothesis.

According to Fama and Schwert (1977) findings, U.S government bonds and bills are hedges against expected inflation. This indicates that expected real returns of these assets are independent of expected inflation. However expected nominal returns are positively correlated with expected inflation.

Huizinga and Mishkin (1984) extend the prior research of the relation between interest rates and inflation by incorporating evidence of longer maturity assets. They find a negative relation of ex ante real rates and inflation. Ex ante real rates have negative relationship also with nominal interest rates. Their evidence shows that relation between real rates and inflation is more negative for longer maturity. Thus, short-term U.S Treasury bills seem to offer best hedges against expected inflation. However, the hedge is far from perfect. Moreover, Huizinga and Mishkin point out that variation in the nominal interest rates of three-month U.S Treasury bills does not indicate variation in expected inflation. Indeed, movements in the nominal interest rates of three-month U.S Treasury bills can indicate changes in ex ante real rates. On the other hand, Smirlock (1986) finds a positive relation between long-term interest rates and unexpected inflation.

The term structure is one of the main implications of interest rate research. Previous studies that use the term structure to predict future interest rates' movements have proposed that the term structure can give some information about future inflation. Mishkin (1990) finds strong opposite evidence of the relation between interest rates and inflation. Mishkin shows that the term structure does not provide almost any information of future inflation for period of six months or less. However, the term structure provides information about future real interest rates. As maturities increase to 9-12 months, the nominal term structure provides information about future inflation, but does not provide information about future real interest rates. Fama (1990) argues that term structure of interest rates does not have much possibility to predict short-term movements in the one-year interest rates. Moreover, Fama shows that expected real returns of one-year bonds move inversely with one-year expected inflation.

Evans and Lewis (1995) show that nominal interest rates and inflation are not correlated which indicates variation in ex post real interest rates. However, they cannot reject hypothesis that expected inflation and nominal interest rate are related one-for-one. Kandel *et al.* (1996) propose negative relation between expected inflation and ex-ante real interest rates. Moreover their evidence shows that nominal interest rates including inflation risk premium are positively correlated with a proxy of inflation uncertainly. Also, in the inflationary periods the nominal interest rates are largely explained by inflation expectations. According to Barr and Campbell's (1997) evidence real interest rate is not stable in the short run and correlation between real rates and expected inflation is strongly negative. However, real interest rates become stable in the long run and negative relation between expected inflation and real interest rates disappears. Thus this relation has insignificant effect on nominal bond returns in the long run. Barr and Campbell supplement their research by showing that around 80 % of variations of long-term nominal rates come from variations of expected long-term inflation.

Evans (1998) finds strong and statistically significant evidence that nominal rates of returns and expected inflation are not one-for-one related. Ang *et al.* (2008) find similar results to previous studies, which imply real rates have negative a relation to inflation. However, in the long run real yields and inflation have positive relation.

In conclusion prior recent findings show that Fisher hypothesis does not hold for the interest rates. During short periods, the relation between interest rates and inflation is negative. However, when maturity increases the relation between interest rates and inflation is less negative or can even be positive. Moreover, interest rates are not hedges against inflation and expected inflation is far from stable. Expected inflation is time varying and it can be said that bonds cannot offer hedges against inflation. Short-term interest rates are also time-varying, so treasury bills are not safe havens either. Long-term investors' point of view the solution is that TIPS can offer inflation-free profit. (Ang 2008 *et al.*, Campbell *et al.* 2009, Evans 1998, Barr & Campbell 1997, Campbell & Viceira 2001 Campbell & Shiller 1991, etc.)

2.3.1 TIPS

In 1997 U.S Treasury began to issue Treasury Inflation Protected Securities (TIPS). U.S Treasury issues 5-year and 10-year and 30-year TIPS. For TIPS, real interest rate is constant, but nominal interest rate moves with inflation during life span of the bond. At the time of maturity, indexed bond received full real amount value of the principal. Consumer Price Index commonly known as CPI is the inflation index for TIPS. TIPS are inflation hedged securities because their yield is bounded to CPI. Therefore, TIPS are the safest available assets without inflation risk. The only risk for the TIPS is interest rate risk. Price of TIPS changes inversely with real interest rates and the price of the conventional bond varies inversely with nominal interest rates. Generally speaking, TIPS are not completely inflation riskless assets because of tax effect. For example when inflation is high, after-tax returns can even be negative. (Shen 1998.)

Many investors and policymakers believe that TIPS could be used to predict future expected inflation. Before TIPS were issued only source for future inflation was the term structure of interest rates. Hence, inflation expectations can be estimated by calculating difference in yields between conventional bonds and TIPS. However, this yield difference can be biased, because it includes liquidity premium. TIPS markets are much less liquid than conventional bond markets. Evidence indicates that yield spread predicts future inflation below its actual level and is unrealistic low. However, yield spread can provide some information about future inflation and when time goes by TIPS market will be more liquid and liquidity premium become sufficiently small. (Shen & Corning 2001.)

Kothari and Shaken (2004) propose positive correlation between inflation and real interest rates for indexed bonds. This indicates that when interest rates fall (rise) price of indexed bond rise (fall) and inflation falls (rise). However, Kothari and Shaken argue that correlation is negative between unanticipated inflation and real interest rates for indexed bond. Nowadays when real interest rates fall (rise), price of indexed bond rise (fall) and unexpected inflation rise (fall).

2.4 Commodities

Commodities have been used widely as hedges against inflation. Historically, commodities have been seen as a story value of assets against inflation, because commodities have been claimed as real assets. Changes and shocks in the economy should affect quickly to prices of commodities.

Consumer Price Index is a widely used inflation index. Thus, when analyzing inflation’s influence on commodity prices it should be noted that CPI consists of about 40 percent weight of commodities and about 60 percent weight of services. Food commodities take 14 percent of these commodities and energy commodities take 4 percent of total weights. (Claude & Campbell 2006.)

Bird (1984) shows that commodities can be used as hedges against inflation. However, each commodity behaves differently against inflation. The results of Bird indicate that tin and cocoa are the most appropriate hedges against inflation. However, Bird points out that tin dominates all other commodities for inflation hedging purposes because it has the lowest storage costs in relation to the value of a physical holding.

Mahdavi and Zhou (1997) show relation between CPI and commodity price index between 1958 and 1994. However, the relation is not one-to-one, but still commodity price index offers at least a partial hedge against inflation. However, the relation between commodity prices and inflation has changed dramatically over time.

Furlong and Ingenito (1996) argue that non-oil commodities are positively correlated with inflation during 1970s and early 1980s. The relation has changed dramatically after 1980s. Since 1980s their evidence shows that the positive relation between commodities and inflation have been weak.

Halpern and Warsager (1998) implie that commodities are a strong inflation hedge during unexpected rise in inflation. Greer (2000) extents Halpern *et al.* study by pointing out that from 1970 to 1999 commodity prices are positively correlated with inflation (0.25), but this relation is even stronger during unexpected rise in inflation rate (0.59). Moreover, Greer argues that commodity prices are not strongly correlated with each other which lead to a different correlation between each commodity and inflation. Gorton and Rouwenhorst (2005) and Worthington and Pahlavani (2006) found similar results than Halpern and Greer within inflation and commodities. However, Gorton and Rouwenhorst propose that positive correlation between commodity futures and inflation is statistically significant in all time horizons and the correlation is even more positive when holding period increases. Kat and Oomen (2006) found that energy, metals, cattle and sugar are the best hedges against inflation. However, their evidence shows that commodities like grains, oil seeds, softs, pork and palladium have very low or even negative correlation with inflation.

Each commodity by itself is differently correlated with inflation. Thus, it is much better to look at how an individual commodity is correlated with inflation. Overall, GSCI (Goldman Sachs Commodity Index) shows that commodity futures are positively correlated with inflation. The correlation between GSCI and actual inflation is positive, but statistically insignificant. Moreover, the correlation between GSCI and unexpected inflation is significant. However, some commodities are uncorrelated by each other. Energy, livestock and industrial metals, heating oil, cattle and copper have statistically significant correlation with unexpected inflation. In conclusion some commodities offer hedges against inflation much better than others. However, it is far away that all individual commodities could be used as hedges against inflation. (Claude & Campbell 2006.)

Claude and Campbell (2006) try to explain the difference of individual commodities and inflation by using roll returns. Roll returns is the difference between spot returns and future returns. They argue that there is a strong correlation between roll returns and unexpected inflation. Their evidence shows that roll returns explain 67 percent of total variation of commodity futures to unexpected inflation. Claude and Campbell show that commodities, which have positive (negative) roll returns, have a high (low) variation to unexpected inflation. Commodities that are difficult to store have positive roll returns and high unexpected inflation. Thus, the difficulty of storage can cause the relation between roll returns and unexpected inflation.

2.4.1 Gold

Historically speaking gold has been seen as a safe haven and store value of asset classes. It is a common belief that gold performs well during economic shocks. During an ongoing financial crisis, gold has been stabilizing financial markets in "stormy weathers". (Baur & McDermott 2010.) McCown and Zinnerman (2006) suggest that gold is a zero-beta asset without market risk. Dimson et al. (2012: 12.) show that value of gold does not reduce because of inflation. On the other hand, long run performance is very poor. However, academic evidence of the relation between gold and inflation is not clear.

In U.S Congress on February 22, 1994, Fed's Chairman Alan Greenspan noted that gold could be used as a hedge against inflation. According to Greenspan gold is a: "store of value measure which has shown a fairly consistent lead on inflation expectations and has been over the years a reasonably good indicator".

Mahdavi and Zhou (1997) find that prior belief for using gold as a hedge against inflation is misplaced. Their evidence shows that gold is too volatile at least in the short run. However, Taylor (1998) proposes that gold can be used as a hedge against inflation in the short run but also in the long run during pre-war period before 1939 and around 1976 during OPEC oil shock. Taylor expands prior evidence by showing that all other precious metals (silver, platinum and palladium) than just gold can be used also at least as partial hedges against inflation on those periods, both in the short run and in the long run.

Chua and Woodward (1982) investigate gold as an inflation hedge in Canada, Germany, Japan, Switzerland, UK and U.S from 1975 to 1980. The results indicate that gold returns have been higher than inflation rate for each of these countries. However, this does not mean that gold is a completely inflation hedge investment. Their research identifies that gold has offered effective hedges against expected and unexpected inflation only in U.S.

The most recent studies (Adrangi *et al.* 2003, Ghost *et al.* 2004, Worthington and Pahlavani 2007) argue that gold is a hedge against inflation. Adrangi *et al.* (2003) found positive correlation between expected inflation with both gold and silver. However, correlation between gold and silver against to unexpected inflation is not statistically significant. These results indicate that gold and silver can be used as hedges against expected inflation also in the long run. Ghost *et al.* (2004) found supporting evidence to gold offering a long term hedge against inflation by using monthly gold price data from 1976 to 1999.

Claude and Campbell (2006) argue completely different results than others by using CSGI. They found a negative and statistically significant relation between inflation and precious metals. However, the reason for this result can be the inability of the inflation model for explaining period-specific return dynamics of gold. Wang *et al.* (2011) show that gold cannot offer a full or absolute hedge against inflation. They found that gold behaves differently in different markets and periods. When momentum is high (low) investing for gold is a good (bad) hedging strategy against inflation in the U.S. Moreover, Wang *et al.* argue that gold cannot offer a good hedge in any market situation in Japan.

Prior articles have explained future inflation by using changes in price of gold. Price of gold has been seen as a proxy for future inflation. Relation between expected inflation and gold price can be explained by carrying cost hypothesis. The carrying cost hypothesis means that when inflation rises, interest rates rises, and cost of carry for gold investment rises which will increase holding costs of the gold. Carrying cost hypothesis displaces speculative profits of gold investing in inflationary periods. Thus, during inflationary periods, gold price will not change, according to the carrying cost hypothesis, because the cost of carry for gold. Evidence shows supporting results with the carrying cost hypothesis that unexpected changes in inflation have no effect for price of gold at the moment of announcement. The results did not find a relationship between price of gold and expected inflation. (Blose 2010.)

2.5 Real Estate

In particular, pension funds and other institutional investors are willing to invest for real estate. Real estate is seen as an important part of diversified portfolio management because of reducing risk.

Fama and Schwert (1977) show that real estate is a only asset which can offer a full hedge against inflation. Actually, real estate is full hedge against expected and unexpected inflation. Brueggeman *et al.* (1984) use a two-factor CAPM to explain correlation between real estate returns and inflation. Their findings shows supporting evidence that real estate returns can be used as hedges against inflation. However, commercial real estate returns cannot offer hedges against unexpected inflation.

On the other hand, Ibbotson and Siegel (1984) point out that real estate returns are not perfect hedges against inflation even though real estate returns offer a far better hedge than other asset classes. Hartzell *et al.* (1987) propose statistically significant evidence that commercial real estate in a part of diversified portfolio are complete hedges against expected and unexpected inflation during 1973-1983.

Gyourko and Linneman (1988) found that different types of real estate are correlated with inflation differently. Their results argue that nonresidential real estate has a strong positive correlation with inflation. Also, owner-occupied homes have a positive relation with inflation. Rubens *et al.* (1989) investigation shows that residential real estate offers a hedge against actual inflation and business real estate provides a hedge against expected inflation.

Commercial real estate returns relationship between inflation behaves differently during high and low inflation periods. In particular, vacancy rate variation has a major impact for real estate returns. Actually, vacancy rates and inflation moves inversely in office markets which lead to a supply-demand imbalance. On the other hand, during high and low inflation periods, vacancy rates are quite stable in industrial markets. Thus, office market returns move with inflation in the long-term, but after adding vacancy rates into it, office returns are not positively related with inflation. Industrial real estate markets move with inflation during high and low inflation times and are much less volatile than office market returns in the short-term. More specifically, vacancy rates do not have much effect on industrial markets. In conclusion, industrial real estate markets are inflation hedges in both low and high inflation periods, because markets supply-demand relation is in balance. However, vacancy rates have a strong effect for office markets. This indicates that office markets can offer hedges against inflation when markets stay in balance. Thus, structural imbalances like overbuilding can have a major impact for real estate returns. (Wurtzebach *et al.* 1991.)

