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Hedging Inflation with Different Asset Classes, The Dutch Case

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Preface and Acknowledgements

This paper has been written in response of the 'hoofdlijnennota' which has been presented by Secretary H. Kamp. In these notes a transition is being proposed and elaborated from the current pension system FTK, to a stricter version FTK 1 and a new framework FTK 2. These new systems are still in development, but already it has encountered criticism. This paper focuses on the implications of the FTK 2 framework, mainly on the indexing of the liabilities of pension funds.
With this paper I hope to contribute to the already existing literature and to add value to the asset allocation decision of pension funds. The goal of this paper is to provide additional insights in relation with the FTK 2 framework on inflation hedging for indexing purposes. During the writing process of this thesis I have learned a lot about pension funds and investment related subjects. This paper clearly opened my mind about the complexity of investment consultancy, asset management and risk management. Also I learned a lot about the different relations between economic variables which influence asset allocation decision.

In the last couple of months I have learned a lot, but for me this is not my greatest achievement. During my thesis I had the pleasure to work with many people, which supported me and with who I had fruitful discussions about a large variety of topics. Of all people, I would like to thank two especially. First of all, Gitta Coenen, which is my supervisor at Towers Watson. She knows a lot about pension funds and investment strategies and if I had a question she was always willing to help me. Secondly, I would like to thank my university supervisor, Laurens Swinkels, who always had the time for recommendations and discussions. At last I am grateful for the opportunity Towers Watson has offered me to write my thesis at one of their offices.

Abstract

This paper investigates which assets provide a hedge against Dutch inflation risk, which becomes more and more important for Dutch pension funds due to changes in the pension system. Seven asset classes are investigated; these are listed real estate, gold, equities, inflation-linked bonds, inflation-linked swaps, commodities and cash. With regression analysis and the Pearson correlation test the relationship between asset returns and the Dutch inflation is determined. With a multivariate regression it is possible to examine if an asset can hedge expected and unexpected inflation. The latter one is most important, because it represents inflation risk. The research shows that commodities and inflation-linked swaps (EMU linked) can hedge Dutch inflation risk. Gold and deposit cash can hedge inflation risk to some extent. The other three assets are not capable of minimizing the inflation exposure. From the regression analysis and the correlation test it can be concluded that inflation-linked bonds are especially negatively related to inflation. Therefore recommendation could be made to pension funds to reconsider their positions in the inflation-linked bonds market and re-allocate to inflation swaps or commodities.

Keywords:

Inflation hedging, pension funds, univariate and multivariate analyses, portfolio management

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Chapter 1: Introduction

Before the credit crisis the Netherlands had one of the most prominent and robust pension systems of the world. Nowadays, in the aftermath of the credit crisis and in the middle of the sovereign debt crisis the limitations of the current system are revealed. The Dutch government wants to take action to prevent scenarios like the one we are currently facing (cutting of pension rights and overall uncertainty).

Historically the Dutch pension system consists of three different pillars, each with its own risk. The first pillar is a general basic (old age) pension, AOW[1], which everybody who has lived in the Netherlands for 50 years receives, regardless of being or having been active on the labour market. Currently individuals[2] receive AOW-pension from the age of 65.[3] The pension is paid out by the 'Sociale Verzekeringsbank'. People indirectly contribute to the AOW through taxes.

The second pillar is a supplementary pension accrued during someone's working life. It is a pension which is to complement the general AOW-pension. In the Netherlands almost 90% of all employees have a supplementary pension. This pension is based on agreements made by several social parties like, labour unions, employees, employers and other social partners and is different for each sector. Employers are not obligated to make arrangements for a supplementary pension, but the social pressure from employees is often quite high. Moreover, pension is a (secondary) working condition. Under the second pillar a small amount of the individual's wages is retained monthly by his or her employer, who transfers it to a pension fund. The individuals' employer also contributes by paying a pension premium. The pension fund will invest the cash flows and when an individual is entitled to a pension he receives his monthly shares based upon his accrued pension rights.

In most countries the second pillar is by far the smallest; in the Netherlands the supplementary pension is about 45% of the total claim of an individual.[4] In 2010 the joint total pension liabilities of pension funds were over 720.5 billion euro.[5]

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[1] Algemene Ouderdomswet

[2] In this paper ''individuals'' are the people that contribute to a pension fund, to obtain a pension after they retire.

[3] The Dutch government decided in 2011 that the age of retirement should go up. In the spring of 2012, a coalition of political parties agreed upon increasing the retirement age to 66 by 2019 and to 67 by 2023.

[4] CBS, De Nederlandse Economie 2008, p. 157.

[5] DNB, Macro-economische statistiek pensioenfondsen.

The third pillar consists of completely voluntary arrangements made by individuals themselves. The most popular income provisions are life insurance, income from equity and bonds and commercial savings.

As stated before, the pension system revealed some flaws due to the financial crisis. The pension funds are struggling to remain solvent, i.e. try to maintain a coverage ratio[6] above 100%.The current interest rate set by the ECB is historically low and investment returns over the last years are very volatile and at times substantially low. The low interest rate environment has an increasing effect on the value of the pension obligations, which is bad news for pension funds.[7] Therefore many pension funds in the Netherlands are in trouble and continue to face serious challenges. Pension funds invest the funds into assets like stocks, bonds, derivatives (e.g. swaps), real estate, hedge funds, infrastructure and commodities. Pension funds invest in assets with the goal of earning a higher return, than if it were invested in a deposit account. This reduces the monthly contributions that the individuals have to make to get the same pension at their retirement date. However, investing in assets bears risk.

Most pension funds continue to be vulnerable to the effects of the crisis, which greatly influences their performances and thus their coverage ratio. One of the effects of the continuing crisis is a very volatile market where large up- and downward movements in returns on an intraday basis are not uncommon. These developments including the historically low interest rate contributed to the fact that the assets of the pension funds are no longer covering their long-term obligations, i.e. coverage ratio's less than 100%. Between 2007 and 2010 the number of pension funds in the Netherlands shrunk from 714 to 512.[8] For small pension funds it is hard to adjust to the changing investment environment of the last couple of years. Often small pension funds do not have the same knowledge as the larger pension funds. Due to the crisis more problems arose and with a low coverage ratio a lot of small pension funds did a buy-out. These were not the only effects; some pension funds face coverage ratio levels that force them to take drastic measures like increasing pension premiums, additional payments from the employer or even cutting into the pension payments. In the latter case, individuals receive less than agreed upon and contributed for and from that point of view these individuals are losing money. For some pension funds it is

[6] Coverage ratio is the ratio between a pension fund's capital and the value of today's long term liabilities

[7] A pension fund needs to discount its outstanding liabilities with the nominal risk free rate. When the rate decreases the value of the liabilities will increase, which results in a lower coverage ratio.

[8] Data retrieved from CBS Statline. The decrease in pension funds is not only because of the crisis, some of the pension funds merged. For many small pension funds it was hard to overview the effects of the crisis and what kind of influences it has on the performance of the pension fund. Therefore a lot of funds had a 'buy-out'. This means that the pension fund directly ensures the already received premiums and the future premiums will be invested in another pension fund.

even necessary to partly cur into their liabilities (not just the current pension payments), which could be regarded as a sort of debt cancellation. The current actions to increase the coverage ratios provoked a heavy debate in the Netherlands about the current pension system, FTK, and the Dutch government is proposing a new system, FTK 2, and a more stricter variant of FTK namely FTK 1.[9]

FTK 2 is designed to maintain the purchasing power of the individuals and to cope with the longevity risk, which is still increasing in the Netherlands (‘people become older and older’). Under the current system pension funds are allowed to pay out nominal entitlements (amounts collected from employees and employers) and are not required to take inflation rates into account. Under FTK 1, the stricter variant of FTK, pension funds maintain the nominal obligation to individuals: pension funds are obligated to pay out the nominal benefits. Both in the current system and FTK 1, pension funds are not obligated to pay out excess investment returns to the individuals, for example increase pension entitlements with (partial) inflation. High investment returns could serve as a reserve in this case. Under the new FTK 2 system, pension funds aim to increase the claims of the individuals with at least the inflation rate, from now on referred to as indexation of the liabilities. This is also known as real ambition; this implies more uncertainty as the individuals’ pensions move along with the (Dutch) inflation rate. For individuals this means that the aim is to preserve purchasing power. Another main difference between FTK 1 and FTK 2 is that in FTK 1 the liabilities are discounted with the nominal interest rate while in FTK 2 liabilities can be discounted with the nominal risk free rate and a risk premium (for risky investments) taking inflation into account. This implies that under the FTK 2 framework the coverage ratio for pension funds will adjust to the level of indexation and the level of the risk premium. To put things into perspective see table 1.

	Nominal	*Real*
Sure	*FTK (1)*	*Y*
Unsure	*X*	*FTK 2*

Table 1. Nominal obligation and real ambition in perspective.

Under FTK 2 the current pension system is not just shifting from nominal to real, but also from sure to unsure. To make it more concrete, a simplified example is presented. Individual A wants to have a €1,000 (lump sum) when he retires, the risk free rate is 3% p.a., the risk premium is 2%, the inflation rate is 2% p.a. and 16 is the number of years to retirement (approximately the average duration of the liabilities of a pension fund).

[9] FTK2 is now in development and they are still deliberating to come to a solid framework. Still, the main differences between FTK and FTK 2 are known. Also the longevity risk provoked a debate about the current framework. Both longevity risk and the bad performance of financial markets were reasons for the Dutch government to propose a new framework.

To calculate the premium that is needed at t=0 to have a €1,000 euro pension at t=16, could be calculated with the following formula,

1) $Premium_{t=0} = \frac{CF_{t=n}}{(1+R_f)^n}$

where $CF_{t=n}$ is the cash flow (benefits) received by the individual when he retires. R_f is the risk free rate and n is the number of years to retirement. Formula 1 corresponds to the current pension system FTK. If investor A wants €1,000 after 16 years, he should pay a premium (lump sum) now of €623.17. Only the risk free rate influences the premium in this case.