Hoesli *et al.* (1997) argue contrary results than prior studies. They present that real estate are not hedges against inflation, but offer at least a partial hedge in the short periods against unexpected inflation. It should be noted that the relationship between inflation and real estate returns varies between different economic environments.

Bond and Seiler (1998) analyze by using Added Variable Regression Method (AVRM) residential real estate correlation with inflation during 1969 to 1994. Their evidence shows that residential real estate can be used as hedges against expected and unexpected inflation. In particular, Bond and Seller propose that real estate should be part of an efficient portfolio because of the effective hedging ability against unexpected inflation.

2.5.1 REITs

Real Estate Investment Trusts (REIT) is a closed-end investment company. Basically, REIT owns assets that are related to real estate and trading is organized on OTC-markets. REITs are divided into mortgage and equity trusts. Mortgage trusts invest primarily for long-term mortgages and equity trusts contain ownership in commercial properties like offices and shopping centers. Prior studies have found that equities are negatively correlated with inflation. On the other hand, physical real estate can offer at least a partial hedge against inflation. Thus, REITs are claimed as "backed" real estate assets. According to their evidence REITs provide a partial hedge against expected inflation (Park *et al.* 1990). In the long run, rents should increase at least the amount as CPI, which should indicate that REITs should offer a hedge against inflation.

However, the most prior results are mixed with older evidence. Liu *et al.* (1997), Gyourko and Linneman (1988) and Chan *et al.* (1990) found negative correlation between REITs and inflation. Actually, Chan *et al.* extent Part *et al.* research by using a multifactor Arbitrage Pricing Model to test REIT's ability to offer hedge against inflation. Their evidence shows that REITs are negatively related with unexpected inflation. Larsen and Mcqueen (1995) present supporting evidence about poor inflation hedging ability of REITs. Liu *et al.* propose more global evidence that perverse relation between REITs and inflation exists in Australia, France, Japan, South Africa, Switzerland, UK and U.S.

3 HYPOTHESIS, DATA AND METHODS

3.1 Research hypothesis

Purpose of this research is to investigate how returns on assets varies against inflation movements. The study finds out, can some asset classes offer hedges against inflation. One of the key elements is to show, how nominal returns are related with inflation and what is the role of real returns. Historically speaking, prior research has concentrated the relation between inflation and returns on assets by using data mainly from U.S. In this research, the idea is to use global data and get evidence that how inflation affects returns on assets in more broad perspective.

The research hypothesis is to find out, can some assets offer hedge against inflation in the long run. Also, inflation is decomposed to expected and unexpected inflation components by using ARIMA model. Moreover, idea is to get and compare evidence that how different rates of inflation affect returns on assets. Quantile regression shows, how inflation is related with returns in different regimes of inflation. Finally, this research uses VAR analysis. VAR analyze includes Granger causality test, impulse-response function and test of cointegration. Granger causality test shows causal relation between inflation and returns on assets. Impulse-response function gives evidence how shock in inflation affect for returns on assets. Finally, the test of cointegration points out cointegration between returns on assets and inflation.

3.2 Research methods

3.2.1 Regression analysis

Regression formulas are used to determine, how returns of asset classes are related with inflation. In the regression (3), according to Fisher hypothesis, assets should have coefficient α_1 = 1.0 for the inflation rate.

$$R_{i,t} = \alpha_0 + \alpha_1 INF_i \quad (3)$$

In Fisher hypothesis, nominal returns of asset classes should vary one-to-one with inflation. If coefficient $\alpha_1 < 1.0$, asset is not a hedge against inflation. More specifically, Fama and Schwert (1977) propose extented (4) Fisher hypothesis.

$$R_{i,t} = \alpha_0 + \alpha_1 B_1 + \alpha_2 B_2 + \eta \quad (4)$$

For now, α_1 is the coefficient of expected inflation and α_2 is the coefficient of unexpected inflation. When $\alpha_1 = 1.0$ asset is a complete hedge against expected inflation and when α_2=1.0 asset is a complete hedge against unexpected inflation. When α_1= α_2=1.0 asset is a complete hedge against inflation. If asset is a complete hedge against inflation, nominal returns on the assets are one-to-one related with both expected and unexpected inflation. Moreover, real returns of the asset does not have any correlation with ex post inflation rate. The variance of disturbance η defines the variance of asset's real return. (Fama & Schwert 1977.)

Fama and Schwert (1997) use U.S Treasury bill rates as a component of expected inflation and unexpected inflation is actual inflation minus expected inflation. In this research is used global data, hence it is not appropriate to use U.S treasure bills as indicator of expected inflation. This research follows Gultekin (1983) article, which uses ARIMA model to decompose inflation rates for expected and unexpected components.

3.2.2 ARIMA model

ARIMA model uses Box and Jenkins (1976) methodology (5) for generating components of expected and unexpected inflation.

$$y_t = a_0 a_1 y_{t-1} + \ldots + a_p y_{t-p} \varepsilon_t + \beta_1 \varepsilon_{t-1} + \ldots + \beta_q \varepsilon_{t-q} \quad (5)$$

Gultekin (1983) uses inflation forecasts of ARIMA model as estimates of expected inflation and forecasts errors as estimates of unexpected inflation. It should be noted that volatility of inflation has changed dramatically over time that can cause challenges for for fitting appropriate ARIMA model in the long run.

In time series analysis ARIMA model means autoregressive integrated moving-average model. ARIMA model is fitted to data to understand or predict future observations of the time series. A nonseasonal ARIMA model is classified ARIMA(p,d,q), where p is the number of autoregressive terms, d is the number of nonseasonal differences and q is the number of lagged forecast errors in the prediction equation. (Enders, 2004: 99.)

Information criteria is used to find out, what kind of ARIMA model fits best into the data. In this research, Akaike information criteria (AIC) and Bayesian information criteria (BIC) is used for choosing the best determinants of the model.

$$AIC = \frac{-2}{T} ln(likelihood) + \frac{2}{T} \times (number\ of\ parameters) \tag{6}$$

In equation (6) the likelihood function is evaluated at the maximum likelihood estimates and T is number of observations. Basic AIC function does not give penalty by the number of parameters used that can lead to overly complex model. BIC (7) gives penalty for each parameter used, thus model does not go too complex. (Tsay 2005: 41–42.)

$$BIC(l) = ln(\sigma_l^2) + \frac{l\ ln(T)}{T} \tag{7}$$

It is important to understand that ARIMA model is a strong memory model because coefficient in its moving-average does not decay to zero over time. This means that prior shocks have permanent effect in the future. (Tsay 2005: 99.)

3.2.3 Quantile regression

Quantile regression divides variable for deciles. Idea of the quantile regression is to show, how the result of basic OLS estimation can differ in distinct quantiles.

Y is random variable and τth quantile of Y is defined as the function (8) where $0 < \tau < 1$.

$$Q(\tau) = inf\{y: F(y) \geq \tau\} \tag{8}$$

The general τth sample quantile $\text{э}(\tau)$ which is the analog of $Q(\tau)$, is calculated as the minimizer Koenker (2005: 10.) of:

$$\text{э}(\tau) = min_{\text{э}\in R} \sum_{i=1}^{n} \rho(y_i - \text{э}) \tag{9}$$

where $\rho_\tau(z) = z(\tau - I(z < 0)), 0 < \tau < 1$, and where $I(\cdot)$ denotes the indicator function. Weight of τ to positive residuals $y_i - \text{э}$ and a weight of 1- τ to negative residuals are added to the loss function ρ_τ. Koenker (2005: 10.)

Finally, quantile regression estimates of the linear conditional function $Q(\tau|X=x)=x^t\beta(\tau)$, can be calculated by using function Koenker (2005: 10.):

$$\hat{\beta}(\tau) = min_{\beta\epsilon R^\rho} \sum_{i=1}^{n} \rho_\tau (y_i - x_i^t\beta) \tag{10}$$

3.2.4 Autocorrelation

Autocorrelation exists if some observation of the data is correlated with prior observation of the data. Hill *et al.* (2001: 341.) defines autocorrelation with error terms. Time series is autocorrelated if its error terms are correlated with each other.

This means that following assumption of the error terms (11) does not hold. Variables e_t and e_s are random errors. (Hill *et al.* 2001: 341.)

$$cov(e_t e_s) = 0, t \neq s \tag{11}$$

Autocorrelations function (ACF) determines the aurocorrelation between two observations. The correlation coefficient between $\mathrm{r_t}$ and $\mathrm{r_{t-\ell}}$ means lag- ℓ autocorrelation of $\mathrm{r_t}$ and in the following equation (12) it is denoted by ρ_ℓ.

$$\rho_\ell = \frac{Cov(r_t r_{t-\ell})}{\sqrt{Var(r_t)Var(r_{t-\ell})}} \tag{12}$$

The null hypothesis of ACF tests $H_0 : \rho_\ell = 0$ which means that if value of the ACF test is zero no autocorrelation exists. In this research, is also used Ljung Box (1978) test of autocorrelation. (Tsay 2005: 26–27.)

Ljung and Box method (13) tests if several autocorrelations of $\mathrm{r_t}$ are jointly zero. Ljung and Box test can be proposed as following:

$$Q(m) = T(T+2)\sum_{\ell=1}^{m}\frac{\hat{\rho}_\ell^2}{T-l} \tag{13}$$

For now $\hat{\rho}$ is consistent estimate of ρ. In Ljung-Box test the null hypothesis should be rejected if $\mathrm{Q(m)} > \mathrm{X}_\alpha^2$ where X_α^2 means the 100(1- α)th percentile of a chi-squared distribution with m degrees of freedom. T means number of observations. (Tsay 2005: 26–27.)

3.2.5 Unit Root Tests for Stationary

In time series analysis important assumption is stationary. Stationary means that mean, variance and covariance are constant over time. This means that they are not time-varying. In situations when time series are not stationary it can lead to spurious regression. Spurious regression means that some variables in regression have statistically significant relations. (Gujarati 2003: 792.)

Stationary is tested by using test of unit-root. Existence of unit-root is done by Said and Fuller's (1984) augmented Dickey-Fuller test (ADF), Phillips and Perron's (1988) Phillips-Perron -test and Kwiatkowski *et al.* (1992) Kwiatkowski-Phillips-Schmidt-Shin –test (KPSS). Generally speaking, traditional DF-test is very sensitive for mistakes and is has quite low explanatory power. In additional, the traditional DF – test assumes that error terms are independently and identically distributed (iid). ADF-test is very useful test for longer maturity time series. ADF –test extents traditional DF –tests' assumption of error terms for adding lagged difference terms. (Gujarati 2003: 817-819.) ADF - test can be estimated using some of the following regressions:

$$\Delta y_y = \gamma y_{t-1} + \varepsilon_t \tag{14}$$

$$\Delta y_y = a_0 + \gamma y_{t-1} + \varepsilon_t \tag{15}$$

$$\Delta y_y = a_0 + \gamma y_{t-1} + a_2 t + \varepsilon_t \tag{16}$$

The first of these models is random walk model, the second model takes into account the drift term and the third model adds drift and linear trend components. Stationary is solved with regression parameter γ. The null hypothesis of ADF-test is non-stationary. (Enders 2004: 181.)

Variable y_t is stationary if its order of integration is zero $I(0)$. On the other hand, variable y_t is integrated order to one $I(1)$ if y_t is non-stationary, but its first difference Δy_t is stationary. Normally, economic variables are non-stationary, but their first differences, returns, are stationary.

PP – test is based on nonparametric methods by taking control of error terms. Moreover, PP –test is useful for testing shorter maturity time series. In times, when ADF- and PP- tests give mixed results, it is appropriate to use KPSS – test for getting more evidence. ADF- and PP- tests assume that null hypothesis is non-stationary. However KPSS –test works other way round, because null hypothesis assumes stationary. Limitation of unit-root tests is important to note. There is no one test that could displace other test. In conclusion it is important to use different unit-root tests together for getting correct and robust results of stationary. (Gujarati 2003: 817-819.)

According to Schwert (1987) results, in ADF- and PP-test possibility to reject the null hypothesis is low. Basically, appropriate way to measure stationary is to use all of these tests.

3.2.6 VAR – model

Assets returns modeling can be done with vector autoregressive model. Vector autoregressive model can be used for analyzing of multivariate time series. In VAR – model can be tested several endogenous variables together. In VAR – model every endogenous variable is explained by its own historical values. VAR – model uses lagged and past values by explaining endogenous variables. In times, when it is not clear that variable is exogenous, good way to analyze it, can be done by analyzing all variables similarly. (Gujarati 2003: 837.)

Simple two variables VAR model can be expressed following:

$$y_t = b_{10} - b_{12}z_t + \gamma_{11}y_{t-1} + \gamma_{12}yz_{t-1} + \varepsilon_{yt} \quad (17)$$

$$z_t = b_{20} - b_{21}z_t + \gamma_{21}y_{t-1} + \gamma_{22}yz_{t-1} + \varepsilon_{zt} \quad (18)$$

where y_t and z_t are stationary. Variables ε_{yt} and ε_{zt} are non-correlated white noise process. Variables y_t and z_t can have some affection for each other, at the same time. So, VAR model incorporates feedback because of y_t and z_t affect to each others. Multiplier $-b_{12}$ represent unit change effect of z_t to y_t contemporanously. Multiplier γ_{12} shows lagged unit change effect of z_{t-1} to y_t. Variables ε_{yt} and ε_{zt} are shocks in variables y_t and z_t. (Enders 2004: 264–265.)

3.2.7 Granger causality test

Causality is important determinant in time series analysis. Statistically speaking, time does not run backward. For example, some event happens before another event. Hence, it is possible that the event before causes the event afterwards. However, the event afterwards cannot cause the event before. Thus, events that have happened past can cause events which will happen now, but not in other way round. In statistical analysis, dependence of one variable to other variables does not always prove causality. There can be relationship between two variables but it does not necessarily imply causality. (Gujarati 2003: 696.)

In time series analysis Granger causality test determines whether one time series is useful in forecasting another. In the model (19), is considered two time series y_t and x_t. If in a regression of y_t all multipliers of x_s are zero, the time series x_t fails to Granger cause y_t.

$$y_t = \sum_{i=1}^{k} \alpha_i y_{t-1} + \sum_{i=1}^{k} \beta_i x_{t-1} + u_t \qquad (19)$$

If $\beta_i = 0$ (i = 1, 2, 3, … , k) x_t fails to cause y_t. Length of the lag, k, can be [0, ∞[. (Maddala & Lahiri 2009: 390.)

In VAR environment, causality test can be done by analyzing how lags of one variable affect to equation for another variable. Idea is to estimate VAR model and to test can lagged values of variable y_t explain variable z_t at statistically significant level. Variable y_t does not Granger cause z_t, if and only if, all lagged values of variable y_t are zero. The null hypothesis is that variable y_t does not Granger cause variable z_t. When variables in the VAR analysis are stationary the following equation (20) can be used to (Enders 2004: 283.):

:

$$a_{21}(1) = a_{21}(2) = a_{21}(3) \ldots = a_{21}(p) = 0 \qquad (20)$$

Granger causality test is very sensitive to lags. So, for getting robust results it is appropriate to use information criteria (21) of Schwarz (1978) for estimating the length of lags (*l*).

$$l = 12 * \left(\frac{T}{100}\right)^{0,25} \tag{21}$$

3.2.8 Impulse-response function

Impulse-response function can be used as a part of VAR analysis. VAR model can be written as a vector moving average (VMA). In the case of two variables VAR in matrix form:

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \bar{y}_t \\ z_t \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} e_{1t-i} \\ e_{2t-i} \end{bmatrix} \tag{22}$$

Vector errors are:

$$\begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} = \frac{1}{1 - b_{12}b_{21}} \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix} \tag{23}$$

After adding vector errors model is:

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \bar{y}_t \\ \bar{z}_t \end{bmatrix} + \frac{1}{1 - b_{12}b_{21}} \sum_{i=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{yt-i} \\ \varepsilon_{zt-i} \end{bmatrix} \tag{24}$$

Previous model is simplified determining 2 × 2 matrix $\emptyset_i$:

$$\emptyset_i = \frac{A_1^i}{1 - b_{12}b_{21}} \begin{bmatrix} 1 & -b_{21} \\ -b_{12} & 1 \end{bmatrix} \tag{25}$$

(Enders 2004: 273-274.)

$\emptyset_i$ is called impulse response functions. Variables y_t and z_t can be represented with structural shocks ε_{yt} and ε_{zt}: (Enders 2004: 273-274.)

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \bar{y}_t \\ \bar{z}_t \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \emptyset_{11}(i) & \emptyset_{12}(i) \\ \emptyset_{21}(i) & \emptyset_{22}(i) \end{bmatrix} \begin{bmatrix} \varepsilon_{yt-i} \\ \varepsilon_{zt-i} \end{bmatrix} \quad (26)$$

VMA-model is practical way to analyze relation between variables y_t and z_t. The coefficient of $\emptyset_i$ can be used to estimate what kind of effect shocks ε_{yt} and ε_{zt} have for time paths of the variables y_t and z_t. Matrix four elements $\emptyset_{jk}(0)$ are called as impact multipliers. Impact multipliers define instant effects of shocks. Using graphs of impulse-response functions is practical way to estimate how shocks affect for time paths over time. (Enders 2004: 273-274.)

In order to define the impulse responses in VAR system it must be identified restrictions. One possibility is to use Choleski decomposition which states that in the case of two variables, variable y_t does not have affection to the variable z_t at the same time. This can be done by setting multiplier b_{21}, so error terms are possible to decompose as:

$$e_{1t} = \varepsilon_{yt} - b_{12}\varepsilon_{zt} \quad (27)$$

$$e_{2t} = \varepsilon_{zt} \quad (28)$$

Choleski decomposition has constraining effect. For now, shock ε_{zt} affects for both variables y_t and z_t at the same time. Shock ε_{yt} has no direct effect to the variable z_t , but there is indirect effect to it through the lagged value of variable y_t. Because of this asymmetric behavior, the variable z_t is said to be causally prior to y_t . (Enders 2004: 273-274.)

3.2.9 Cointegration

Normally nonstationary time series cannot be used together in order to avoid possibility of spurious regression. However, cointegration is an exception. Time series has to be non-stationary that it is possible to test cointegration between two series. Cointegration means that at least two time series share same stochastic drift. In fact, the difference between time series is stationary, so they never go too far away from each other. Thus, if two time series are cointegrated they have long run equilibrium relationship. So, in the case of cointegration time series are mean-reverting. (Hill *et al.* 2001: 38.)

Cointegration does not mean that time series moves one-to-one all time time. It just means that time series have some common spread where both series always return. Hence, time series does not have to behave similarly all the time, because it is enough that they return to the level of stable spread. Sometimes, spread can be widening or lowering, but homever both series are mean-reverting towards some "stable" spread between each other.

Johansen (1988) cointegration test is based on the maximum likelihood test for testing the relationship between the rank of the matrix and its characteristic roots. Johansen method is based on simple VAR model (29):

$$x_t = A_1 x_{t-1} + \varepsilon_t \tag{29}$$

Where the change of x_t can be expressed as following:

$$\Delta x_t = A_1 x_{t-1} - x_{t-1} + \varepsilon_t = (A_1 - I)x_{t-1} + \varepsilon_t = \pi x_{t-1} + \varepsilon_t \tag{30}$$

where x_t and ε_t = (n × 1) vectors,
A_1 = (n × n) matrix of parameters,
I = (n × n) identity matrix,
and π = $(A_1 - I)$ = number of cointegration vectors.
(Enders 2004: 348.)

The amount of independent cointegrating vectors is equal to π which is the rank of matrix. Level of the rank identifies number of the cointegrating vectors. If rank is zero, rank(π)=1 non of the roots does not differ from zero and there is no cointegrating vector. If rank is one, rank(π)=1, there is one cointegrating vector and thus, πx_{t-1} can be used as a error-correction term. If rank is n, rank(π)=n, all vectors are stationary. In the case, where 1 < rank(π) < n, all vectors can be stationary. (Enders 2004: 352.)

Rank(π) and its roots can be estmate by using following equations where, $\ddot{Y}_i$ is the estimated values of the characteristic roots from matrix and T is the number of observations. (Enders 2004: 352–353.)

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} ln(1 - \ddot{Y}_i) \tag{31}$$

$$\lambda_{max}(r, r+1) = -Tln(1 - \ddot{Y}_{r+1}) \tag{32}$$

Using first test value λ_{trace}, it is possible to test the null hypothesis, which states that there is equal or less than r cointegration vectors. Alternative hypothesis states that there is more than r cointegration vectors. Exact amount of cointegration vectors can be estimated using the test value λ_{max}. In this case, the null hypothesis states that there is r cointegration vectors. More specifically, critical values of the test statistics λ_{trace} and λ_{max} are obtained from Monte Carlo simulation. (Enders 2004: 353.)

3.2.10 R^2, t-test and F-test

R^2 is a measure of the proportion of variation in the dependent variable. It is explained by variation in the explanatory variable. In the case of multiple regression, proportion of variation in the dependent variable is explained by all the explanatory variables.. The coefficient of determination is used to tell as a predictive ability of the model. Normally in regression programs, goodness of the fit can be measured by using adjusted $\bar{R}^2$ (33).

$$\bar{R}^2 = 1 - \frac{SSE/(T-K)}{SST/\,(T-1)} \tag{33}$$

where SSE = sum of squared least squares residuals, portion of the variation which the model is not explained,

SST = total variation of the dependent variable,

K = number of observations and
T = number of explanatory variables.

Adjusted $\bar{R}^2$ varies between 0 and 1. If $\bar{R}^2$ is high (low) it means high (low) explanatory power and model fits well (poorly) into the data. (Hill *et al.* 2001: 162-163.)

Generally speaking, testing significance of a single coefficient is done by t-test. Purpose of t-test is to give evidence whether the data provide evidence of significance of the one variable. Testing significance is called testing the null hypothesis (34). Testing parameters using t-test hypothesis are followings:

$$H_0 : \beta_k = 0$$
$$H_1 : \beta_k \neq 0$$

$$t = \frac{b_k}{se(b_k)} \sim t(T-k) \tag{34}$$

(Hill *et al.* 2001: 159–160.)

The F-test is widely used test for comparing statistical models that have been fit into the data. The idea of the F-test is to compare the sum of squared errors from the multiple regression model to the sum of squared errors from a regression model when null hypothesis is assumed to be true. If these sums of squared errors are different, the assumption that the null hypothesis is true, reduces the compatibility of the model and data. Then, data cannot support the null hypothesis. On the other hand, if the null hypothesis is true, data is compatible with the parameter conditions. So, there is a little variation in the sum of squared errors when the null hypothesis holds. Hypothesis for the F-test are following:

$$H_0: \beta_1 = 0, \beta_2 = 0, \dots, \beta_n = 0$$
$$H_1: \text{at least one } \beta_j \neq 0.$$

The F-test is referred test of the overall statistical significance of the regression model. So, the F-test does not give answer which variables by itself are statistically significant. (Hill *et al.* 2001:170-176.)

3.2.11 Data

Purpose of this research is to analyze inflation relation with returns of asset classes by using global data. Basically, almost all prior articles are based on U.S data. However, it is very relevant and important to analyze global data for getting more broad results. One of the objectives is to compare prior results from U.S for this global evidence. However, global data is not available for all assets why it is a must for some assets to use U.S data.

In this research all data is gathered by using monthly observations. As a global inflation index is calculated from OECD's total Consumer Price Index (CPI). Inflation is a logarithmic difference of CPI index. CPI is a appropriate inflation indicator and it is widely used in academic research. OECD's Consumer Price Index is gathered from OECD's statistical database. OECD's total Consumer Price Index is formed by weighting countries based on their previous year's household private final consumption expenditure of households and non-profit institutions serving households that can be present in purchasing power parity (PPP). OECD –total Consumer Price Index includes OECD member countries and six non-member countries: Brazil, China, India, Indonesia, Russia and South Africa. OECD –total Consumer Price Index data is from January 1970 to February 2012.

Stock market data in this research contains three different global stock indexes. Data of stocks, bonds and commodities are gathered from Thomson Reuter's database. MSCI World Equity Index is a global stock market index that contains over 1600 stocks from developed markets. MSCI World Equity index is price index without dividends. Data is from December 1969 to March 2012. For getting more accurate results this research is done also for small and large cap indexes. MSCI World AC small cap and large cap indexes are used. Data of small and large cap indexes is from May 1994 to March 2012. It should be noted that MSCI World index contain global data from developed countries. However MSCI World AC small and large cap indexes contains data also from emerging markets that is important to notice.

As a global commodity index is used Goldman Sachs Commodity Index (GSCI). Data is from December 1969 to May 2012. GSCI is weighted index which contains 24 commodities from all commodity sectors. In academic research GSCI is widely used commodity index, but it should be noted that, it has higher exposure to energy sector than many other commodity index. As a gold index is used Gold London Bullion Market index where one unit is one troy Ounce. The date is taken from Thomson Reuters database and it is from January 1968 to March 2012.

Merril Lynch Global Government Index is the bond index that is used in this research. Data is from May 1994 to March 2012. In this research, it is also used Barclays U.S Aggregate Government Bond Index because Merril Lynch Global Government Bond Index is available just from early 90s. The data for Barclays U.S Aggregate Goverment Bond Index is from January 1973 to March 2012. The data for both bond indexes is gathered from Thomson Reuter's database. For inflation-linked bond index is used Barclays's U.S Equity TIPS index which is also known as U.S Government Inflation-Linked Bond Index. U.S TIPS index measures the performance of the U.S Treasure Inflation Protected Securities including TIPS with one or more years remaining maturity. Data is taken from January 2004 to March 2012 from Bloomberg database.

Data for interest rates is taken from FED website. U.S interest rates is used, because global interest rate data is not available. As interest rates is chosen U.S treasury securities at 3 months, 12 months and 10 years maturity. Data is from January 1962 to December 2011.

Global REIT index is taken from Bloomberg database and for now it is used as a global property index. SP / Citigroup REIT Index (SREITGL) is a global property index comprised of property companies. Data is from January 1995 to April 2012. Again, global REIT data is available only from early 90s, thus it is also used FTSE NAREIT U.S Real Estate Index. FTSE NAREIT index includes commercial real estates across U.S economy. Data for FTSE NAREIT index is from January 1972 to March 2012 and it is taken from Bloomberg database.

CPI is fitted separately for every indexes, because the length of time series differ across asset classes. Global assets data is compared with OECD total CPI and U.S assets data is analyzed against U.S CPI. Data for U.S CPI is taken from Fed's website.

In this research, full names of asset classes are shortened in the following tables. MSCI World Equity Index is known as MSCI World, MSCI World small means MSCI World AC Small Cap Index and MSCI global large means MSCI World AC Large Cap Index. Fed's 3-months and 12-months treasury bills are known as 3- and 6-months t-bill. Then, 10 years interest rate is known as 10 yrs interest rate. Merril Lynch Global Government Index is named on Global govt. index and Barclays U.S Aggregate Bond Index is named on U.S aggr. bond. U.S Government Inflation-Linked Bond Index is known as U.S TIPS. Goldman Sachs Commodity Index is known as GSCI and Gold London Bullion Market index is known as Gold LBM. S&P Global REIT index is named on SREITGL and FTSE NAREIT U.S Real Estate Index is known as NAREIT. All the data is analyzed by using statistical RStudio 0.95.262 software.

All the test is done using logarithmic values. The nominal rates of returns R_i are taken from index values as logarithmic differences at time t - 1 to time t and CPI is changed for inflation similarly.

$$R_i = difference[log(index\ value)] \tag{35}$$

Index values are changed for the real rates of returns R_r for the following way:

$$R_r = difference[log(index\ value/CPI)] \tag{36}$$

Naturally, there is no index values for interest rates (r), hence interest rates R_{ir} are changed logarithmic values by taking logarithmic for the following way:

$$R_{ir} = log(1 + r/100) \tag{37}$$

4 EMPIRICAL RESEARCH

4.1 Results

4.1.1 Nominal and real returns

Table 1 illustrates how nominal and real returns vary across asset classes and time periods. The returns are calculated with logarithmic values. Correlation in the last row presents the correlation between asset and inflation. Historically, almost all asset classes offer positive annual nominal returns, but the case is completely different with real returns. Interestingly, real returns have been even negative for some assets. In fact, it is not enough that assets' nominal returns are positive if the inflation rate is at the same time even bigger. Nominal returns on assets have to be positive that there would be some chance for getting inflation hedge return.