Under a nominal system, but with an unsure payment (X in table 1) the formula is slightly different,

2) $Premium_{t=0} = \frac{ECF_{t=n}}{[(1+R_f) \times (1+R_p)]^n}$

where R_p is the risk premium. $CF_{t=n}$ changes to $ECF_{t=n}$, because the height of the cash flow is uncertain (contains an expectation) and therefore bears a risk. Because of this risk the expected cash flow is discounted with a risk premium. The amount that individual A has to pay under this construction is €453.94. The risk premium influences the premium paid by individual A, but the expected cash flow that he receives in this example is no different from formula 1. Individual A can pay a lower premium because there is uncertainty about the actual cash flow. The cash flow after 16 years could be lower or higher than expected and therefore it is more risky. The more risk there is about the expected cash flow, the higher the risk premium and therefore lower the lump sum that has to be paid by individual A.

The formula for a pension system with a sure real ambition (Y in table 1.) is as follows,

3) $Premium_{t=0} = \frac{CF_{t=n} \times (1+\pi^e)^n}{(1+R_f)^n}$

where π^e is the expected level of inflation. Individual A now has to pay a premium of €855.47 in order to receive a cash flow after 16 years that is exactly worth €1,000, but is corrected for inflation. Every year the benefit of the individual increases with the expected inflation, in this example it is 1% lower than the risk free rate. If the expected inflation would be higher than the risk free rate, individual A has to pay more than €1,000 to receive a pension of €1,000 which is corrected for inflation.

Under FTK 2, formula 2 and 3 are combined:

4) $Premium_{t=0} = \frac{ECF_{t=n} \times (1+\pi^e)^n}{\left[(1+R_f) \times (1+R_p)\right]^n}$

When calculating the premium at t=0 for an unsure cash flow which is indexed over time, the actual premium is €623.17. The difference between formula 1 and formula 4 are the main differences between FTK and FTK 2. In this example, under FTK 2 the pension fund receives the same premium, but it is expected that the pension fund will apply indexation on the benefits of the individuals. The expected inflation and the risk premium are both 2% p.a. and therefore they roughly cancel each other out, so under the same conditions (but under a different regime, FTK 2) it is suggested that pension funds should increase their liabilities with the expected inflation each year. If the expected inflation rises and the risk free rate does not adjust, pension funds have to pay out higher pensions due to the indexation policy and the premiums paid by investors should be higher as well. On the other hand, when inflation decreases and interest rates do not move one-on-one the premiums that individuals pay will be lower. As stated earlier the risk premium and the expected inflation cancel each other out in this example, therefore you get approximately the same premium. The difference between FTK and FTK 2 is that with approximately the same premium a higher pension is demanded under FTK 2 due to indexation of the pensions.

Nowadays, Dutch pension funds are having difficulties to pay out their nominal obligations. From the proposed transition from FTK to FTK 2, new problems could arise with the coverage ratios of pension funds due to the risk premium in the discount rate and indexing with the inflation rate.
Although FTK 2 is still in development, the indexation component will become mandatory in this regime. Next to already known risks such as longevity risk, financial risk and price risk, inflation risk gets more prominent. The intended obligated indexation under FTK 2 requires pension funds to gain a return of at least the inflation rate plus the risk-free rate on average (and possibly taking the risk profile into account). Not to mention the fact that under both contracts a theoretical risk free curve will come in effect, the Ultimate Forward Rate (UFR), which cannot be replicated in the market. The UFR and the potential impact of the UFR on the investment policy of pension funds are beyond the scope of this paper.

Several articles are written on how pension funds invest. Rauh (2008) investigates the risk attitudes and investment policies of corporate pension funds. Bikker, Broeders en Dreu (2010) investigate what the influence of stock market performance is on the asset allocation decisions of Dutch pension funds. Unfortunately there have not been many scientific papers on managing risk within pension funds and especially inflation risk. This paper studies the relationship between assets and inflation and to what extent they are useful for hedging purposes. Their paper focuses on the Netherlands and on the Dutch inflation rate and what the possible implications are for the asset allocation decision of a Dutch pension fund under FTK 2. The directory for this paper is based on the article of Fama and Schwert (1977) and Martin (2010), who has both investigated the inflation-hedging characteristics of different asset classes. Although the two researches were based on the U.S. inflation rate, both articles can be used to investigate the inflation-hedging characteristics of assets with regard to the Dutch inflation rate. Next to these articles a lot of other research has been done on which assets provide good hedges against inflation. Kat and Oomen (2007) and Spierdijk and Umar (2010) investigated the inflation-hedging possibilities of commodities. Ghosh, Levin and Macmillan (2004) and Dempster and Aretigas (2010) investigated the potential of hedging inflation with gold. Fama and Schwert (1977), Gyourko and Linneman (1988) and Hoesli and Lizieri (2008) researched real estate as hedging asset against inflation. Huang (2007) investigates the fundamentals and characteristics behind real estate as an inflation hedge. Bodie (1988) reviews the relationship between index-related bonds and inflation and researched the possibilities of hedging on the short-term and on the long-term horizon. On the relationship between stock returns and inflation there are many articles. Bodie (1976), Kaul (1987), Boudoukh and Richardson (1993), Ely and Robinson (1997), Schotman and Schweitzer (2000) and Du (2006) investigated the relationship and hedging possibilities of (common) stock. Geske and Roll (1983) investigated the fundamentals driving stocks and dividends and the fiscal and monetary linkage. All these investigations are mainly performed on the U.S., U.K, Hong Kong and European data. While there are a lot of articles on inflation hedging for those countries, for the Netherlands there are just a few and are not related to the field of pension funds.

The contribution of this paper is that it investigates the relationship between different asset classes and the Dutch inflation rate. The relationship between these two variables is well described for U.S., U.K. and other industrialized countries, but for the Netherlands it is not. Another contribution to the already existing literature is that it can support research towards the implications of effective inflation hedging for Dutch pension funds and what this potentially means for its participants.

In this paper a wide variety of assets will be investigated like listed real estate, gold, stocks, inflation-linked bonds, inflation-linked swaps, commodities and the interest rates earned on cash. This paper tries to identify the assets that could provide a hedge against Dutch inflation risk. This can benefit pension funds in constructing their portfolio for possible indexation.

The structure of this paper is as follows. Chapter 2 gives an overview of the assets under consideration and reviews the literature on these assets. Section 3 will describe the methodology that is used in this paper and the methodology used in related literature. Section 4 describes the dataset used for investigating the relation between assets and inflation. Section 5 discusses the results of the different asset classes as a potential hedge against Dutch inflation. Finally, section 6 concludes, discusses and provides recommendations for further research.

Chapter 2: Overview of assets and existing literature

Around the nineteenth century the only investment assets on the financial market were stocks and bonds. Nowadays, there is a large variety of investment assets that could easily be obtained. Pension funds invest in various types of assets trying to acquire a positive return. Pension funds face specific risks like longevity risk, financial risk, price risk, macro-economic risk and inflation risk. Assets are driven by fundamentals. For instance, stock prices are driven by dividends, growth opportunities and the cost of capital. Prices for commodities are driven by fundamentals as scarcity and other macro-economic factors. The most common model for determining the price of assets is the discounted cash flow method, which discounts all future expected cash flows to a present value. The discounted cash flow method which discounts all expected cash flows until infinity is:

5) $P_{asset} = \sum_{t=0}^{\infty} \frac{ECF_t}{(1+r)^t}$

where, ECF_t is the expected cash flow at time *t and r* is the discount rate, which takes the time value of money into account and the extra return investors demand to be compensated for the uncertainty surrounding the outcome of the cash flows (there is a probability these cash flows might not be realized).

In formula 5 an expected growth rate, *g*, can be added which implies that the cash flows will grow with a constant growth rate to infinity. Through the expected growth rate the cash flows are no longer an expectation but are known in advance. Formula 5 changes to,

6) $P_{asset} = \sum_{t=0}^{\infty} I_{asset} \times \frac{(1+g)^t}{(1+r)^t}$

where I_{asset} is the income at time *t* on a certain asset, which could consist of more than one income component. Because the cash flows are no longer expected cash flows, the formula can be rewritten as,

7) $P_{asset} = I_{asset} \times \frac{1+g}{1-r}$

This implies that the following equation must hold:

8) $P_{asset} = \frac{I_{asset}}{r-g}$

Formula 8 is better known as the Gordon-growth model or dividend discount model. In the Gordon growth model there are three variables which can influence the price of an asset. First of all, the income of the asset is positively related to the price of the asset. When the income of an asset is higher (ceteris paribus) the price should also be higher. Secondly, the required rate of return also determines the price. If investors know that an asset bears more risk, they require a higher return on their capital, which decreases the price (ceteris paribus). The last variable is the perpetual growth level, which indicates the growth annually in percentages. The growth variable has a positive relation with the pricing of an asset. This pricing formula has some drawbacks. First of all, the assumption of a perpetual growth rate over time is questionable. Also, the model assumes that the growth rate is less than the required rate of return. The growth rate cannot be negative, otherwise the model fails but an non-negative growth rate does not need to hold in reality. However, in this paper we look at long horizons and indices, therefore this assumption cannot be seen as a problem in this paper. Secondly, the price of an asset is highly sensitive to changes in the constant growth rate *g*.

In this chapter the fundamental drivers of the price of listed real estate, gold, stocks, index-related bonds, inflation-linked swaps, commodities and the interest rate will be investigated. Furthermore the relationship between the different assets and inflation risk will be discussed from the review of the already existing literature.