Table 1. Nominal and real returns on assets

Asset	Years	Total nominal return	Total real return	Yearly avg. nominal return	Yearly avg. real return	Correlation
Stocks						
MSCI World	1970-2011	253%	-3.7 %	6.20%	-0.1 %	-0.0003
MSCI World small	1995-2011	90 %	37%	5.30%	2.2 %	0.0898
MSCI World large	1995-2011	60 %	6.4 %	3.50%	0.4 %	0.1144
Interest rates						
3 months t-bill	1962-2011	261%	59%	5.30%	0.012	0.4354
12 months t-bill	1962-2011	288 %	86 %	5.90%	0.018	0.4260
10 yrs interest rate	1962-2011	336%	134 %	6.90%	2.7 %	0.3565
Bonds						
Global govt. index	1994-2011	109 %	50%	6%	2.8 %	-0.0285
US aggr. bond	1973-2011	9.9 %	-159 %	0%	-4.1 %	-0.1303
TIPS US	2004-2011	14.0 %	- 6.0 %	1.70%	-0.7 %	0.2689
Commodities						
GSCI	1970-2011	391 %	134%	9.50%	3.3 %	0.2849
Gold						
Gold LBM	1970-2011	391 %	134 %	9.50%	3.3 %	0.1137
REITs						
SREITGL	1995-2011	56 %	2.8 %	3.30%	0.2 %	0.1765
NAREIT	1972-2011	446%	275 %	11.40%	7.1 %	0.1145

Table 1 shows how nominal and real returns on assets vary and differ across asset classes. It is interesting to see the role of inflation in the long run when comparing total nominal returns with total real returns. Total nominal returns are positive for all asset classes, but because of inflation, real returns turn out to be negative for some assets. For example, U.S Aggregate Bond Index, MSCI World and U.S TIPS offer negative total real return. The last two rows show average annual returns of asset classes. Again, all asset classes offer positive annual nominal returns, but real returns are negative for some assets. NAREIT, GSCI, Gold LBM, Global Govt. Bond Index, 10 years interest rate and MSCI World offer quite decent average annualized nominal return. Interestingly, NAREIT has given 7.1 percent average real return per annual. Moreover, GSCI and Gold LBM have offered 3.3 percent average annual real return. On the other hand, MSCI World, U.S Aggregate Bond Index and U.S TIPS real returns are negative.

The correlation results in table 1 indicate positive relation between inflation and assets except MSCI World, Global Govt. Bond Index and U.S Aggregate Bond Index. The highest positive correlation is around 40 percent between U.S treasury interest rates and inflation. Also, GSCI, U.S TIPS and REITs contain high positive correlation with inflation. Moreover, Gold LBM, MSCI AC small and large cap have around 10 % positive correlation between nominal returns and inflation.

It should be noted that at the moment global financial crisis is still going on and stock prices have dropped dramatically during the past few years. On the other hand, gold and some commodities have been rallying. Thus, these results in table 1 would have been very different, if the data would have ended for the year 2007. However, table 1 shows the true figures of the current situation using historical data available from the beginning to the present. In addition, these correlation numbers are only approximations of dependency between inflation and returns providing some insight, but leaving a gap for final conclusion.

It is easy to say that for assets those real returns are close to zero or even negative, cannot offer hedge against inflation in the long run. On the other hand, if both nominal and real returns are positive, there is some opportunity to get hedge against inflation. Although, if some asset is hedge against inflation in the long run, the situation can be opposite in the short run.

4.1.2 Autocorrelation

In table 2, there is proposed autocorrelations for nominal returns across assets. In the beginning, autocorrelation of this sample is divided into 12 different lags by following Fama and Schwert (1977). In order to get robust results, autocorrelation is also tested with Box-Ljung test by using 12 lags. Overall, the results suggest that nominal returns on assets are autocorrelated.

Table 2. Autocorrelation of monthly nominal rates of return

Asset	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	ρ_7	ρ_8	ρ_9	ρ_{10}	ρ_{11}	ρ_{12}	Box-Ljung
Stocks													
MSCI World	0.122	-0.035	0.078	0.046	0.044	-0.071	-0.016	0.004	0.006	0.040	-0.024	0.060	19.191*
MSCI World small	0.231	-0.024	0.081	0.076	-0.061	-0.104	-0.017	-0.022	-0.047	-0.031	-0.039	-0.001	18.846*
MSCI World large	0.143	-0.004	0.117	0.089	-0.019	-0.053	-0.011	0.006	-0.040	0.004	-0.029	0.045	10.919
Interest rates													
3 months t-bill	0.986	0.971	0.957	0.943	0.928	0.914	0.899	0.885	0.871	0.856	0.842	0.828	6016.584***
12 months t-bill	0.987	0.975	0.962	0.950	0.937	0.924	0.912	0.899	0.887	0.874	0.862	0.849	6167.511***
10 yrs interest rate	0.991	0.983	0.974	0.966	0.957	0.949	0.940	0.931	0.923	0.914	0.906	0.897	6516.224***
Bonds													
Global govt. index	0.105	-0.085	0.011	-0.066	-0.213	-0.034	-0.180	0.061	0.100	0.048	0.135	-0.118	27.784***
US aggr. bond	0.141	-0.125	-0.086	-0.037	-0.004	-0.041	-0.072	0.024	-0.004	0.052	0.104	-0.004	30.941***
TIPS US	-0.027	-0.147	0.024	-0.036	-0.036	0.105	-0.016	-0.137	-0.047	0.049	-0.074	-0.103	8.287
Commodities													
GSCI	0.130	0.053	0.045	-0.034	0.022	-0.018	-0.058	-0.037	0.033	0.025	0.148	-0.054	28.322**
Gold													
Gold LBM	0.062	-0.053	0.002	-0.004	0.053	-0.028	-0.003	0.109	0.094	0.092	0.126	0.094	34.718***
REIT													
SREITGL	0.182	-0.073	0.160	0.238	-0.001	-0.176	0.010	0.039	-0.064	-0.141	0.063	0.103	41.122***
NAREIT	0.114	-0.134	0.078	0.158	0.004	-0.137	0.015	0.042	-0.052	-0.124	0.103	0.148	65.063***
Inflation													
OECD global inf.	0.753	0.600	0.602	0.572	0.558	0.591	0.563	0.541	0.559	0.519	0.602	0.668	2195.548***
Inflation USA	0.564	0.409	0.294	0.297	0.264	0.257	0.288	0.271	0.310	0.346	0.420	0.430	969.771***

Symbols ***. ** and * denote. 0.01. 0.05 and 0.10 significance levels respectively.

However, by looking more deeply at Box-Ljung statistics, nominal returns of stocks are not highly autocorrelated. The Box-Ljung statistics indicate similar results for U.S TIPS. With both stocks and U.S TIPS ratios of all the 12 lags are quite close to zero which states non-autocorrelation. Box-Ljung statistics show that all other nominal returns of asset class are highly autocorrelated. Moreover, 12 lags differ from zero more dramatically between other asset classes than stocks or U.S TIPS. The highest autocorrelation is for interest rates. Gold LBM, REITs, U.S Aggregate Bond Index, Global Government Bond Index and inflation are quite heavily autocorrelated. By comparing global inflation to U.S inflation, evidence is almost the same.

Shortly speaking, level of autocorrelation for nominal returns are different across asset classes. For example, as autocorrelation evidence shows, inflation is a long-memory process. This means that inflation movements are quite permanent. Moreover, interest rates give similar results.

Tsay (2004: 89-91.) explains that long-memory processes are time series whose ACF decays slowly to zero at polynomial rate as lag increases. Normally, ACF decays to zero exponentially. If fractional differences of long-memory processes follows ARMA (p,q) model, then x_t is called an ARFIMA(p,d,q,) process.

Table 3 shows autocorrelation of real returns across assets. The real return is nominal return minus the observed inflation rate for the period. Generally speaking, autocorrelation is a little bit lower for real returns than for nominal returns. However, autocorrelation still exists for various assets.

Table 3. Autocorrelation of monthly real rates of return

Asset	ρ1	ρ2	ρ3	ρ4	ρ5	ρ6	ρ7	ρ8	ρ9	ρ10	ρ11	ρ12	Box-Ljung
Stocks													
MSCI World	0.127	-0.064	0.071	0.048	0.052	-0.061	-0.004	0.015	0.005	0.04	-0.022	0.062	19.060*
MSCI World small	0.224	-0.03	0.081	0.085	-0.05	-0.094	-0.007	-0.014	-0.048	-0.036	-0.04	0	17.719
MSCI World large	0.132	-0.014	0.112	0.096	-0.014	-0.05	-0.003	0.012	-0.044	-0.004	-0.031	0.046	10.341
Interest rates													
3 months t-bill	0.503	0.312	0.187	0.189	0.144	0.131	0.170	0.165	0.198	0.250	0.343	0.361	526.114***
12 months t-bill	0.522	0.337	0.217	0.218	0.173	0.163	0.202	0.195	0.226	0.275	0.361	0.376	616.611***
10 yrs interest rate	0.541	0.363	0.249	0.248	0.209	0.201	0.237	0.223	0.254	0.297	0.378	0.386	719.771***
Bonds													
Global govt. index	0.129	-0.072	-0.007	-0.075	-0.128	-0.053	-0.174	0.063	0.113	0.069	0.153	-0.098	30.331***
US aggr. bond	0.205	-0.078	-0.055	-0.006	0.021	-0.031	-0.058	0.027	0.012	0.093	0.141	0.034	41.159***
TIPS US	-0.066	-0.125	0.019	-0.028	-0.015	0.084	-0.028	-0.129	-0.032	0.078	-0.06	-0.059	6.358
Commodities													
GSCI	0.122	0.052	0.042	-0.042	0.027	-0.018	-0.065	-0.039	0.037	0.023	0.146	-0.059	27.993***
Gold													
Gold LBM	0.053	-0.055	-0.003	-0.008	0.052	-0.029	-0.002	0.105	0.096	0.098	0.134	0.101	34.826***
REITs													
SREITGL	0.174	-0.08	0.156	0.24	0.002	-0.162	0.019	0.045	-0.06	-0.143	0.064	0.105	39.647***
NAREIT	0.114	-0.13	0.078	0.158	0.006	-0.13	0.02	0.049	-0.045	-0.121	0.106	0.147	63.470***

Symbols ***. ** and * denote. 0.01. 0.05 and 0.10 significance levels respectively.

Again, US treasury rates show high autocorrelation. For stocks and U.S TIPS, non-autocorrelation stays quite stable when comparing nominal and real returns. Except the first lag, autocorrelations are quite close to zero for many assets. However, autocorrelation remains high for GSCI, bonds, Gold LBM and REITs.

Overall, autocorrelation exists little stronger for nominal returns than for real returns. In Fama & Schwert (1977) article, autocorrelation exists for nominal returns, but almost disappears for real returns. They argue that autocorrelation for nominal returns indicate that nominal returns vary with inflation. On the other hand, real returns are not correlating with inflation. Basically, Fama and Schwert evidence indicates that assets can be hedged against inflation, because nominal returns are related with inflation and real returns are not.

Evidence of table 2 present that autocorrelation exists for nominal returns which support Fama & Schwert's (1977) prior findings. However, table 3 shows that real returns of many assets are also autocorrelated which challenges previous results.

Thus, because real returns are autocorrelated it is possible that assets are not hedged against inflation.

4.1.3 Unit-roots

It is important to test stationary of the data to get robust results. Stationary is tested by ADF-, PP- and KPSS-tests. These three methods are used, because unit-roots are sensitive to errors. Economically speaking, almost all economic variables are non-stationary, but their returns are stationary.

Table 4. Existence of unit-roots for index values

Assets	ADF	Lag	PP	Lag	KPSS	Lag
Stocks						
MSCI World	-3.2084*	7	-16.234	6	7.853***	5
MSCI World small	-2.848	5	-12.794	4	4.085***	3
MSCI World large	-2.673	5	-10.011	4	1.868***	3
Bonds						
Global govt. index	-1.748	6	-8.954	4	5.430***	3
US aggr. bond	-3.514**	7	-33.37***	5	4.719***	4
TIPS US	-1.491	4	-8.809	3	1.232***	2
Commodities						
GSCI	-3.630**	7	-27.842**	6	7.853***	5
Gold						
Gold LBM	1.427	8	3.886	6	4.303***	5
REITs						
SREITGL	-2.412	5	-6.766	4	2.550***	3
NAREIT	-2.404	7	-9.114	5	6.3442***	5
Inflation						
OECD Global CPI	-4.1163***	7	-6.886	5	8.588***	5
CPI USA	-3.8716**	8	-6.465	6	10.542***	5

Symbols ***. ** and * denote. 0.01. 0.05 and 0.10 significance levels respectively.

Existence of unit-roots for index values of asset classes is analyzed in table 4. The results support the general belief that economic variables are non-stationary. ADF-test shows non-stationary in every other asset class except GSCI, U.S Aggregate Bond Index and inflation. Also, Phillips-Perron test shows non-stationary in all other assets except commodities and U.S Aggregate Bond Index. However, according to KPSS test all asset classes are non-stationary.

In this research, the main focus is on returns. Returns are calculated from index values by using logarithmic differences. In table 5, is analyzed existence of unit-roots for nominal returns. The evidence suggests that index values are non-stationary, but their logarithmic differences are stationary except interest rates.

Table 5. Existence of unit-roots for differences

Assets	ADF	Lag	PP	Lag	KPSS	Lag
Stocks						
MSCI World	-7.798***	7	-459.861***	5	0.102*	5
MSCI World small	-5.567***	5	-174.196***	4	0.045*	3
MSCI World large	-5.567***	5	-192.761***	4	0.097*	3
Interest rates						
3 months t-bill	-2.216	8	-8.654	6	3.034***	5
12 months t-bill	-2.041	8	-7.212	6	3.141***	5
10 yrs interest rate	-1.629	8	-4.238	6	2.728***	5
Bonds						
Global govt. index	-7.6217***	6	-197.670***	4	0.031*	3
US aggr. bond	-8.431***	7	-347.438***	5	0.021*	4
TIPS US	-4.868***	4	-92.865***	3	0.113*	2
Commodities						
GSCI	-8.413***	7	-426.643***	5	0.231*	5
Gold						
Gold LBM	-6.242***	8	-568.777***	6	0.238*	5
REITs						
SREITGL	-5.513***	5	-171.176***	4	0.072*	3
NAREIT	-7.547***	7	-421.985***	5	0.066*	5
Inflation						
OECD global inflati	-5.072***	7	-199.836***	5	5.513*	5
Inflation USA	-4.464***	8	-300.641***	6	1.449*	5

Symbols ***. ** and * denote. 0.01. 0.05 and 0.10 significance levels respectively.

The results of table 5 show clearly that returns are integrated order to one $I(1)$.

4.1.4 Nominal returns against inflation

At the beginning, the relationship between returns on asset classes and inflation is investigated using basic OLS estimation method. Lags for regression are estimated by using Schwert information criteria and Newey-West correction is made for error terms. Graham (1996) argues that (3) equation does not divide inflation between expected and unexpected components, but nevertheless provides same useful information about inflation hedging possibilities of asset classes.

Table 6. Results from the OLS estimation $R_{i,t} = \alpha_0 + \alpha_1 INF_i$

Asset	Coefficient estimates				
	α_0	$(\alpha_0)t$	α_1	$(\alpha_1)t$	Lag
Stocks					
MSCI World	0.005	1.004	-0.003	-0.004	18
MSCI World small	-0.001	-0.085	1.9970	1.013	14
MSCI World large	-0.003	-0.414	2.284	1.465	14
Interest rates					
3 months t-bill	0.003***	9.827	0.291***	4.147	19
12 months t-bill	0.004***	10.015	0.304***	4.270	19
10 yrs interest rate	0.005***	13.888	0.215***	3.961	19
Bonds					
Global Govt. index	0.006***	2.780	-0.229	-0.355	15
US aggr. bond	0.002**	2.267	-0.521***	-2.812	18
TIPS US	-0.001	-0.331	1.16	1.419	14
Commodities					
GSCI	-0.017**	-2.000	4.904***	2.974	18
Gold					
Gold LBM	-0.003	-0.484	2.030	1.266	18
REITs					
SREITGL	-0.008	-0.510	4.027	0.969	14
NAREIT	0.004	1.188	1.549**	2.517	18

Symbols ***. ** and * denote. 0.01. 0.05 and 0.10 significance levels respectively.

The regression in table 6 provides information between inflation and nominal returns of asset classes in the long run. Conclusion is based on Fama and Schwert (1977) argument that nominal returns on assets should be related one-to-one with inflation that assets could provide hedge against inflation.

Table 6 shows the results of OLS estimation between inflation and returns on assets. Explanatory variable is inflation and dependent variable is return. Evidence indicates that MSCI World is negatively related with inflation. On the other hand, MSCI World small and large cap indexes seem to offer hedge against inflation. The reason for this mixed result can be that small and large cap indexes contain stocks also from emerging high inflation markets. This supports Choudhry (1999) and Spyrou (2004) prior findings that stocks from emerging high inflation countries can give better hedge against inflation than stocks from developed countries. However, time series are quite sort for MSCI World AC small and large cap, so it cannot conclude too much from this evidence.

Interest rates are all positively related with inflation at statistically significant level. However, positive relation is quite small which indicates no hedging ability against inflation. Global Government Bond Index and U.S Aggregate Bond Index are negatively related with inflation. Thus, bonds are the worst assets against inflation. Althought, Even U.S TIPS seem to offer hedge against inflation, but the result is not statistically significant.

Table 6 shows that GSCI offer the best and statistically significant hedge against inflation. In fact, GSCI is highly positively related with inflation. Gold LBM offer also hedge against inflation, but the result is not significant. Both of REIT indexes are positively related with inflation and actually REITs seems to offer hedge against inflation. Moreover, NAREIT index offers statistically significant evidence at 95 percentage significance level.

In conclusion, the results in table 6 indicate that GSCI offers the best and full hedge against inflation compared to other assets in the long-term. Moreover, REIT, Gold

LBM, interest rates, U.S TIPS, MSCI World AC small and large cap are also positively related with inflation. In fact, REIT, Gold LBM, GSCI and U.S TIPS perform better against inflation than traditional asset classes. However, MSCI World, Global Government Bond Index and U.S Aggregate Bond Index cannot offer any hedges against inflation in the long run.

4.1.5 Nominal returns against expected and unexpected inflation

Previous table 6 proposed how nominal returns of asset classes behave against inflation by using OLS estimation. In this section is examined, how nominal returns are related with expected and unexpected inflation. Forecasts of ARIMA model are used as an components of expected inflation rates α_1 and forecast errors are components of unexpected inflation rates α_2. As it has been mentioned earlier, length of time series differ which means that appropriate ARIMA model and inflation components have to estimate for every time series separately. The last row of following table shows, what kind of ARIMA model has been selected. Appropriate ARIMA model is chosen by using AIC (Akaike Information Criteria) and BIC (Bayesian Information Criteria). According to Fama and Schwert (1977) article, variance of disturbance, $S(\eta)$, in this case is the variance of the asset's real return.

Table 7. Hedges against expected and unexpected inflation, $R_{i,t} = \alpha_0 + \alpha_1 B_1 + a_2 B_2 + \eta$

Asset	Coefficient estimates								
	α_0	α_0(t)	α_1	α_1(t)	α_2	α_2(t)	S(η)	R^2	ARIMA
Stocks									
MSCI World	0.007*	1.782	-0.438	-0.607	0.741	0.782	0.00192	0.002	(1.0.2)
MSCI World small	0.005	0.682	-0.181	-0.074	3.367*	1.736	0.00274	0.014	(0.0.2)
MSCI World large	-0.001	-0.145	1.550	0.707	2.745	1.576	0.00221	0.014	(0.0.2)
Interest rates									
3 months t-bill	0.002***	14.965	0.685***	19.816	0.053**	1.968	0.00000	0.399	(2.0.1)
12 months t-bill	0.002***	16.163	0.726***	19.602	0.048*	1.677	0.00000	0.393	(2.0.1)
10 yrs interest rate	0.004***	28.470	0.552***	16.670	0.010	0.390	0.00000	0.318	(2.0.1)
Bonds									
Global govt. index	0.011***	3.958	-2.059**	-2.380	0.899	1.321	0.00036	0.033	(0.0.2)
US aggr. bond	0.001	0.630	-0.178	-0.608	-0.748***	-3.144	0.00023	0.022	(1.0.2)
TIPS US	0.000	-0.131	0.934	1.242	1.264***	2.451	0.00037	0.074	(0.0.2)
Commodities									
GSCI	-0.001	-0.229	1.723**	1.966	10.267***	8.680	0.00300	0.137	(1.0.2)
Gold									
Gold LBM	0.003	0.592	0.855	0.858	4.043***	3.094	0.00336	0.020	(1.0.2)
REITs									
SREITGL	-0.010	-1.258	4.828*	1.915	3.525*	1.762	0.00288	0.032	(0,0,2)
NAREIT	0.010**	2.262	-0.098	-0.097	2.569***	3.258	0.00258	0.022	(1.0.2)

Symbols ***, ** and * denote, 0.01, 0.05 and 0.10 significance levels respectively.

Table 7 shows that MSCI World and MSCI World small cap indexes are negatively related with expected inflation and cannot offer any hedges. On the other hand, MSCI World large cap index offers hedge against both, expected and unexpected inflation. Moreover, variance of disturbance shows that real return for MCSI World large cap is not affected by inflation. It should be noted that data for MSCI small and large cap indexes is available only from 1995 to early 2012 and it has been very low inflation period. However, the results for stock indexes are not statistically significant.

Data for interest rates shows that interest rates cannot offer hedge against expected or unexpected inflation. Interest rates are statistically significantly positive related with expected inflation, but, the coefficient of α_1 is under one which states that they cannot offer hedge against expected inflation. Also, interest rates are poor hedge against unexpected inflation. The explanatory power for interest rates is high.

Global Government Bond Index and U.S Aggregate Bond Index cannot offer hedge against expected or unexpected inflation. In fact, both bond indexes are negatively related with inflation. On the other hand, evidence shows that U.S TIPS can offer at least partial hedge against expected and unexpected inflation.

As it has been seen in table 6, GSCI offers the best hedge against inflation. Table 7 shows that GSCI gives statistically significant hedge against both, expected and unexpected inflation components. Also, the explanatory power of this regression is decent. For GSCI, the variance of disturbance shows that inflation has no affection for real returns. Gold LBM index provides statistically significant hedge only against unexpected inflation.

REIT indexes are giving mixed results. S&P Global REIT Index provides hedge against expected and unexpected inflation. However, S&P Global REIT Index hedge is statistically significant only at 90 percentage level and data starts from 1995 including only periods of low inflation. Data for U.S NAREIT REIT Index starts from 1972 including inflationary periods and as it shows, NAREIT can offer statistically significant hedge against unexpected inflation. Interestingly, NAREIT is negatively related with expected inflation.

In conclusion, GSCI offers the best and full hedge against expected and unexpected inflation in the long run. In addition, Gold LBM, U.S TIPS and REITs indexes can offer at least partial hedge against inflation. For the opposite, stock and bond indexes are even negatively related against expected inflation.

4.1.6 Quantile regression

Table 8 presents the results of quantile regression. In quantile regression explanatory variable is inflation and dependent variable is return on assets. Quantile regression divides inflation for desiles. For example, desile of 0.05 takes into account 5 percentage of the lowest inflation rate observations. The results show that in low desiles, for example 0.05, 0.1 and 0.25 the relation between inflation and returns on assets is positive.

Table 8. Quantile regression, $R_{i,t} = \alpha_0 + \alpha_1 B_1 + \eta$

Asset	Coefficient estimates													
	0.05	t-value	0.1	t-value	0.25	t-value	0.5	t-value	0.75	t-value	0.9	t-value	0.95	t-value
Stocks														
MSCI World	0.005	0.667	0.005	0.965	0.003	0.752	0.001	0.131	-0.010*	-1.792	-0.007	-1.110	-0.010	-1.562
MSCI World small	-0.009	1.359	0.001	0.106	0.002	0.573	0.002	0.676	0.004	1.034	0.007	1.517	0.010**	2.335
MSCI World large	0.011	0.603	0.001	0.085	0.005	1.041	0.003	0.972	0.005	1.260	0.009*	1.732	0.011**	2.322
Interest rates														
3 months t-bill	0.400**	2.425	0.430***	6.344	0.593***	10.016	0.618***	11.362	0.709***	9.358	0.725***	6.891	0.807***	4.408
12 months t-bill	0.385***	2.618	0.408***	5.793	0.524***	9.274	0.570***	10.670	0.626***	9.499	0.679***	6.711	0.752***	4.216
10 yrs interest rate	0.500***	2.980	0.392***	5.078	0.505***	8.400	0.516***	7.610	0.788***	7.061	0.877***	6.065	0.889***	4.143
Bonds														
Global govt. index	-0.015	-0.899	-0.010	-0.663	0.008	0.674	0.004	0.453	0.019**	2.113	0.015	0.868	0.006	0.487
US aggr. bond	-0.060**	-2.420	-0.054***	-4.031	-0.011	-1.233	-0.019*	-1.912*	-0.030**	-2.351	-0.040	-1.551	-0.036	-1.032
TIPS US	0.144**	2.003	0.130***	3.588	0.082	1.573	0.007	0.278	-0.013	-0.419	-0.042	-1.260	0.015	0.429
Commodities														
GSCI	0.025***	8.869	0.023***	6.566	0.019***	7.290	0.020***	7.274	0.015***	3.055	0.007	1.521	-0.001	-0.045
Gold														
Gold LBM	0.003	1.456	0.004	1.445	0.004*	1.713	0.003	0.909	0.007*	1.944	0.007*	1.898	0.007	0.872
REITs														
SREITGL	0.020***	6.513	0.012	1.382	0.003	0.503	-0.001	-0.319	0.001	0.240	-0.007	-1.262	0.010**	2.368
NAREIT	0.020	1.205	0.008	1.421	0.004	1.195	0.003	1.063	-0.004	-1.013	-0.004*	-1.780	0.005	0.544

Symbols ***, ** and * denote, 0.01, 0.05 and 0.10 significance levels respectively.

The results of MSCI World stock index show that the relation between inflation and returns is positive in deciles 0.05, 0.1, 0.25 and 0.5. However, the relation is negative in deciles 0.75 and 0.9. This means that when higher inflation observations are taken more into account, the relation turns out to be negative. Thus, MSCI World has positive relationship between inflation during low inflation times, but in inflationary periods the relationship is negative. Again, MSCI World small and large cap indexes behave differently compared to MSCI World stock index. In fact, the relationship between inflation and returns is positive in every decile for MSCI World small and large cap stock indexes. It should be noted that time series are short and contains only low inflation period observations for MSCI World small and large cap indexes which explains this result.

3-month, 12-month and 10 years interest rates are positively related with inflation in every decile and the results are statistically significant. Thus, interest rates behave similarly against inflation during lower or higher inflation time periods. The result of U.S Aggregate Bond Index shows that the relationship between return and inflation is negative in every decile. The result is statistically significant in deciles of 0.05, 0.1, 0.5 and 0.75. Interestingly, Global Government Bond Index gives different result, but it contains only low inflation observations. On the other hand, U.S TIPS are positively related with inflation from decile 0.05 to 0.5. The results are statistically significant for decile of 0.05 and 0.1. However, data of U.S TIPS contain only low inflation observations.

GSCI is positively related with inflation in every decile except decile of 0.95. Thus, as it has been mentioned in previous tables, GSCI offer the best hedge against inflation. However, even GSCI cannot offer hedge against inflation, when extremely high inflation observation has been taken into account. The result is statistically significant for GSCI from decile 0.05 to decile 0.75. Gold LBM index is positively related with inflation in every decile. The positive relationship is even bigger when larger inflation observations are taken into account. This supports common prior findings that gold is safe haven of assets.

REIT indexes have positive relationship with inflation for smaller deciles. Thus, REIT indexes seem to offer at least partial hedge during low inflation time periods. However, in larger deciles REIT indexes are negatively related with inflation.

In conclusion, GSCI is positively related with inflation in every decile except decile of 0.95. The results of GSCI are statistically significant from decile of 0.05 to 0.75. Gold LBM and interest rates are positively related with inflation in every decile. However, the result of Gold LBM is not significant. MSCI World, U.S TIPS and

REITs are positively related with inflation during low deciles, but the relationship is negative during high deciles. U.S Aggregate Bond Index and Global Government Bond Index are negatively related against inflation almost in every decile.