2.1 Real estate

Some Institutional investors and companies, but also some large and small private investors invest in real estate. Investing in real estate means investing (directly or indirectly) in buildings like residential real estate, commercial real estate and office buildings. Direct or private investments in real estate are related to holding, maintaining, selling and buying of property or investing in a private equity real estate fund. The first is not a core competency of pension funds and the second, investing in a private equity real estate fund, has the major drawback of illiquidity. Another drawback is that these funds demand investment fees and therefore the real return is hard to measure. However, direct real estate could be a good asset to hedge inflation risk. Another way of investing in real estate is in an indirect investment. Indirect investments in real estate are via the purchase of equities of companies that are active in the real estate sector. Indirect investments in real estate could be accomplished through vehicles like real estate investment trusts (REITs). The literature on direct and indirect real estate will be reviewed to see which fundamentals drive the price of real estate. In this paper only indirect or listed real estate is investigated.[10]Data of indirect investments on real estate are a lot simpler to obtain than direct real estate, because a lot of REITs and other related real estate companies are listed and publish publicly available information.

Investing in indirect real estate has several advantages and drawbacks. Investing through REITs gives the investor the opportunity to invest in more than one company which gives him the possibility to diversify risk within the asset class of real estate. Another advantage of investing in REITs is that these assets are very liquid. A possible drawback of investing in REITs is that these companies are possibly (highly) correlated with stocks, because REITs are listed companies. For instance, large investors buy whole indices which also contain REITs. Therefore the correlation is expected to be higher between common stocks and REITs than for direct real estate and common stocks. The fundamental drivers behind real estate are vacancy and rental rates, which both influences each other and both determine the price of properties and the yield. From formula 8, it is obvious that rental income is the income of the asset real estate. The price from real estate is than required by the growth of the rental income and the required rate of return. If real estate is to be a good hedge against inflation it should be the case that the prices of real estate should move one-to-one with inflation. The variables rental income, required rate of return and the growth rate could take on different values and still provide the same price for real estate. Capital accumulation is often seen as a second form of real estate income, but is just the difference between the price at time t and t +1, which is determined by the three variables of the Gordon-growth model. The interaction between the three variables determines more or less whether real estate is a good hedge or not. For listed real estate this could be somewhat different, because it is more likely that other factors, such as the sentiment in the stock market, influence the price. Martin (2010) has as traditional argument for real estate being an inflation hedge. He states that real estate is an essential component of the economic infrastructure. Martin hypothesized that during periods of sustained inflation, such as the 1970s, real estate prices tended to be positively correlated with expected inflation, but that during normal times, real estate prices are likely to experience short-term negative effects from changes in the macro environment that are associated with increases in inflation. Martin's research showed that when inflation is highly persistent private real estate is a positive hedge for inflation risk.

[10] For investing direct real estate the IPD / ROZ index could be used. However, it was not possible to obtain the correct data, because the index is not publicly available.

On the long-term the characteristics of real estate as an inflation hedge is uncertain. Martin stated that due to the relationship between the persistence of inflation and the hedging effect, indirect real estate could not be seen as a good asset to hedge against inflation risk on the short horizon.

Huang and Hudson-Wilson (2007) estimated the relationship sensitivity between inflation and private real estate. They used the National Council of Real Estate Investments Fiduciaries (NCREIF) property sector indices of Office, Apartments, Retail and industrial. These indices are published on a quarterly basis and just look at the price changes in these sectors. These sector indices could be characterized as unlisted (or private) real estate, just as the

IPD / ROZ in the Netherlands. Huang and Hudson-Wilson find that these property indices have a positive sensitivity to expected and unexpected inflation. The authors also analysed the inflation sensitivity in terms of capital appreciation and return in income. The conclusion on the latter is that it is uncorrelated with inflation. On the other hand, capital appreciation is positively correlated with both unexpected and expected inflation, while most investors always thought that the inflation characteristics of real estate were dependent on the income return. Their paper states that the retail sector is the only real estate property type that could be used for diversification purposes.

Le Moigne and Viveiros (2008) also investigated the relationship of income return and capital appreciation on inflation. They looked at direct or private real estate. Le Moigne and Viveiros used Canadian data and they found other results than Huang and Hudson-Wilson. The authors found that income return was negatively correlated with inflation and that the capital movements were positively related with the direction of inflation. Both Huang and Hudson-Wilson and Martin conclude that real estate was a good inflation hedge in the past, but is not in the last couple of decades. Huang and Hudson-Wilson state that it is likely that it will happen again in the future. The article of Hoesli et al. (2008) is one of the most recent articles on hedging inflation with public and private real estate. For REITs in the U.S. they find that unexpected inflation has a negative sign for the short- and long-run. For the U.K. they also found a negative relationship on the short run, but insignificant. On the long-run Hoesli et al. found that the relationship between REITs returns and unexpected inflation is positive.

One of the most famous articles about hedging inflation with different asset classes is Fama and Schwert (1977). They investigated for instance public and private real estate over the period 1953 to 1971 to determine which asset could be used by investors to hedge themselves against expected and unexpected inflation. Fama and Schwert concluded that public real estate is not able to provide a hedge. On the other hand, they found that private real estate was a good hedge against both expected and unexpected inflation.

Paper	Year	Country	Period	Short Horizon Inflation Hedge?	Long Horizon Inflation Hedge?	Listed or Unlisted?
Martin	2010	-	-	No	Uncertain	Both
Huang and Hudson-Wilson	2007	U.S.	1978-2006	No	No	Unlisted
Le Moigne and Viveiros	2008	Canada	1973-2007	Mixed	Mixed	Unlisted
Hoesli et al.	2008	U.K. and U.S.	1977-2003	No	U.S. no - U.K. yes	Both
Fama and Schwert	1977	U.S.	1953-1971	Public no - Private yes	Public no - Private yes	Both
Gyourko and Linneman	1988	U.S.	1960-1986*	Listed no / Private yes	-	Both

Table 2. Summary of literature on inflation hedging with listed and unlisted real estate.
* Depends on the variable. For more information I refer to the article of Gyourko and Linneman (1988)

Gyourko and Linneman (1988), using REITs from the U.S., reported a significant negative coefficient for the unexpected inflation level and a positive coefficient for the expected inflation level.

Scott (1990) concluded that prices of REIT stocks deviate from the fundamentals of real estate and that REITs cannot be seen as reliable indicators of the fundamentals of the real estate market.

From the review of the already existing literature it is expected that listed real estate companies would not provide hedging possibilities. For a short summary see table 2. Private real estate should be a better hedge against inflation than indirect investments in real estate, because returns and prices of REITs are not driven by the same drivers as the real estate market. On the short term real estate may not be a hedge, while it could be that on the long-run real estate has a positive relationship with inflation. In the past real estate has sometimes been a good hedge according to the empirical evidence, but it is dependent on country specific elements, such as which economic policy is conducted and the research methodology, like what horizon is being examined. It is to be expected that direct real estate is a poor hedge against Dutch inflation, although direct and private real estate could provide positive hedge results, but these are not investigated in this research.

2.2 Gold

Until the end of 1931 the gold standard existed in the U.K. and many other countries. In this period the economic unit of account is an absolute fixed weight of gold. One of the main advantages of the gold standard was the virtue of long-term price stability. Gold was used as an underlying value of money and in this way prevented high levels of inflation. Nowadays, some investors use gold as a “safe haven” and are convinced that gold is a good hedge against inflation, especially in times of crisis. In the past gold has been seen as a good hedge against inflation. However, there is little statistical evidence that supports this belief. Many articles are written about the hedging characteristics of gold against inflation. The results from past empirical evidence are at best mixed. Gold belongs in the asset class commodities, but it does not share the same fundamentals as most commodities. Ghosh et al. (2004) stated that the demand of gold could be divided into two categories. The first category is the “use demand” and the second is the “asset demand”. The use demand refers to the usage of gold for industrialized processes. The asset demand could be divided into two other categories, investment asset and emotional asset. The former one has become more and more popular over the last couple of decades and increasing the volatility in the price of gold. Gold also has emotional value which makes it different from commodities like timber, copper and oil. Determining the price of gold is not easy. When looking at the Gordon growth model, the price of gold is dependent on the income of the asset, the required rate of return and the growth rate for gold. However, gold does not provide income. The only income an investor could earn is from the rise in gold prices. Increases and decreases in the price of gold are for the most part determined by demand and supply. As stated before, gold is not solely used as a hard material in industrial processes, but it is also used for investment purposes. The underlying value of gold is not clear, because it is used for several purposes.

Wang et al. (2010) investigated the short- and long-run hedging capabilities of gold for the U.S. and Japan during the period 1971 and 2010. This research found that the rigidity between the price of gold and the consumer price index affects the inflation hedging ability of gold in the long-run. Wang et al. stated that there are two essential keys of inflation hedging, which are time selection and market selection. Time selection means that investors should choose a period of high momentum or the period of time wherein gold prices respond faster on different levels of inflation. In a period of low momentum, gold is unable to provide an effective hedge against inflation. Market selection suggests that investors should not invest high percentages of their portfolio in gold for the long horizon. The authors state that the hedging characteristics of gold are not present in all markets and differ from time to time. Wang et al. also investigated the cross-elasticity of gold and the CPI level and revealed that when markets are more competitive, the price of gold and CPI adjust more synchronized. Ghosh et al. (2004) found evidence from their theoretical model and conclude that the short-run volatility on gold prices is consistent with the prices of gold over time and with the rate of inflation. They also analysed the capabilities of gold as an inflation hedge on the long-run. With data from the U.S from the period 1976-1999 they found that on the long-run gold prices are moving with the general rate of inflation. Dempster and Artigas (2010) concluded that gold can be seen as a portfolio diversifier in terms of strategic asset allocation, which is in line with Martin (2010). They argue that gold has a role of a diversifier mainly due to the diverse drivers of gold's demand and supply. Dempster and Artigas also compared investment strategies and find that gold has a lower volatility on average than the S&P GSCI and BB REITs[11]. This is something most investors would not expect. Chua and Woodward (1982) examined to which extent gold has been an effective hedge against inflation, for both expected and unexpected inflation. They investigated a period of 5 years and did a cross-sectional study of six major industrial countries: Canada, Germany, Japan, Switzerland, U.K. and U.S. They find that the inflation hedging value of gold is determined by the magnitude and the volatility of the domestic inflation rate relative to the changes in the value of gold. They also conclude that the inflationary characteristics of gold differ considerably among the six industrialised countries. Therefore Chua and Woodward state that the inflation hedge possibilities of gold are dependent on country specific elements. The most important one is the exchange rate risk, which means that a European investor does not have to earn the same return on gold in comparison to an U.S. investor. Due to the differences in exchange rates across time, it is expected that the returns on gold are also different across countries.