4.1.7 Causality

Causality analysis has been done by using Granger causality test. It should be noted that the results of Granger causality test can change very dramatically if lag values are different and, thus, the test has been done with different lags. Fama and Schwert (1977) general idea for monthly data is to use 12 lags. In table 8, in the first row, lags are estimated for Schwarz (1978) information criteria.

Table 9. Granger causality between inflation and returns

Assets	F	Lag	F	Lag
Stocks				
MSCI global	1,746**	18	1,706*	12
MSCI global Small	1,930**	14	1,733*	12
MSCI global Large	2,078**	14	1,569*	12
Interest rates				
3 months t-bill	0.784	19	1.332	12
12 months t-bill	0.874	19	1.487	12
10 yrs interest rate	1.567*	19	2.230***	12
Bonds				
US aggr. Bond	0.570	18	0.832	12
Global Govt. index	0.889	15	0.775	12
TIPS US	1.422	14	1,687*	12
Commodities				
GSCI	1,812**	18	2,011**	12
Gold				
Gold LBM	2,656***	18	2,746***	12
REIT				
SREITGL	1,730*	14	2,033**	12
NAREIT	0.896	18	1.105	12

Symbols ***, ** and * denote, 0.01, 0.05 and 0.10 significance levels respectively.

The results give clear evidence that inflation has Granger causal impact on stocks, GSCI, Gold LBM and S&P Global REIT Index. However, inflation does not have Granger causal effect for bond indexes. Interestingly, evidence indicates Granger causal effect for 10 years interest rate with inflation, but causality disappears for shorter maturity treasury rates. Again, REIT indexes give mixed results. Finally, evidence shows that causal effect does not exist between inflation and nominal returns of NAREIT.

4.1.8 Impulse-response analysis

Impulse-response function estimates how one standard deviation impulse affects response function by using bootstrapping method. For now, idea is to analyze how one standard deviation shock in inflation affects nominal logarithmic returns on assets.

In the figure of impulse-response function, the red line means balance level of asset class logarithmic return. Red dotted lines denote upper and lower bands of significance level at 95 percentage level. Black line describes movements of logarithmic return of asset during inflation shock. At the time, when the black line is in the middle of upper and lower bands the result is not statistically significant. Horizontal axis shows how many months shock in inflation affects for returns and the vertical axis points out percentage change of returns.

For time series of Gold LBM, GSCI and MSCI World time length is long and one standard deviation in inflation is 0.34 percentages. Thus, the results analyze what kind of an impact on 0.34 percentage shock in inflation has for logarithmic returns.

Following figures, Gold LBM shows that inflation shock have positive impact to logarithmic returns of gold. In 0.34 percentage shock in logarithmic inflation have instant 0.55 percentage positive impact on the logarithmic returns of gold. This figure shows that gold offers quite good hedge against inflation shock in the short run. The figure of Gold LBM shows that impacts hold over 10 months. However, this evidence is not statistically significant.

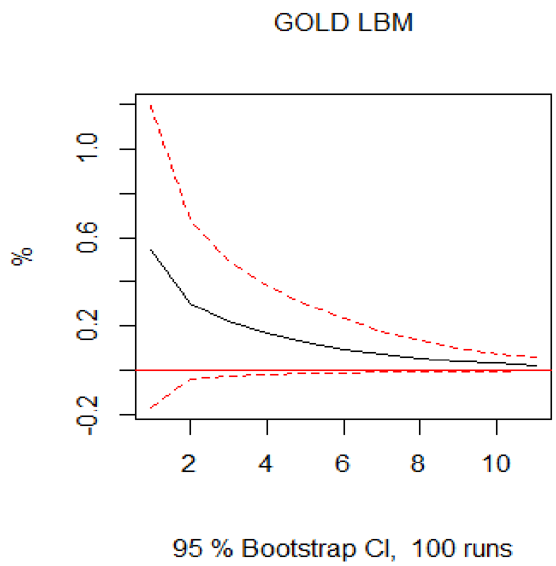

Figure 2. Impulse-response function for Gold LBM

Figure 3 shows that one standard deviation shock in the logarithmic inflation have 0.19 percentage positive impact on logarithmic returns of GSCI.

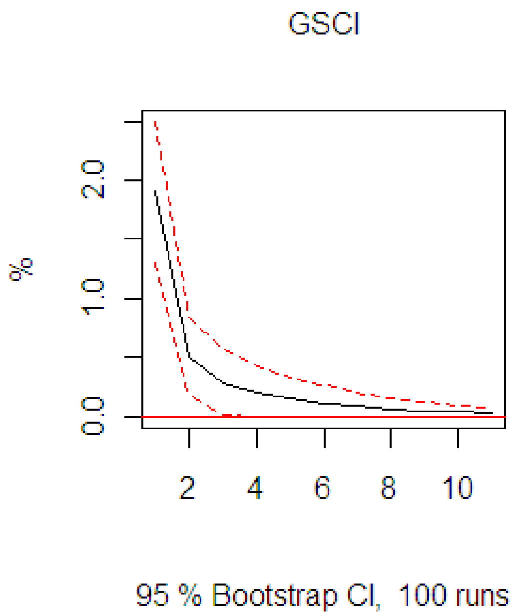

Figure 3. Impulse-response function for GSCI

The shock holds around 10 months. The result of GSCI indicates that instant reaction is statistically significant. Moreover, in the short-term GSCI offers at least partial hedge against inflation shock.

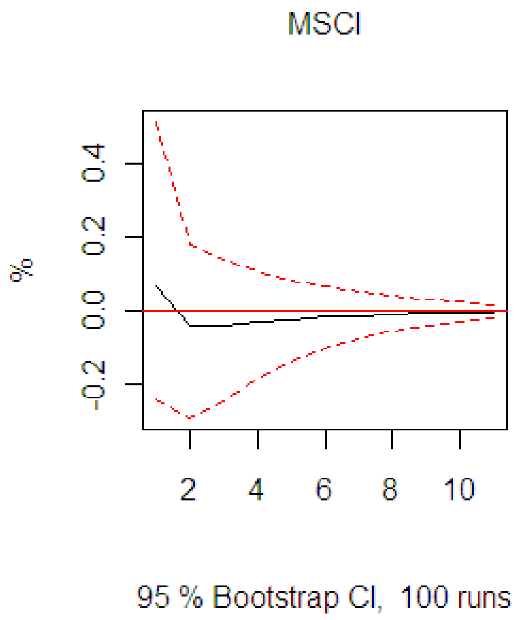

Figure 4. Impulse-response function for MSCI World

The figure of MSCI World shows different results than GSCI or Gold LBM. MSCI World index does not have almost any reaction against inflation shock. Affection of shock holds 10 months until index return for balance level. Thus, MSCI World stock index cannot offer hedge against inflation shock in the short run, but result is not statistically significant.

In the case of MSCI World AC small and large cap index time series is shorter, so inflation has to be matched. For now, one standard deviation shock in the logarithmic inflation is 0.24 percentage.

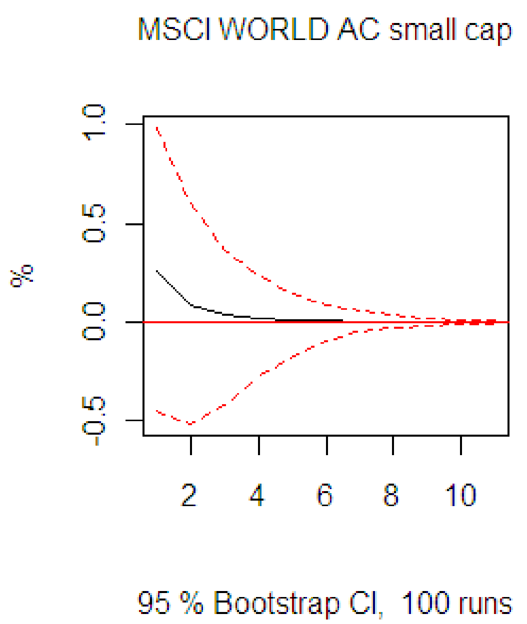

Figure 5. Impulse-response function for MSCI World AC small cap

MSCI AC small cap index indicates same kind of results than MSCI World. Figure 5 indicates that 0.24 percentage shock in the logarithmic inflation does not have almost any impact on logarithmic returns of small cap index. However, the result is not statistically significant.

However, the figure 6 shows the result of MSCI AC large cap index The results differ previous stock indexes and the evidence shows clearly that shock in the logarithmic inflation has 0.27 percentage positive impact on logarithmic returns of MSCI World AC large cap index. Impact of inflation shock rise logarithmic returns even the second month. Impaction of inflation shock holds around 8 months. So, this indicates that MSCI World AC large cap index offers the best hedge against inflation shock compared to other two stock indexes. Again, the result is not statistically significant.

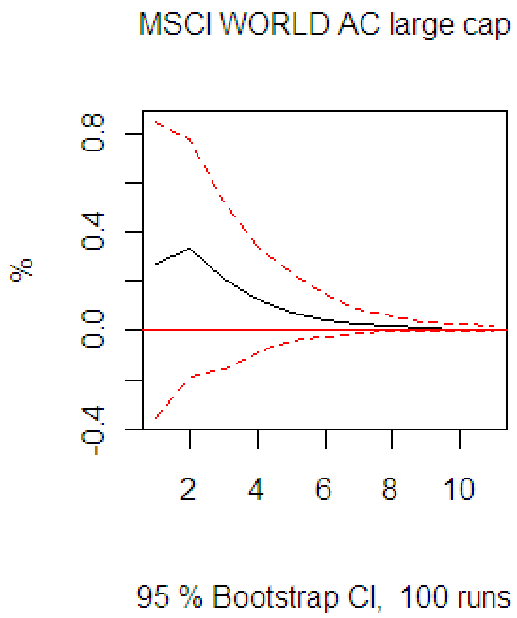

Figure 6. Impulse-response function for MSCI World AC large cap

Figures 7,8 and 9 explain, how interest rates reacts against inflation shocks. For interest rates inflation shock is in this case 0.36 percentage. The figure of three months Treasure bills shows that inflation shock has 0.003 percentage positive affection for the rate and affection of shock holds around 4 months. For the 12 months Treasury bill inflation shock has quite similar affection. Inflation shock has 0.004 percentage positive impact on the 12 months t-bill.

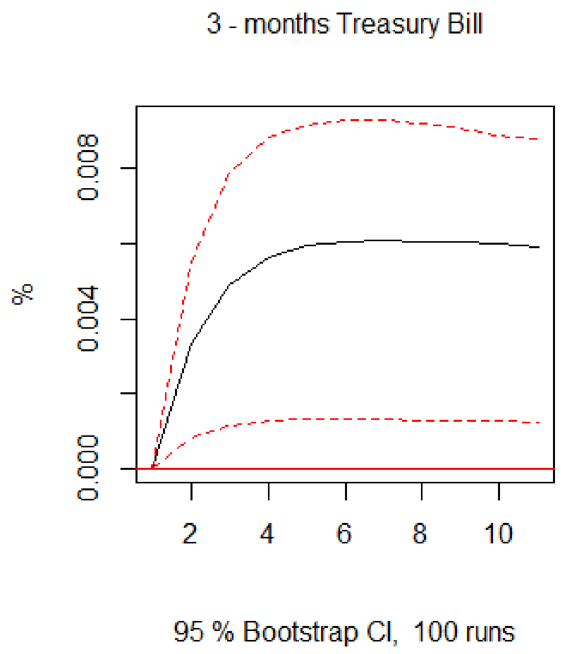

Figure 7. Impulse-response function for 3-months t-bill

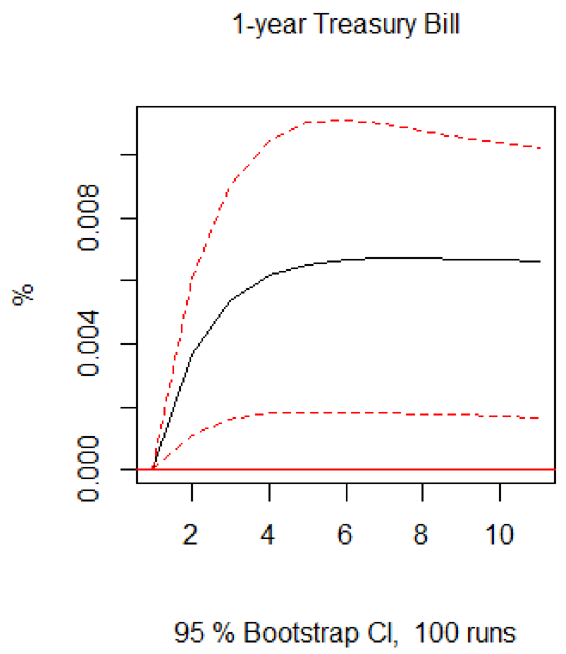

Figure 8. Impulse-response function for 12-months t-bill

In the case of 10 years interest rate, inflation shock has more permanent affection. Inflation shock has also 0.003 percentage positive impact for 10 years interest rate, but shock holds around 7 months.

It can be said that inflation shock of 0.36 percentage has positive impact for the short and long maturity interest rate. Instant reaction for the shock is similar for all interest rates, but shock is more permanent for longer maturity interest rates. Interest rates' positive reaction against inflation shock is much less than actual shock. Interestingly, the results for the interest rates are statistically significant.

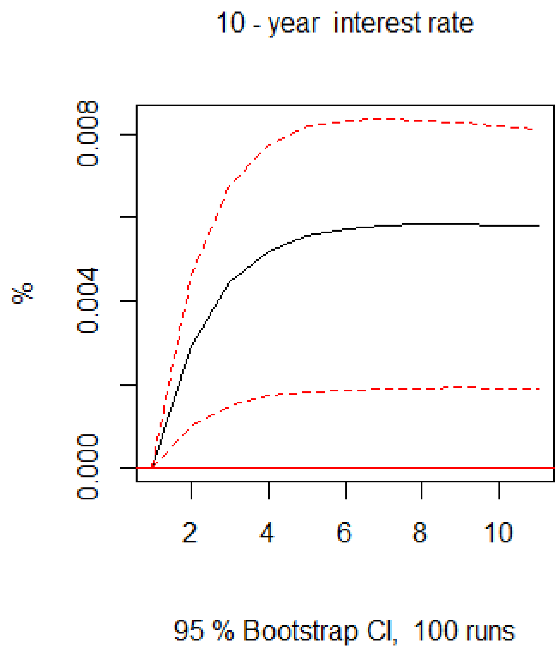

Figure 9. Impulse-response function for 10 years interest rate

The following figure shows how 0.24 percentage shock in inflation affects returns of Global Government Bond Index.