Paper	Year	Country	Period	Short Horizon Inflation Hedge?	Long Horizon Inflation Hedge?
Wang et al.	2010	U.S. and Japan	1971-2010	Depends on the market and timing	No
Ghosh et al.	2004	U.S.	1976-1999	No	Yes
Dempster and Artigas	2010	U.S.	1974-2009	No	No
Chua and Woodward	1982	Canada, Germany, Japan, Switzerland, U.K. and U.S.	1975-1980	Mixed, depends on market	Mixed, depends on market
Blose *	2010	-	-	Mixed results	Mixed results

Table 3. Summary of already existing literature on inflation hedges with gold.
* Blose investigated 11 empirical researches on the hedging capabilities against inflation risk. In his summary he concludes that the results are at best mixed.

[11] S&P GSCI is a production-weighted commodity index that is often used by institutional investors. BB REITs stands for the Bloomberg real estate investment funds index. It is a capitalization-weighted index of real estate investment funds which has at least 15 million U.S. dollar of market capitalization.

Another reason is that the inflation rate is different between countries. Inflation rates between highly industrialized countries are correlated but not perfectly. Blose (2010) studied 11 recent articles which describe the relationship between expected inflation and the value of gold[12]. Blose concluded that four articles found a significant relationship between expected inflation and gold prices. Four of the eleven articles concluded that the evidence on the relationship is at best mixed and three researches found none empirical evidence on the inflation hedge characteristics of gold.

The empirical evidence found in the already existing literature is slightly negative (see table 3). Gold is a well-known investment asset, but it seems that its hedging capabilities are time and country dependent. A long- or short-run strategy may influence the hedging effectiveness of gold. When making an average statement on the reviewed articles, gold can be seen at best as a diversifier within a portfolio of an institutional investor.

2.3 Stocks

In the past decades, extensive research has been done on the characteristics of stock prices. One of the oldest propositions in the literature on inflation is from Fisher (1930). He stated that the expected nominal return on assets should move in the same proportion relative to expected inflation. Fisher thought that the monetary and real sectors of the economy were independent. His view was that the real rate was only depending on real variables such as productivity of capital and labour. However there is plenty empirical evidence that concludes that there is a negative relationship between inflation and stock returns (see e.g. Lintner, 1975; Bodie, 1976; Fama and Schwert, 1977; Fama, 1981). One possible explanation for these findings is introduced by Fama (1981) and is called the “proxy” hypothesis. Fama argued that stock prices are mainly determined by the expected future discounted cash flows or its future earnings potential. The cash flows from stocks are the dividends paid out and the capital appreciation. According to the Gordon growth model dividends are the income of stocks and r represents the required return demanded from the shareholders. The third variable, g, in the model stands for the annual growth of the dividends. These three variables determine the price of a stock, which is in line with Fama (1981).

[12] For more information on these 11 studies, see Sherman (1983), Jaffe (1989), Moore (1990), Garner (1995), Larsen and McQueen (1995), Mahdavi and Zhou (1997), Cecchetti et al. (2000), Cristie-David et al. (2000), Lawrence (2003), Adrangi et al. (2003) and Tkacz (2007).

Fama and Schwert (1977) find evidence that common stock returns are negatively correlated with the expected inflation rate. They also suggest that it is plausible that there was not always a negative relation between the two variables. Due to the negative relationship they also suggest that it will not imply any causality.

Kaul (1987) researched to what extent stocks could provide a hedge against inflation in the pre-World War II period in the U.S. and found that the negative relation was not present at that time. Kaul used post-war data to compare both periods. The results suggest that there is a negative relationship between stock returns and inflation.

Gultekin (1983) investigated the relationship between common stock returns and inflation in 26 countries after World War II. His results did not support the Fisher hypothesis and he stated that there is a certain lack of consistency in the relationship between stock returns and inflation. In the regression analysis the independent variables for the 26 countries were mostly negative[13].

Boudoukh and Richardson (1993) investigated probably the longest datasets available at their time. They studied the long-horizon relation between inflation and stock returns for the U.K. for the period 1802 – 1990. They also investigated the U.S. for the period 1820 – 1998. For both countries they find evidence that returns of stocks and inflation are positively correlated at five year holding periods. It makes sense to look at such long holding periods, because most investors hold stocks for a long period of time.

Ely and Robinson (1997) also investigated the relation on the long-horizon. They included 16 industrialized countries into their dataset. Only for the United States they find evidence that on the long term an inflation shock influences the U.S. share prices in a negative way. In the case of the other 15 remaining countries the evidence of a relation between stock returns and inflation shocks are not supportive.

Barnes, Boyd and Smith (1999) divided the level of inflation into three types, low inflation, medium inflation and high inflation economies. Their research provided new insides in the hedging capabilities of stocks against inflation. Barnes, Boyd and Smith concluded that equity returns are negatively correlated or uncorrelated for all low and moderate economies. For high inflation economies the correlation with stock returns is highly positively correlated. They also regressed countries' stock returns on the U.S. inflation rate and they conclude that the U.S. inflation rate influences the stock returns in foreign countries with major financial centers. This is especially the case for Germany, U.K. and Switzerland where the U.S. inflation rate is more correlated with the countries' stock returns than its own inflation rate.

Schotman and Schweitzer (2000) investigate the relationship between inflation and stock returns over different time horizons and look at how the horizon effects this interaction.

[13] Gultekin performed regression analysis in the form of $R_i = \beta_1 + \beta_2 \pi + e_i$. Where R_i is the stock return, π is the inflation rate and e_i is an error term.

Schotman and Schweitzer conclude that a negative sign between the two on the short-run is consistent with a positive hedge ratio as implied by the proposition of Fisher in the long-run. They state that the key element is inflation persistence, the longer the persistence of inflation the better and the more effective stocks are as a hedge. Also, the longer stocks are held by investors the better the hedge performance against inflation. Schotman and Schweitzer investigated their hypothesis analytically and showed that it is theoretically possible. However, they have not done an empirical research.

Much literature has been written on western industrialized countries and there is little research of emerging markets. Adrangi et al. (2002) investigated the emerging market of Brazil. They found some evidence that on the long-run a relationship between stock prices, price levels and real activity could exist. Their results support the notion that the effect could be valid on the long-run but not in the short-run.

Du (2006) tests the suggestion that the relationship between the returns of stocks and inflation depends on two things: the monetary policy regime and the importance of demand and supply shocks. Du looks at four regimes, which all had a different monetary policy. In the period 1926-1939 there was a strong procyclical monetary policy due to the Great Depression. Du argues that because of this monetary policy inflation and stock returns were positively correlated. Du concluded that during the period 1952-1974 there was a negative correlation between stock returns and inflation. His explanation for this negative relation was that this period is characterized by stagflation, which can be regarded as a supply shock and which influences inflation. Du states that the relationship is mostly altered by the unexpected demand or supply shocks and the monetary policy a country has in place.

Martin (2010) also investigated the relationship between different industrial sectors over time. He finds that all sectors are not significantly correlated in the period 1990-2008, although the sign is negative. For the period 1945-1989 Martin find a negative relation and the correlations are significantly negative. One sector gives other results that are different from the rest. The energy sector has a positively significant correlation with inflation between the periods 1930-2008, 1990-2008 and 1930-1944.

One of the largest researches on inflation hedging with stocks and bonds is performed by Bekaert and Wang (2010). They investigated 45 countries and not only developed countries, but also emerging markets. They used a simple OLS model with inflation as independent variable and nominal return as the dependent variable, the same as Gultekin (1983). Bekaert and Wang assume that the OLS model follows a random walk and that the change at inflation between t-1 and t=0 is the unexpected inflation. Their article concludes that standard securities, like stocks and regular bonds are poor assets to hedge inflation.

Paper	Year	Country	Period	Short Horizon Inflation Hedge?	Long Horizon Inflation Hedge?
Fama and Schwert	1977	U.S.	1953-1971	No	-
Kaul	1987	Canada, Germany, U.K. and U.S.	50's-80's *	No	No
Gultekin	1983	26 countries	1947-1979	Mostly negative	Mostly negative
Boudhoukh and Richardson	1993	U.K and U.S.	U.K. 1802-1990 U.S. 1820-1998	-	Yes (5 year holding)
Ely and Robinson	1997	16 countries	1957-1992	-	No
Barnes, Boyd and Smith	1999	25 countries	1957-1996	-	Only for high inflation economies
Schotman and Schweitzer **	2000	-	-	No	Could be
Adrangi	2002	Brazil	1986-1997	No	Could be
Du	2006	U.S.	1926-2001	Depends on the monetary policy that is being conducted and the types of shocks	
Bekaert and Wang	2010	45 countries	-	Stocks and bonds poor assets to hedge against inflation	

Table 4. Summary of already existing literature on inflation hedges with stocks.

* Kaul investigates four countries. For every country the sample period is different. Canada 1951-1983, Germany 1957-1983, U.K. 1957-1983 and U.S. 1953-1983.

** Not an empirical research, but an analytical article that investigates their hypothesis with a theoretical framework.

In the seventies the first articles appeared on the negative relationship between inflation and stock returns. Many articles are written and many markets are already investigated. The main conclusion is that stocks are not capable of hedging inflation risk, but some researches have shown that this depends on the country specific elements like the time period, the sector investigated, the monetary policy and the macro economic shocks. For a brief overview see table 4.

2.4 Index related bonds

In 1996 the U.S. treasury issued a new type of bond on the U.S. financial markets. Almost risk-free securities linked to the consumer price index (CPI) of the U.S. were introduced. The economic rational about investment returns is that it is wise to focus on real returns opposed to nominal returns. The former one determines in the end the consumption level of an individual.

Indexation of income or debt is not completely new. Deacon and Derry (2004) found an example that goes back two centuries ago. In 1742 the state of Massachusetts issued government bills that were linked to silver. After a few years the risk of indexation with a single commodity became clear when the price of silver rose over all other goods. Therefore a single commodity was replaced with a wider range of commodities for indexation purposes. In the year 1780 indexed notes were issued again. These notes were given as wages to the soldiers in the American Revolution. These notes were indexed against the market value of five bushels of corn, sixty-eight and four-sevenths pounds of beef, ten pounds of sheep wool, and sixteen pounds of sole leather.

With the introduction of CPI linked bonds institutional and individual asset allocation decisions changed. The CPI linked bonds are the only true long-run hedge against inflation risk (Bodie, 1988). These bonds can eliminate the main issues of indexation of the benefits in pension plans. Bodie states that a pension fund could hedge its liabilities by investing in the CPI linked bonds with the same duration as its liabilities.

CPI linked bonds are also called treasury inflation-protected securities (TIPS) in the U.S. Nowadays in many countries inflation-linked bonds are available. The U.S. TIPS are the most liquid market with an issuance over 500 billion dollar. The U.K (GILTs) and French (OATi/OAT€i) bonds have respectively an issuance of 300 and 200 billion dollar. For the Dutch inflation level or consumer price-index inflation-related bonds are still not available.

Regular bonds and inflation-related bonds differ and inflation-related bonds have its advantages and drawbacks. The main difference is the indexation of the principal and the coupon payments. Suppose an investor buys a regular 5-year government bond (semi-annual payments) with a face value of €1,000[14]. Then the investor receives the following payments (Table 5):

Coupon: 4% Original face value: 1000 Semi-Annual payments 5-year note

Month	*6*	*12*	*18*	*24*	*30*	*36*	*42*	*48*	*54*	*60*
Payment	20	20	20	20	20	20	20	20	20	1020

Table 5. Payments of a conventional bond.

When the investor buys an index-related bond, the semi-annual payments are adjusted for inflation. The coupon rate is still a fixed rate, but the coupon payments differ because the rate is applied to the principal that is adjusted for inflation. The semi-annual coupon payments are determined by multiplying the coupon rate times the adjusted principal and divided by two. To summarize, the investor earns a fixed coupon rate, but the payments vary because the principal is adjusted to inflation semi-annually.

[14] In most countries a 5-year bond is available, next to 10, 20 and 30 year inflation-related bonds.

The payments for an index-related bond are as follows (Table 6):

Coupon: 4% Original face value:1000 Semi-Annual payments 5 Year note

Month	*6*	*12*	*18*	*24*	*30*	*36*	*42*	*48*	*54*	*60*
Inflation	1%	1.50%	1.25%	1.60%	1.40%	2%	1.85%	1.70%	1.30%	1.75%
Payment	20.20	20.50	20.76	21.09	21.39	21.81	22.22	22.60	22.89	1187.79

Table 6. Payments of a real bond.

The difference in the principal payments between the nominal and real bond is more than €167. The difference in the principal amount is the adjustment for inflation. The €1,187.79 in month 60 is worth €1,000 in month 0.

The benefits of TIPS and other inflation-related bonds are diversification, inflation hedge, safety and liquidity. The first advantage states that these bonds are uncorrelated with stocks or other regular bonds. Thus it can be seen as a diversifier within a broad portfolio. Inflation-linked bonds are expected to be a more or less perfect hedge against inflation risk, which makes it very suitable for indexation of benefits within a pension funds plan. However, inflation-linked bonds bears risks and therefore it is not necessarily a hedge against inflation. Another advantage is the safety of the asset. In the late 80's the first indexed-related bonds were issued by public banks, nowadays governments (central or federal banks) issue these bonds and therefore the bonds are virtually risk-free (depending on the government issuing the bond). On the other hand there are four drawbacks with index-related bonds. First of all these bonds will decrease in value in times of deflation, but this only effect the interest payments. The final payment, the principal, is protected against deflation. When, the principal is adjusted for inflation and is less than the face value, the investor gets the original principal amount back at maturity. Secondly, not every country has bonds that are linked to their own inflation rate. For the Netherlands, as stated before, there are no inflation-linked bonds available that are linked to the Dutch CPI[15]. Therefore when a Dutch pension fund tries to hedge their inflation risk with inflation-linked bonds they have to find a CPI index which is highly correlated with the Dutch inflation rate. It is plausible that inflation-linked bonds that are for instance issued by the European Central Bank deviate from the Dutch CPI level. In that case inflation-linked bonds do not provide a full hedge against Dutch inflation. This is also called mismatch risk, which is created by going long in these products. This mismatch risk could be substantial and could make the relation between bonds and inflation not

[15] Example of inflation indices used for inflation-linked bonds: U.S. uses U.S. CPI, the U.K. uses the RPI, France uses France CPI ex-tobacco (OATi), for Europe the European inflation rate, EU HICP ex-tobacco is being used, Canada uses Canada All-Items CPI, Australia uses All-Group Index. Most countries in Europe which issue index-related bonds use the inflation index EU HICP ex Tobacco (HICPxT).

significant. The third disadvantage of inflation-linked bonds is that when comparing it with conventional bonds, the former one is less liquid. Campbell, Shiller and Viceira (2009) argue that this is often mentioned as a drawback, but it is important to recognize that inflation-linked bonds are illiquid relative to regular bonds, which are one of the most liquid assets in the world. Inflation-linked bonds are one of the most liquid long-term investment assets and are cheap to trade. According to Campbell et al. governments all over the world issued more and more inflation-indexed bonds over the last couple of years. Finally inflation-linked bonds still bear a large risk, namely interest rate risk. The risk is determined by the yield curve demanded by investors. The yield curve has an instant effect on the price of inflation-linked bonds.

One of the seldom researches on the relation between Dutch CPI and European inflation-linked bonds is from Mahieu and de Roode (2011). They researched the risk of going long in a foreign inflation-linked bond for hedging the national inflation rate. The difference or mismatch between both inflation rates is called mismatch risk. In their article they conclude that this mismatch risk is substantial. For a Dutch investor this means that European inflation-linked bonds turns out to be a risky asset when trying to hedge the Dutch CPI. Mahieu and de Roode also researched the relation between the European inflation and the Dutch inflation. The correlation they found was not quite high, implying that the European inflation-linked bonds only introduce mismatch risk.

Kothari and Shanken (2004) conducted extensive research on the implications of inflation-linked bonds within portfolios. In their time series Kothari and Shanken found that the real return (inflation adjusted) on indexed bonds is less volatile than the returns on conventional (regular) bonds. To conclude, the standard deviation and variance of the return on indexed bonds is lower than for conventional bonds. A second thing they investigated was the correlation between index bonds, stocks and conventional bonds. Conventional bond returns and stock returns have a correlation around 0.4, while stock returns and indexed bond returns are almost uncorrelated. Due to the lower correlation and volatility of indexed bonds, the standard deviation of an equally-weighted portfolio of stocks and bonds is according to Kothari and Shanken around 13% lower when indexed bonds are used. For very conservative portfolios which consist primarily of bonds, the risk reduction doubles. The authors also state that when the risk premium for inflation risk is high enough it could be more beneficial to invest in conventional bonds instead of inflation-protected bonds. However, Kothari and Shanken use simulated time series. They create series of prices and then compute hypothetical five-year returns and use these returns in their regression analysis. Therefore, the results are strongly dependent on the assumptions used.

Campbell (2009) concluded that nominal bonds are very interesting for short-term equity investors when these bonds are negatively correlated with stocks. Campbell argued that has been the case in the 2000s and during the outbreak of the financial credit crisis. Conventional bonds are interesting for long-term investors when the long-term inflationary rate is stable. In that case nominal bonds are a reasonable substitute for inflation-linked bonds.

Swinkels (2012) did a cross-section study on 9 emerging countries and investigated the correlations and risk-return characteristics of inflation-linked bonds on inflation. Swinkels documented that these bonds are more correlated with realized inflation on the short- and long-run than conventional bonds. He also states that including inflation-linked bonds in portfolios that consist of these emerging markets improves the risk-return ratio of the portfolio.

Martin (2010) investigates the link between inflation-linked bonds and the actual level of inflation. He argues that index-related bonds are not a perfect hedge against inflation and Martin makes some comments on the drawbacks of these bonds. First of all, Martin states that for pension funds long-lived index-linked bonds are necessary to hedge its liabilities with the appropriate duration. These long-duration assets may introduce credit risk and these assets also may be less liquid and rarer. Liquidity could be an issue when inflation rates are low and are steady over time, because pension funds are more likely to sell their bonds in that case. A second point Martin addresses, is that the expected future inflation that is forecasted with the break-even inflation does not have to be a good predictor. Martin concludes that inflation-linked bonds provide institutional investors a somewhat effective hedge against inflation; however it does not offer a perfect hedge in his opinion.