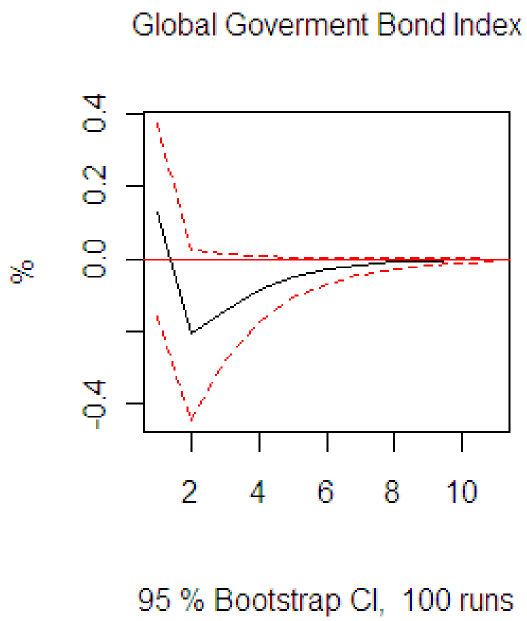

Figure 10. Impulse-response function for Global Government Bond Index

This result gives opposite evidence than any previous asset class. The result shows that shock in the logarithmic inflation has instant 0.13 percentage positive impact on logarithmic returns of bonds. However, after instant reaction shock turns out to negative. Impact of shock holds around 7 months. Moreover, this result is statistically significant.

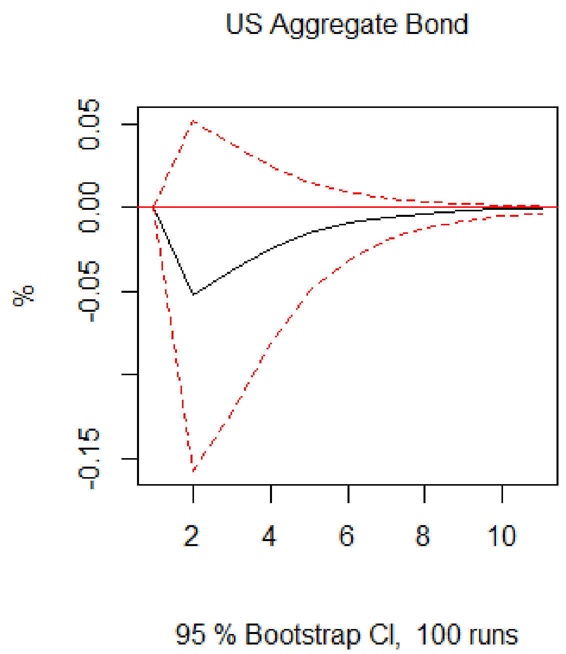

Figure 11. Impulse-response function for U.S Aggregate Bond Index

As figure of U.S Aggregate Bond Index shows, 0.38 percentage shock in logarithmic inflation causes 0.05 decreases in the index. Both bond indexes give similar results: shock in inflation have negative impact on bond returns.

Interestingly, U.S TIPS have completely opposite reaction for inflation shock than bond index. In the U.S data logarithmic inflation shock is 0.46 percentages and it has instant 0.56 percentages positive impact on logarithmic returns of U.S TIPS. In the case of U.S TIPS inflation shock holds around 6 months.

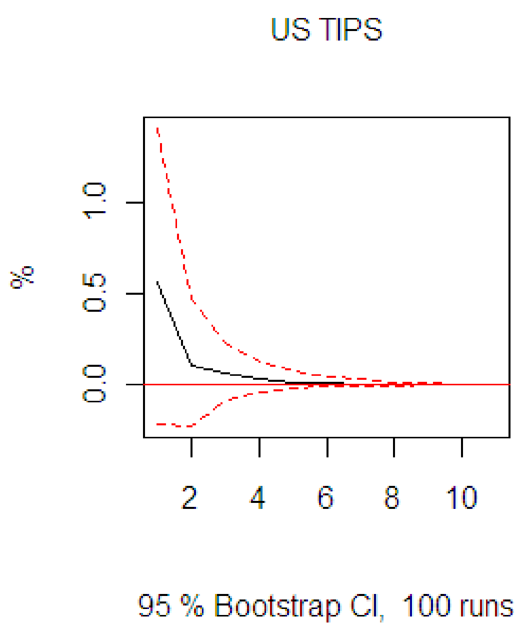

Figure 12. Impulse-response function for U.S TIPS

S&P Global REIT Index has positive reaction against shock in inflation. 0.24 percentage logarithmic inflation shock has 0.74 percentage positive impact on returns of REITs. This indicates that REIT offers good hedge against inflation shock in the short run. Shock holds around 6 months. However, the result is not statistically significant.

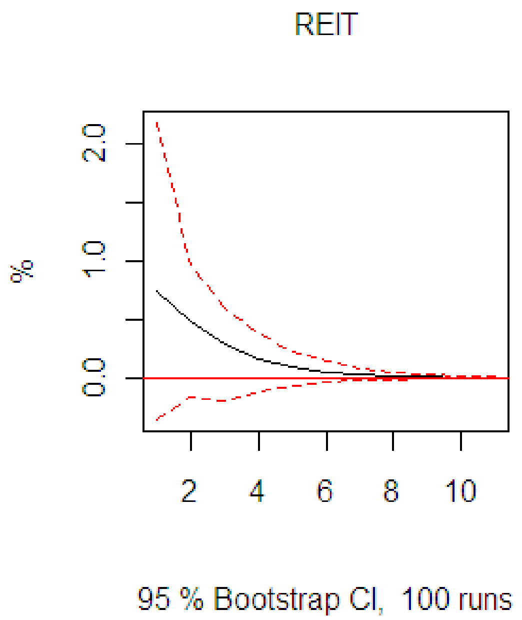

Figure 13. Impulse-response function for Global REIT Index

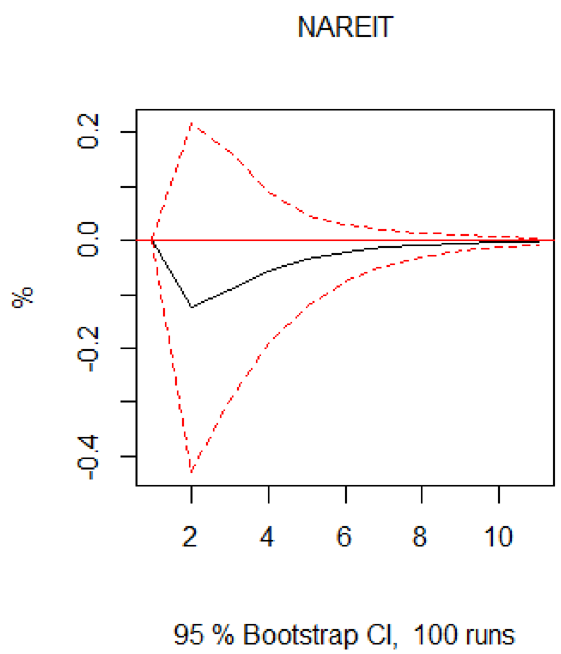

Figure 14. Impulse-response function for NAREIT Index

U.S NAREIT index gives completely different results than previous global REIT index. Time series of NAREIT contain evidence from high inflation periods which can explain this phenomenon. Figure shows that 0.38 percentage shock in inflation causes 0.12 percentage decrease in NAREIT.

Overall, the results show clearly that different asset classes have different reaction against inflation shock. GSCI, Gold LBM, MSCI World AC large cap, interest rates and U.S TIPS have positive reaction against inflation shock. Thus, this indicates that these asset classes offer the best short-term hedge against inflation shock. The results of REITs are mixed. Global Government Bond Index reacts completely opposite way against inflation compared to other assets. Bonds react negatively against inflation shock which indicates that they cannot offer short-term hedge against inflation shock. MSCI World and MSCI World AC small cap indexes do not react almost at all for inflation shock. So, stocks are not good hedge against inflation in the short run either. Interestingly, figures of GSCI and interest rates show clearly that inflation shock has an instant, statistically significant impact on returns. It could be said that GSCI and interest rates offer the best hedge against inflation shock compared to other asset classes.

4.1.9 Cointegration

Cointegration between returns of asset classes and inflation is tested by using Johansen and Phillips-Ouliar's methods. Purpose of cointegration test is to find out, if there is some common relation between returns and inflation in the long run. Johansen method is based on following critical values:

rank	10pct	5pct	1pct
r <= 1	6.50	8.18	11.65
r = 0	12.91	14.90	19.19

Starting point for Johansen method is to look at rank 0. If the test value of rank 0 is lower than critical values, it means no cointegration. On the other hand, if the test value is above critical values, values at rank 1 is looked. Then, in rank 1, if the test value is lower than critical values, there is cointegration. In some cases, in rank 1 the test value can be above critical values again between two time series. This means that Johansen method cannot give answer of cointegration. Amount of ranks is same than amount of time series. Lags are estimated using Schwert information criteria for Johansen method. Philips-Ouliar test estimates lags by itself.

Table 10. Cointegration tests

Asset	Johansen			Phillips-Ouliar	
	λ_0	λ_1	Lag	Test value	Lag
Stocks					
MSCI World	18.13***	0.36	18	-17.475*	5
MSCI World small	15.38***	3.77	14	-7.865	2
MSCI World large	12.20***	4.41	14	-2.497	2
Interest rates					
3 months t-bill	23.740	1.61***	18	-2.818	5
12 months t-bill	23.880	1.07***	18	-2.617	5
10 yrs interest rate	28.490	0.16***	18	-1.080	5
Bonds					
Global Govt. index	8.38***	0.200	15	-7.138	2
US aggr. bond	21.81	0.52***	18	-14.239	4
TIPS US	9.47***	0.000	14	-4.085	0
Commodities					
GSCI	12.14***	0.070	18	-23.217**	5
Gold					
Gold LBM	15.830***	0.070	18	-0.8789	5
REITs					
SREITGL	6.800***	4.610	14	-2.361	2
NAREIT	6.640***	0.330	18	-7.334	4

Symbols ***, ** and * denote, 0.01, 0.05 and 0.10 significance levels respectively.

In table 10, Johansen method shows that cointegration exists in U.S Aggregate Bond Index and interest rates at 95 percentage significance level. However, Philips-Ouliar method rejects cointegration in the cases of interest rates and U.S Aggregate Bond Index. Thus, there is no reliable information of cointegration.

4.1.10 Returns against inflation in periods

As it has been noted before, inflation has changed dramatically over time. 1970s and early 80s were high inflation periods globally. After early 80s inflation has lowered clearly and last 15 years have been very low inflation periods. Periodic analysis includes assets those data is available from 1970 to 2011.

Table 11 presents the relation between inflation and returns on assets from 1970 to 1983 by using OLS estimation. Again, Newey-West correction is made for error terms and lags are estimated using Schwert information criteria. During that time period average global inflation was 10.2 percentage annually.

Table 11. Hedges against inflation $R_{i,t} = \alpha_0 + \alpha_1 INF_i$

Asset	Coefficient estimates				
	α_0	$\alpha_0(t)$	α_1	$\alpha_1(t)$	Lag
1970-1983					
MSCI World	0.013**	2.294	-1.1580	-1.356	14
3 months t-bill	0.005***	5.201	0.226**	2.299	14
12 months t-bill	0.006***	5.393	0.201**	1.977	14
10 yrs interest rate	0.007***	3.415	0.0683	0.647	14
US aggr. bond	0.003	0.828	-0.4840	-1.060	13
GSCI	0.007	0.693	0.5570	0.389	14
Gold LBM	-0.018	-0.874	4.154	1.472	14
NAREIT	0.012	1.643	-0.250	-0.242	13

Symbols ***, ** and * denote, 0.01, 0.05 and 0.10 significance levels respectively.

As table 11 shows, assets cannot offer hedge against high inflation. In fact, MSCI World stock index, U.S Aggregate Bond Index and NAREIT are negatively related with inflation. Interestingly, even GSCI cannot offer hedge against inflation. Gold LBM seems to offer full hedge against inflation, but the result is not statistically significant.

Table 12. Hedges against inflation $R_{i,t} = \alpha_0 + \alpha_1 INF_i$

Asset	Coefficient estimates				
	α_0	α_0(t)	α_1	α_1(t)	Lag
1984-1996					
MSCI World	0.018**	2.374	-1.626	-1.070	13
3 months t-bill	0.004***	9.378	0.182***	3.535	13
12 months t-bill	0.005***	10.13	0.191***	4.023	13
10 yrs interest rate	0.006***	14.968	0.138**	3.685	13
US aggr. bond	0.004*	1.843	-1.180**	-1.980	13
GSCI	-0.024**	-2.220	6.429***	2.953	13
Gold LBM	-0.005	-0.737	0.954	0.677	13
NAREIT	0.015**	2.317	-1.665	-0.802	13

Symbols ***, ** and * denote, 0.01, 0.05 and 0.10 significance levels respectively.

Table 12 shows, how returns are related with inflation from 1984 to 1996. During this period average global inflation was 6.8 percentage annually. Again, MSCI World, U.S Aggregate Bond Index and NAREIT are negatively related with inflation. However, GSCI offers full and statistically significant hedge against inflation. Gold LBM is at least a partial hedge against inflation.

Table 13. Hedges against inflation $R_{i,t} = \alpha_0 + \alpha_1 INF_i$

Asset	Coefficient estimates				
	α_0	α_0(t)	α_1	α_1(t)	Lag
1997-2011					
MSCI World	-0.003	-0.381	2.047	1.170	14
3 months t-bill	0.002*	1.781	0.019	0.750	14
12 months t-bill	0.003*	1.898	0.019	0.757	14
10 yrs interest rate	0.004***	5.502	0.004	0.280	14
US aggr. bond	0.002*	1.797	-0.691**	-2.238	14
GSCI	-0.042***	-4.645	18.682***	6.705	14
Gold LBM	0.003	0.684	2.599**	2.334	14
NAREIT	-0.001	-0.136	4.241	1.344	14

Symbols ***, ** and * denote, 0.01, 0.05 and 0.10 significance levels respectively.