Overall, country specific inflation-linked bonds could be a good hedge against the inflation rate over time. Going long in inflation-linked bonds also bears risk like interest rate and mismatch risk. Because, in the Netherlands there are no bonds linked to the Dutch inflation this mismatch risk could be substantial. In chapter 5 it will be investigated if European index-related bonds could provide a possible hedge against Dutch inflation.

2.5 Inflation swaps

An inflation swap is a derivative that is used to transfer inflation risk from one party to another. In an inflation swap one party pays a fixed rate on a notional amount and the other party pays a floating rate on the principal amount. The fixed rate is often related to the expected inflation over the maturity and the floating rate is linked to the realized level of the CPI. The difference between the CPI and the fixed rate agreed to in the contract determines the transfer of the cash flows. For example, the floating party receiver pays a fixed swap rate times the notional amount agreed on. If the fixed rate is 4% and the actual inflation at maturity is 3.5% than the floating rate receiver has to pay the 0.5% multiplied by the notional amount. If the actual inflation is 5% then the fixed rate receiver has to pay the 1% to the floating rate buyer. In this way a pension fund could eliminate its inflation risk. These derivatives are over-the-counter or exchange traded derivatives. Inflation swaps have become more and more popular over the last decade. For pension funds inflation swaps are very useful, because the inflation-linked swaps transfer inflation risk to another party and match the future liabilities.

There are three common types of inflation swaps. The first is a zero coupon inflation-linked swap or also known as standard interbank inflation-linked swaps. Here the exchange of the cash flows happens on the maturity date. It pays out the cumulative difference between inflation and the fixed rate multiplied by the notional principal. These inflation swaps are traded over-the-counter, via the mechanism of supply and demand. These contracts often have a very long maturity. Long-lived inflation swaps are used for duration matching purposes. Pension funds are mostly interested in inflation swaps with a maturity longer than 15 years.

A second well-known inflation swap is a year-on-year swap or month-on-month swap. With the zero coupon swap, settlement occurs at maturity. While with these swaps settlement occurs on a yearly or monthly basis. In the numerical example below an investor agreed on an inflation swap with a time to maturity of 5.5 years. The investor pays a fixed rate of 1.8% over the notional principal of 100 million euro on a semi-annual basis (See table 7).

Date	**Semi-annual CPI (indexed)**	**Inflation rate (%)**	**Floating cash flow received**	**Fixed cash flow paid**	**Net cash flow**
Apr. 1, 2004	100	-	-	-	-
Oct 1, 2004	101.75	1.75%	1,750,000	-1,800,000	-50,000
Apr. 1, 2005	103	1.23%	1,230,000	-1,800,000	-570,000
Oct 1, 2005	105.25	2.18%	2,180,000	-1,800,000	380,000
Apr. 1, 2006	106.85	1.52%	1,520,000	-1,800,000	-280,000
Oct 1, 2006	109.5	2.48%	2,480,000	-1,800,000	680,000
Apr. 1, 2007	112	2.28%	2,280,000	-1,800,000	480,000
Oct 1, 2007	113.7	1.52%	1,520,000	-1,800,000	-280,000
Apr. 1, 2008	115	1.14%	1,140,000	-1,800,000	-660,000
Oct 1, 2008	118.4	2.96%	2,960,000	-1,800,000	1,160,000
Apr. 1, 2009	121.2	2.36%	2,360,000	-1,800,000	560,000
Oct. 1, 2009	124	2.31%	2,310,000	-1,800,000	510,000
Total					**1,930,000**

Table 7. Numerical example of a year-to-year inflation swap, settlement occurs semi-annually. Notional principle is 100 million, fixed semi-annual rate is 1,8% and time to maturity is 5.5 years.

For a zero-coupon inflation-linked swap the only cash flow that takes place is the total net cash flow of €1,930,000. In this case the party that has to pay the fixed rate has hedged his 100 million against inflation risk and receives at the end of the swap almost 2 million, because the floating rate received is higher than the fixed rate paid.
For the year-to-year (or semi-annual swap) inflation-related swap the settlement occurs first on the first of April 2004 and after this semi-annually till the first of October 2009. Inflation swaps that are paid on year-to-year basis are useful for investors who would like to protect their income or cash flows. Also these early payments reduce credit risk which is involved in a swap transaction. In standard interbank inflation-linked swaps the credit risk could be substantial. Therefore the two parties could agree on to a securitized agreement through a Credit Support Annex (CSA) agreement.
The government and companies in utilities and real estate benefit from higher levels of inflation as it provides larger profits (or debt reduction). For pension funds and most other institutional investors it is better that inflation is low. When inflation increases yearly margins or real return shrinks. Pension funds benefit from hedging themselves against inflation risk.
A disadvantage of inflation-linked swaps is that when the global economy is changing drastically and if that results in large upward shifts in the inflation rate, than companies and pension funds cannot profit from the situation. Pension funds do not solely secure themselves against downside risk, but also against upward profits.
As stated earlier swaps are traded over-the-counter, therefore these contracts could be tailored made. Inflation-linked swaps related to the Dutch inflation therefore exist. However, inflation-linked swaps to the Dutch CPI are not always issued, because the risk for the counterparty is too high. Therefore pension funds could not simply assume that these contracts are available. That is why in this paper European inflation-linked swaps are investigated. As with the inflation-linked bonds this creates a mismatch risk (as explained in the previous section), which could be severe and causes the inflation-linked swaps to be a less efficient hedge.

2.6 Commodities

The asset class commodities could be divided into categories, like agriculture, precious metals, industrial metals, livestock, energy and natural gasses. All these categories could be subdivided into concrete examples, for instance, aluminium, timber, crude oil and cows. Commodities could be obtained in four different ways, via directly investing in commodities, through mutual funds, through direct equity and trading in derivatives. In this paper, only investing in derivatives is examined. Directly investing in commodities is via the purchase of real commodities (e.g. sugar, livestock or oil), but for a pension fund it is not desirable to obtain these commodities physically, therefore this method of investing in commodities is not researched. Mutual funds have the disadvantage of demanding fees and transaction costs to their investors which is not preferable. Mutual funds provide a service but it is hard to measure the real return on commodities due to these costs. However, pension funds invest in mutual funds, but the data on time-series data on these funds are often not available, therefore mutual funds are not investigated in this paper. The main drawback of direct equity comes from the fact that it is related to stocks and therefore has an exposure to the stock market. Large investors who want to have a diversified portfolio often buy indices, which also include commodity related stocks. The price of commodity stocks is not solely driven by the demand for the commodity, but also by the demand for the index. Investing in derivatives can be done on the basis of futures contracts. Futures are contracts in which two parties agree to buy or sell an asset at a certain point in time for a certain price. Futures contracts are traded on public exchanges and could be bought by companies, private investors and institutional investors. The buyer and the seller of the contract do not know each other and therefore the exchange provides a mechanism which guarantees that both parties will honor the contract. The settlement and exchange of cash flows happens on a daily basis with a margin account. One way of obtaining commodity futures is to invest in a commodity index. The ease of investing in a commodity index is that investors do not have to select and monitor the portfolio.

The pricing fundamentals of commodities could not be explained with the Gordon-growth model, because there is no visible income on commodities. The most common commodity indices are unleveraged commodity indices, which have T-bills as collateral. To be unleveraged, every position in a futures contract must be collateralized with T-bills, which will provide a current return. For instance, to go long a 20 ton coffee futures contract, at €600 per ton, the investor should allocate €12,000 from his portfolio to support the long position in the futures contract. Next to a certain income of the risk-free asset the investor get an unleveraged exposure to the future prices of coffee. Greer (2000) investigates the nature of the returns on unleveraged commodity indices and states that there are four sources of return on commodities, of which one could be neglected. The first one is the T-Bill rate. This return is riskless and accrues on the collateral component. The T-bill rate exists of expected inflation plus the real rate of return. The second return component according to Greer is the insurance premium. The seller of the futures contract does not know the future spot price of his goods and therefore has a price risk. The seller wants to insure himself against decreasing prices in the future. For instance, if the spot price of today's wheat is €100 per ton and the farmer could harvest and sell his wheat in about six months. During this period the price of wheat increases or decreases with 30%, both outcomes are even likely. In a transparent market both the farmer who sells the futures contract as the buyer of the futures contract knows these probabilities. Farmers need to insure themselves against price risk (or have a chance to go out of business) and have a greater incentive than the buyers. Therefore buyers have a better negotiation position and could demand a premium. This premium makes it possible that the seller of the contract could hedge away the price risk of the future goods. The third inherent return is unexpected inflation and market surprises. When unexpected inflation takes place, most people expect stock and bond prices to drop due to higher interest rates. For unleveraged commodities it is the opposite. If the forward prices of futures contracts rise, than the inflation expectations should rise as well. It is expected that from an economic point of view that commodity indices are positively related with unexpected inflation. The CPI of most countries is depending a lot on commodities prices as crude oil, brent oil and heating oil. Also, you could expect that commodity prices are negatively correlated with more traditional assets, such as stocks and bonds.

An example of an unleveraged commodity index is the S&P 500 GSCI. This index tries to contain as many commodities as possible[16]. The current index exists of 24 different commodities including, crude oil, life cattle, lead and corn. Such indices comprise commodities from all kinds of sectors to keep the index sort of balanced and more resistible against expected and unexpected supply and demand shocks. Therefore these indices could provide diversification benefits to an investor's portfolio. The idiosyncratic risk from a single commodity is averaged out by the whole index. Every sector and every commodity within the index has its own weight. These weights are selected in such a way that the index could resist macroeconomic changes that influences particular sectors or commodities.

At maturity the buyer get the underlying assets of the futures contract physically delivered. One could understand that this is not what the management of a commodity index wants; therefore it sells its contracts before maturity and buys new ones. The selling and buying of futures contracts for this particular reason is known as rolling-over. See figure 1 for a visualization of a roll-over strategy.

The yield of commodities comes from the difference in the purchase price and sale price of a futures contract. If in figure 1 an investor buys futures contract A for €5000 and sells it at t=1 for €5300, than the investor makes a return of €300. John Maynard Keynes, wrote in his book *Treatise on Money (1930),* that the future spot price will be higher for a commodity than the forward price. This is also known as "normal backwardation". Keynes argued that backwardation is not a rare market situation, but is economically rational from the fact that suppliers (producers) of commodities have a higher incentive to hedge their price risk than consumers (also known as the previously mentioned insurance premium).

[16] The GSCI does not include every commodity. Some commodities are excluded to maintain a liquid portfolio.

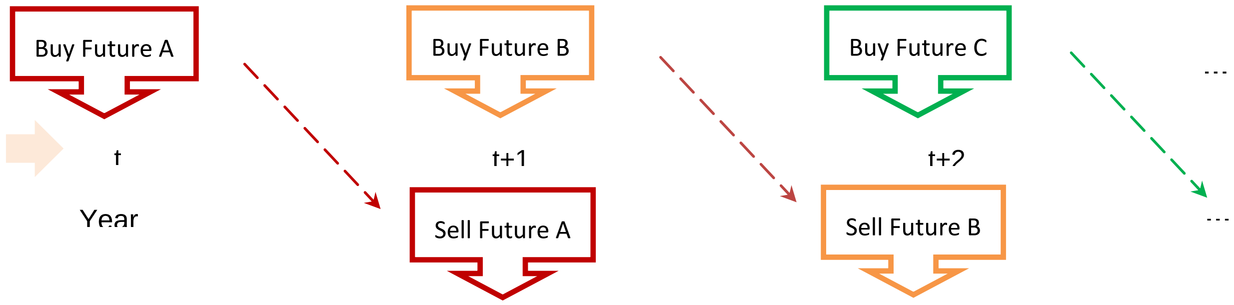

Figure 1. Roll-over strategy visualized. When futures contract A is sold, a new futures contract B is bought etc. Contract B has a longer time to maturity than futures contract A.

Greer argues that there is a fundamental rationale for believing in positive returns from commodity indices. To sum up, real rate of return, expected and unexpected inflation, insurance premium and the rebalancing yield. Therefore he states that commodity returns should be somewhat positively correlated with inflation, which causes a negative correlation between commodities and the returns of stocks and bonds.

Hoevenaars et al. (2008) used U.S. quarterly data from the period 1970 till 2005 to research the relation between commodities and inflation. They conclude that for long-term inflation hedging, commodities are useful in hedging inflation risk. Hoevenaars et al. also state that commodities are the best asset diversifier to deal with risk properties. From an asset allocation perspective they think that commodities are mostly used by pension funds due to their risk diversifying qualities. Bodie and Rosansky (1980) found evidence that commodities are a very effective hedge against inflation. The four best years of commodity returns coincided with four of the seventh best years of inflation rises. Furthermore, Bodie and Rosansky find evidence for a negative correlation between commodities and bonds, which is in line with Greer (2000). Another interesting finding is that most commodities in their research were not correlated with each other. This gives an investor the opportunity to diversify within his commodity portfolio. Furlong and Ingenito (1996) state that commodity prices are the leading economic indicators of inflation. First of all, commodity prices respond faster to economic shocks, such as an increase in supply. The second reason is that changes in prices reflect idiosyncratic shocks. When these shocks occur, the effects are subsequently shown in the prices of commodities. However, Furlong and Ingenito conclude that the relation between commodity price indices and CPI inflation has changed over time. Gorton and Rouwenhorst (2006) researched the link between the U.S. CPI and commodity futures prices over the period 1959 till 2004. They find a positive relationship between the two variables for both expected and unexpected inflation. Martin (2010) gives an explanation in his article on the question, why are investors so much focusing on commodities lately?

He states that commodities have an ability of offering a lower Sharpe ratio[17] in stock and bond portfolios (Froot; 1995, did extensive research on diversifying portfolios with real assets). Martin concludes that commodity price indices could provide a hedge against

Paper	**Year**	**Country**	**Period**	**Hedge against inflation?**
Greer	2000	U.S.	1970-1999	He finds a low positive correlation
Hoevenaars et al.	2008	U.S.	1970-2005	Yes, most positively correlated asset
Bodie and Rosansky	1980	U.S.	1949-1976	Effective hedge, tested on short-term
Furlong and Ingenito	1996	U.S.	1955-1995	Reasonable indicator for inflation. Changed over time
Martin	2010	U.S.	1991-2008	Mostly short-run. Most effective are energy commodities
Gorton and Rouwenhorst	2006	U.S.	1959-2004	Positive correlation with imputed changes for both expected and unexpected inflation
Amenc et al.	2009	U.S.	1973-2007	Over the whole period commodities remain their hedging properties

Table 8. Summary of already existing literature on inflation hedging with commodities.

inflation on the short-run, but he argues that it is mainly related to the large weight of energy related commodities in the indices. Martin found that the correlation of heating oil and unleaded gas are visibly higher than for the other commodities. The correlation between inflation and commodity returns differ from time to time. For the period 1991-2004 Martin find that commodities are only weakly positively correlated. During the period 2005-2008 the link between inflation and commodity prices increased significantly. Martin argues that energy products are a large component of the CPI and when there are global concerns about the scarcity of energy products the relationship between energy commodities and the U.S. CPI tend to increase. Amenc et al. (2009) found empirical evidence that commodity returns remain their positive hedging properties, although the correlation differs across periods.

The already existing literature and empirical evidence shows that commodities could provide a hedge against inflation (see table 8). There is a difference between the short-run and long-run hedging characteristics of commodities according to the literature. The inflation hedging capabilities of commodities could also be influenced by the period investigated. In this paper not the American CPI will be investigated, but the Dutch CPI.

[17] The Sharpe ratio is defined as: $S = \frac{E[R - R_f]}{\sigma}$ and calculates the risk-return ratio. The higher the *S,* the better the reward an investor gets for an unit of risk. For more details, see Sharpe (1994).

2.7 Cash

Next to the most traditional assets like stocks and bonds, cash could be seen as a different kind of asset class. Large investors like pension funds, institutional investors and large private investors have most of the time a well-diversified portfolio. These portfolios consist of several asset classes to optimize the risk-return relationship. In times of very volatile markets investments in cash become more popular. Therefore it is interesting to investigate whether cash could provide a hedge against inflation.

The value of cash is a decreasing function over time due to inflation. Positive inflation rates ensure that you can buy fewer goods than the previous year. When investors deposit their money at a bank they receive an interest rate, which compensates investors for the time value of money. Although the interest rate received by investors does not only depend on the inflation rate, it still could be that the two variables are correlated over time. Fisher (1930) states, that the real inflation rate is the nominal interest rate minus the inflation rate. Therefore the interest received on deposits is defined in part by the inflation rate. Domestic deposits receive a domestic interest rate which depends partially on the inflation rate in that period according to Fisher.

From the theory of purchasing power parity and interest rate parity foreign currencies are also suitable. If in another country the interest rate is higher than in the domestic country than the above theories suggest that the exchange rate between the two currencies should eliminate this difference, otherwise there is an arbitrage opportunity for investors. In this paper will be investigated whether the Dutch interest rate could provide a hedge against inflation and to what extent. Due to the Fisher equation it is expected that the interest rate should be positively related to the Dutch inflation rate.

2.8 Conclusion

A lot of research has been done on the previously discussed asset classes. The already existing literature about inflation hedging with real estate provides some mixed results. Most articles suggest that unlisted or private real estate could deal with inflation risk. On the other hand, listed real estate is often not seen as an inflation hedge. The returns of listed real estate are influenced by the stock market, which is not the case with unlisted real estate. Unlisted real estate is purely driven by rent and capital appreciation. That is why the results differ much between listed and unlisted real estate. In times of crisis a lot of investors tend to believe that gold is a ‘safe haven’. From the already existing literature it can be concluded that this is not always the case. The hedging capabilities of gold differ greatly from time to time. The third asset class that will be investigated are stocks. The “proxy hypothesis” of Fama (1981) states that the prices of stocks are mainly determined by the discounted expected future cash flows. Therefore inflation will only have a very small influence on stock returns which is in line with the earlier findings. The fourth asset, inflation-linked bonds, should be according the theory a good hedge. The Dutch Central Bank does not issue index-related bonds, so it is interesting to see how EMU-linked inflation-linked bonds and other index-related bonds are related to the Dutch inflation rate. It is expected that mismatch and interest rate risk cause the inflation-linked bonds to be less effective. The fifth asset class are the inflation-related swaps. These swaps should provide an effective hedge against inflation. Swaps have the same problem as the indexed bonds. Both assets are investigated when linked to the EMU inflation rate. The sixth asset class under consideration are commodities. The results are mostly positive about the hedging characteristics of commodities. The last asset class is cash. According to the Fisher hypothesis it is expected that the real interest rate is dependent on the nominal rate and the inflation rate. Therefore it is interesting to investigate whether there is a positive or negative relationship between the two variables. From the literature research it is expected that inflation-linked bonds, inflation-linked swaps, commodities and cash could provide a (partial) hedge against Dutch inflation risk.