Table 13 shows data from 1997 to February 2012. On that time global average inflation has been 3.5 percentage annually. For now, MSCI World, GSCI, Gold LBM and NAREIT offer hedge against inflation. However, the results are statistically significant only for GSCI and Gold LBM indexes.

Overall, the results show that returns on assets have different relations with inflation. In fact, during inflationary period none of the asset classes cannot offer statistically significant inflation hedge. On the other hand, when inflation is low, MSCI World, GSCI, Gold LBM and NAREIT can offer hedge against inflation.

4.1.11 Returns against expected and unexpected inflation in periods

Periodic analysis between returns on assets against expected and unexpected inflation is done by using ARIMA model. Again, periodic analysis includes assets those data is available from 1970 to 2011. Table 14 shows the relationship between inflation and nominal returns on assets from 1970 to 1983. In that time, average global inflation was at 10.2 percentage annually.

Table 14. Hedges against expected and unexpected inflation, $R_{i,t} = \alpha_0 + \alpha_1 B_1 + a_2 B_2 + \eta$

Asset	Coefficient estimates								
	α_0	α_0(t)	α_1	α_1(t)	α_2	α_2(t)	S(η)	R^2	ARIMA
1970-1983									
MSCI World	0.020	1.619	-2.0741	-1.340	-0.422	-0.304	0.0016	0.011	(1.0.1)
3 months t-bill	0.004***	7.992	0.459***	6.238	0.095*	1.722	0.0000	0.203	(2.0.0)
12 months t-bill	0.005***	9.463	0.421***	5.464	0.078	1.352	0.0000	0.161	(2.0.0)
10 yrs interest rate	0.006***	14.724	0.176**	2.560	0.008	0.154	0.0000	0.038	(2.0.0)
US aggr. bond	-0.003	-0.581	0.4630	0.597	-0.925*	-1.750	0.0004	0.026	(2.0.0)
GSCI	0.032	1.782	-2.5394	-1.160	3.047	1.550	0.0032	0.023	(1.0.1)
Gold LBM	-0.005	-0.171	2.385	0.729	5.577*	1.900	0.0071	0.025	(1.0.1)
NAREIT	0.037***	3.197	-4.105**	-2.389	1.756	1.420	0.0021	0.052	(2.0.0)

Symbols ***, ** and * denote, 0.01, 0.05 and 0.10 significance levels respectively.

As table 14 shows, almost none of these assets cannot provide hedge against expected or unexpected inflation. In fact, MSCI World, GSCI and NAREIT are negatively related against expected inflation. Moreover, MSCI World and U.S Aggregate Bond Index are negatively related against unexpected inflation. Interestingly, Gold LBM seems to offer hedge against expected and unexpected inflation. Additionally, variance of disturbance shows that real return does not vary with inflation. However, this result is not statistically significant. It should be noted that explanatory power is very low for assets except 3 and 12 months interest rates.

Table 15. Hedges against expected and unexpected inflation, $R_{i,t} = \alpha_0 + \alpha_1 B_1 + a_2 B_2 + \eta$

Asset	Coefficient estimates								
	α_0	α_0(t)	α_1	α_1(t)	α_2	α_2(t)	S(η)	R^2	ARIMA
1984-1996									
MSCI World	0.02517	1.510	-2.970	-0.954	-1.211	-0.697	0.0017	0.009	(0.0.1)
3 months t-bill	0.004***	7.564	0.433***	2.615	0.147**	2.419	0.0000	0.078	(0.0.1)
12 months t-bill	0.004***	7.924	0.454**	2.523	0.154**	2.334	0.0000	0.073	(0.0.1)
10 yrs interest rate	0.006***	12.191	0.327**	2.026	0.111*	1.886	0.0000	0.049	(0.0.1)
US aggr. bond	0.005	1.014	-1.743	-0.981	-1.098*	-1.740	0.0002	0.026	(0.0.1)
GSCI	-0.010	-0.638	3.716	1.328	7.265***	4.653	0.0014	0.133	(0.0.1)
Gold LBM	-0.007	-0.504	1.363	0.499	0.828	0.543	0.0013	0.004	(0.0.1)
NAREIT	0.028**	2.477	-6.230	-1.632	-1.052	-0.777	0.0010	0.021	(0.0.1)

Symbols ***. ** and * denote. 0.01. 0.05 and 0.10 significance levels respectively.

Table 15 shows the relation between nominal returns on assets againt expected and unexpected inflation from 1984 to 1996. During that period, average global inflation was at 6.2 percentage annually. Basically, inflation has lowered from 10 percentages towards 4 percentages during that period. As table 15 shows, MSCI World, U.S Aggregate Bond Index and NAREIT are negatively related against expected and unexpected inflation. GSCI offers hedge against expected and unexpected inflation. Variance of disturbance remains low, so real returns are not affected by inflation. Actually, GSCI seems to offer full hedge against inflation during that time. The result of GSCI is statistically significant against unexpected inflation. Explanatory power of GSCI seems to be decent. Gold LBM offer hedge against expected inflation, but the result is not statistically significant.

Table 16. Hedges against expected and unexpected inflation, $R_{i,t} = \alpha_0 + \alpha_1 B_1 + a_2 B_2 + \eta$

Asset	Coefficient estimates								
	α_0	α_0(t)	α_1	α_1(t)	α_2	α_2(t)	S(η)	R^2	ARIMA
1997-2011									
MSCI World	-0.001	-0.194	1.444	0.538	2.365	1.216	0.0024	0.010	(2.0.0)
3 months t-bill	0.002***	12.2	0.047	0.686	0.011	0.300	0.0000	0.003	(1.0.0)
12 months t-bill	0.002***	13.481	0.047	0.684	0.010	0.278	0.0000	0.003	(1.0.0)
10 yrs interest rate	0.004***	40.319	0.013	0.372	0.002	0.090	0.0000	0.001	(1.0.0)
US aggr. bond	0.002*	1.812	-1.111**	-2.175	-0.567**	-2.043	0.0002	0.048	(1.0.0)
GSCI	-0.032***	-3.709	14.479***	4.536	20.898***	9.026	0.0034	0.368	(2.0.0)
Gold LBM	0.000	-0.063	3.913	1.456	1.906	0.978	0.0024	0.017	(2.0.0)
NAREIT	-0.001	-0.148	4.07	1.521	4.291***	2.954	0.004	0.059	(1.0.0)

Symbols ***. ** and * denote. 0.01. 0.05 and 0.10 significance levels respectively.

Table 16 shows, how nominal returns are related against low inflation. During that period, average global inflation has been 2,8 annually. For now, MSCI World, GSCI, Gold LBM and NAREIT seems to offer hedge against expected and unexpected inflation. Also, variances of disturbances shows that inflation does not affect for real returns. So, during period from 1997 to 2011 MSCI World, GSCI, Gold LBM and NAREIT offer full hedge against inflation. Again, the explanatory power is very low for all assets except GSCI. In contrast, U.S Aggregate Bond Index is negatively related against expected and unexpected inflation.

As these periodic tables show, assets' relation against inflation varies across assets and periods. During inflationary period, none of these assets except gold cannot offer hedge against expected or unexpected inflation. However, during low inflation period, all assets except bonds are positively related against expected and unexpected inflation. More specifically, MSCI World, GSCI, Gold LBM and NAREIT seem to offer full hedge against both expected and unexpected inflation.

5 CONCLUSION

This research proposes evidence between returns on assets and inflation by using global data. For those assets that do not have global data available the research is done by using U.S data. First of all, this research describes the relation between nominal and real returns on assets. Evidence identifies that nominal returns on assets are all positive. On the other hand, after inflation correction, real returns are even negative for MSCI World, U.S Aggregate Bond Index and U.S TIPS. Thus, at least assets which real returns are negative, obviously cannot offer hedge against inflation.

Evidence of the autocorrelation test shows that nominal returns are autocorrelated which supports Fama and Schwert (1977) prior evidence. In fact, the level of autocorrelation varies between assets. For example, stock indexes and U.S TIPS are not highly autocorrelated, but interest rates and inflation are. More specifically, evidence shows that inflation and interest rates are long-memory processes. Thus, movements of interest rates and inflation are quite permanent. Interestingly, evidence of this research proposes that real returns are autocorrelated. These findings, repeals Fama and Schwert (1977) prior evidence which states that real returns are not autocorrelated. Consequently, existence of autocorrelation for real returns questions the idea of hedging ability of assets. Generally speaking, Fama and Schwert (1977) argue that assets can be hedged against inflation, because nominal returns are related with inflation and real returns are not.

The test of stationary suggests that index values are non-stationary, but their logarithmic differences which are known as returns are stationary except interest rates. This means that returns are integrated order to one I(1). This finding supports the general belief that almost all economic variables are non-stationary, but their logarithmic differences are stationary.

This research uses OLS and ARIMA models to get long run evidence how inflation is related with nominal returns on assets. Evidence of OLS and ARIMA models show that stocks cannot offer hedge against inflation. OLS estimation shows that

MSCI World stock index cannot offer hedge against inflation although MSCI World AC small and large cap indexes are positively related against inflation. More specifically, ARIMA model states that MSCI World is negatively related against expected inflation. On the other hand, MSCI World AC large cap index seems to offer hedge against expected and unexpected inflation. The reason for these mixed results of stock indexes can be that small and large cap indexes contain stocks from emerging high inflation markets. This finding supports Choudhry's (1999) prior evidence that stocks can offer at least partial hedge against inflation in emerging markets. Furthermore, time series for MSCI World AC small and large cap indexes contain data only for low inflation period.

OLS estimation explains that interest rates are positively related with inflation and the result is statistically significant. However, the relation is small, which states no hedging ability. ARIMA model gives supporting evidence that interest rates cannot offer hedge against either expected and or unexpected inflation.

According to OLS estimation, bond indexes seem to be negatively related against inflation. ARIMA model proposes that bond indexes cannot offer any hedge against expected or unexpected inflation. In fact, bonds are the worst assets against inflation. U.S TIPS offer hedge against inflation, but the result is not statistically significant. Unfortunately, time series for U.S TIPS is quite short so too much cannot be concluded from that.

OLS estimation shows that GSCI offers the best and statistically significant hedge against inflation. Interestingly, by using ARIMA model GSCI seems to offer hedge against both, expected and unexpected inflation. Moreover, Gold LBM and REIT indexes offer hedge against inflation, but the result is not statistically significant at 99 percentage significancy level. Fascinatingly, ARIMA model shows that Gold LBM can be used as a hedge against unexpected inflation, but not against expected inflation.

Periodic analysis of OLS estimation proposes that none of the assets can offer hedge against inflation during high inflation periods. However, ARIMA model gives mixed result since Gold LBM offers hedge against expected and unexpected inflation during high inflation periods. Quantile regression shows that in the cases of GSCI and Gold LBM, the rate of inflation does not affect the hedging ability of those assets. Thus, GSCI and Gold LBM seem to offer at least partial hedge against inflation almost in every decile.

During the periods when inflation is low, OLS estimation shows that MSCI World, GSCI, Gold LBM and NAREIT can offer hedge against inflation. Quantile regression gives similar results that MSCI World, U.S TIPS and REIT indexes seem to offer hedge against inflation, when the rate of inflation is low. However, when the rate of inflation turns out to be bigger, the relationship between returns and inflation is negative. ARIMA model gives supporting evidence of low inflation periods that MSCI World, GSCI, Gold LBM and NAREIT seem to offer hedge against both expected and unexpected inflation. Again, the results of quantile regression show that bonds are the worst assets against inflation. In fact, bonds are negatively related against inflation almost in every decile.

VAR analysis uses Granger causality test, impulse-response function and cointegration to give evidence between nominal returns and inflation. The result of Granger causality test shows that inflation has Granger causal impact on stocks, GSCI, Gold LBM and S&P Global REIT Index. However, inflation does not have Granger causal effect on none of the bond indexes. Impulse-response function shows that GSCI, Gold LBM, MSCI World AC large cap, interest rates and U.S TIPS can offer at least partial hedge against inflation shocks in the short-term. In fact, the results of GSCI and interest rates are statistically significant which indicates that GSCI and interest rates can have some hedging possibility against inflation shock. Again, bonds react negatively against inflation shock which indicates that they cannot offer any hedge. Interestingly, stocks do not react almost at all against inflation shock. Finally, the test of cointegration cannot give clear evidence of cointegration between nominal returns on assets and inflation.

Summarized, the findings of this research indicate that existence of inflation should be noted when investment decisions are done. The research shows clearly, how real returns differ from nominal returns. Economically speaking, inflation environment has a strong effect on returns of different assets. In the long run, GSCI seems to be the best asset against inflation. As it has been mentioned earlier, GSCI offers hedge against expected and unexpected inflation in the long run. Moreover, GSCI offer hedge against inflation shock. However, even GSCI cannot offer full hedge against inflation during high inflation environment. Gold is seen as a safe haven of assets and evidence of this research indicates that it is the only asset which can offer hedge against high inflation. Bonds are the worst assets against inflation.

This research achieved its goal to show how asset are related against inflation by using global data. More deeply, this research gives information how assets are related against expected and unexpected inflation. Impulse-response function points out interesting results how asset are related against inflation shocks. However, there is not enough global data available to get clear results for all assets. For example, Merrill Lynch Global Diversified Inflation-Linked Index starts from 2010, so it cannot be used in this research and also data of U.S TIPS starts from 2004. Time series of MSCI World AC small and large cap indexes, SREITGL, Global govt. index and U.S TIPS do not contain any evidence of high inflation periods, because of their shortness. It should be noted that global data is not available for deflation environment. Unfortunately, it is not possible to investigate how assets behave against deflation by using global data. Thus, there is not global evidence that would support the common belief that bonds can be used as a hedge against deflation.

Hence, in the future when more global data is available it should be study how global asset indexes are related against inflation and deflation in different periods. Furthermore, there is not enough evidence how new investment products, for example, hedge funds are related against inflation.

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