Chapter 3: Methodology

Fama and Schwert (1977) have provided the most widely known regression model for measuring the relation between inflation and an asset's return. Fama and Schwert uses an ordinary least squares (OLS) regression model, which measures the effectiveness of hedging against inflation. Over the years a lot of empirical research has been done on inflation hedging. Therefore alternative methods were introduced to investigate the possible relations. One of the alternative approaches is the Pearson correlation test that is used by Hoevenaars et al. (2008). This test measures the correlation between inflation and the nominal asset return and is useful for inflation hedging within an asset and liability management (ALM) model. Another approach for measuring the relation is with the use of a cointegration test. Ely and Robinson (1997) used this method for calculating the hedging characteristics of stock returns on inflation. The last common approach is the use of the hedge ratio by Bodie (1976). Schotman and Schweizer (2000) and Bekeart and Wang (2010) uses a different hedge ratio which is related to the approach of inflation tracking. Here the OLS regression that is used is a so-called reverse regression. An economic tracking regression is a regression in which returns track an economic variable.
For this paper it is a relevant question, which method gives the best hedging measure. Spierdijk and Umar (2010) compare the above mentioned methods and investigate with the use of the S&P GSCI total return index which method gives the "best" results. Spierdijk and Umar (2010) state that they could not say whether one of the hedging measures is better than the rest. According to Spierdijk and Umar each method has its pros and cons and focuses on a distinct aspect of inflation hedging. Therefore the choice of a particular approach will depend on the context and for which purpose an asset will be analysed.

3.1 A comparison between approaches

Every measurement approach has its own properties of hedging. The Fama and Schwert equation measures the effect of changing inflation rates over time on an asset's return. It is a linear regression and the coefficient measures the marginal effect in the explanatory variable. Fama and Schwert (1977) used the following formula for testing their hypothesis,

$$9)\ \tilde{R}_{jt} = \alpha + \beta_j E(\tilde{\Delta}_t|\phi_{t-1}) + \gamma_j [\Delta_t - E(\tilde{\Delta}_t|\phi_{t-1})] + \tilde{\eta}_{jt}$$

, where $\widetilde{\boldsymbol{R}}_{jt}$ is the nominal return from *t* -1 to *t* on asset *j*, $\boldsymbol{E}(\tilde{\Delta}_t|\boldsymbol{\phi}_{t-1})$ is the best estimate of the inflation rate given the information available of $\boldsymbol{\phi}_{t-1}$. The unexpected inflation between *t – 1* and *t* is reflected as $[\Delta_t - \boldsymbol{E}(\tilde{\Delta}_t|\boldsymbol{\phi}_{t-1})]$. The error term is represented by $\tilde{\boldsymbol{\eta}}_{jt}$. If $\boldsymbol{\beta}_j$ = 1 than the asset is a one-on-one hedge against expected inflation. When $\boldsymbol{\gamma}_j$ = 1 than the asset is a one-on-one hedge against unexpected inflation. The Fama and Schwert regression can easily handle to what extent an asset provides a good hedge against expected and unexpected inflation. A disadvantage of the method is misspecification due to the imposed causality of inflation rates on asset returns. Geske and Roll (1983) discusses the issue of the direction of the causality. However, this regression model is one of the only methods that could measure the relation of the expected and unexpected inflation. Most methods focus on the total (ex-post) inflation. It is desirable that the relation between unexpected inflation and an asset's return is known. The unexpected part is the change between the inflation over time, therefore it could be argued that the unexpected inflation captures the inflationary shocks. These shocks are a risk to a pensions fund's liabilities, which provides the inflation risk.

The Pearson correlation method, which Hoevenaars et al. (2008) uses, has a link with the OLS approach. A simplified OLS regression of equation 9, where there is only the ex-post inflation variable is used (Gultekin; 1983, uses this exact simplified regression in his paper) looks like:

$$\mathbf{10)}\ \boldsymbol{R}_{jt} = \boldsymbol{\alpha} + \boldsymbol{\beta}\,\boldsymbol{\pi}_t + \boldsymbol{\epsilon}_{jt},$$

, where $\boldsymbol{\pi}_t$ is the inflation at time *t* and $\boldsymbol{\epsilon}_{jt}$ the error term for asset *j* at time *t*. The relation between the OLS equation and the Pearson correlation test manifests itself in β. The coefficient is based on the covariance between $\boldsymbol{R}_{j,t}$ and $\boldsymbol{\pi}_t$ and the variance of $\boldsymbol{\pi}_t$. The Pearson correlation $\boldsymbol{\rho}_{(j,\pi|t)} = \boldsymbol{Corr}\,(\boldsymbol{R}_{j,t}\,, \boldsymbol{\pi}_t)$, is related to β,

$$\mathbf{11)}\ \boldsymbol{\beta} = \frac{\boldsymbol{Cov}\,[\boldsymbol{R}_{j,t}\,, \boldsymbol{\pi}_t]}{\boldsymbol{Var}\,[\boldsymbol{\pi}_t]} = \boldsymbol{\rho}_{(j,\pi|t)} \left(\frac{\boldsymbol{Var}\,[\boldsymbol{R}_{j,t}]}{\boldsymbol{Var}\,[\boldsymbol{\pi}_t]}\right)^{\mathbf{1/2}}$$

The main difference between both approaches is in the variances. To calculate the beta, the covariance is divided by the variance of $\boldsymbol{\pi}_t$. For calculating the correlation statistic, the covariance is divided by the standard deviation of $\boldsymbol{R}_{j,t}$ and $\boldsymbol{\pi}_t$.

Spierdijk and Umar (2010) stated that the β is a scaled down version of the correlation. They also state that from equation 11 it is clear that the influence of inflation on the nominal return of an asset is dependent on the correlation between inflation and the nominal return and a factor that is related to the scale difference between the two variables. Similarly, the hedge-ratio of Schotman and Schweizer (2000) is also a scaled down version of the correlation coefficient. The hedge-ratio could be written as,

$$12)\quad \Delta = \boldsymbol{\rho}_{(\boldsymbol{\pi},\boldsymbol{j}|\boldsymbol{t})} \left(\frac{\boldsymbol{Var}\,[\boldsymbol{\pi}_{\boldsymbol{t}}]}{\boldsymbol{Var}\,[\boldsymbol{R}_{\boldsymbol{j},\boldsymbol{t}}]}\right)^{\mathbf{1/2}}$$

, where Δ is the hedge ratio. The hedge-ratio has the reciprocal of the scaling factor of the Fama and Schwert equation. Spierdijk and Umar concluded that when investigating the Pearson correlation, the Fama and Schwert equation and the Schotman and Schweizer hedge-ratio, the magnitude of the three approaches are different and are depending on the differences in the scaling down between the nominal asset returns and the inflation rates.
The Pearson correlation coefficient measures the strength of the linear relationship between the inflation rates and the asset returns. One possible drawback of the Pearson correlation is that it assumes that the input and output variables are normally distributed.
Ely and Robinson (1997) use the concept of cointegration to investigate long-run inflation hedges. To capture short-run and long-run dynamics between various macroeconomic variables they use a vector error correction model. These particular models are extremely useful in determining the implications of real and monetary shocks on returns and inflation rates. In this paper the main question is what is the relation between asset returns and changes in the inflation rate. Cointegration tests are useful when other variables and relations have to be determined, but that is not the purpose of this research.

3.2 Research method

In this paper an OLS regression like the one of Fama and Schwert (1977) will be used to investigate the relationship between different asset class returns and inflation rates. The relation between the two variables will be investigated on the 1-year and the 3-year horizon. For measuring the hedging characteristics of an asset class, equation 10 and an adjusted version of equation 9 will be used. Equation 13 is the adjusted version and describes to what extent expected and unexpected inflation can be hedged with different asset returns,

$$13)\quad \boldsymbol{R}_{\boldsymbol{jt}} = \boldsymbol{\alpha} + \boldsymbol{\beta}_{\boldsymbol{j}}\, \boldsymbol{\pi}_{\boldsymbol{t-1}} + \boldsymbol{\gamma}_{\boldsymbol{j}} \Delta\boldsymbol{\pi}_{\boldsymbol{t}} + \boldsymbol{\varepsilon}_{\boldsymbol{jt}}$$

with,

$$\Delta\boldsymbol{\pi_t} = \boldsymbol{\pi_t} - \boldsymbol{\pi_{t-1}}$$

, where $\boldsymbol{\beta_j}\ \boldsymbol{\pi_{t-1}}$ is the expected component and $\boldsymbol{\gamma_j}\Delta\boldsymbol{\pi_t}$ the unexpected inflation component. In comparison with equation 9, where the expected inflation is similar to the best guess of the inflation rate according to the information available at *t-1*, here the expected inflation is equal to the realized inflation rate of *t-1*. For the three year returns this means that the expected inflation at *t* is exactly the same as the realized inflation rate over three years three years ago (or the inflation between *t-3* and *t-6,* if *t* represents years*)*. The unexpected inflation lengthens according the horizon of the asset return. For the three year asset returns the unexpected inflation is measured over three years. The error term in equation 13 is represented by $\boldsymbol{\varepsilon_{jt}}$.

Most economic variables are non-stationary. This means that the variance and mean of an economic variable changes when shifted through time. Prices of indices historically rises, this causes the indices to be non-stationary. However, for investigating the hedging characteristics of different assets it is not the price level that is interesting but the returns. Asset returns are stationary, because returns have on average the same mean and variance throughout the time-series. When calculating the asset returns, the first difference in the price has to be taken according to the time horizon to get these returns. When calculating the returns of the different asset classes not the logarithmical returns, but the arithmetic returns are calculated. Often log returns are used for returns in finance, but log returns are only useful and representative when investigating daily returns or intraday returns. Therefore log returns are less useful and arithmetic returns are used for investigating the hedging possibilities of different assets.

Another econometric problem that will exist is that of autocorrelation. On the short-run it could be expected that the time series of the one year returns or the one year inflation are serial correlated. This is the relation between the one year return or inflation and its previous values. A Newey-West test measures the degree of similarity between the time series and the lagged version of itself. The time series of the one year and three year horizon are expected to be serial correlated, because these returns are calculated on a semi-annual basis (see figure 2).

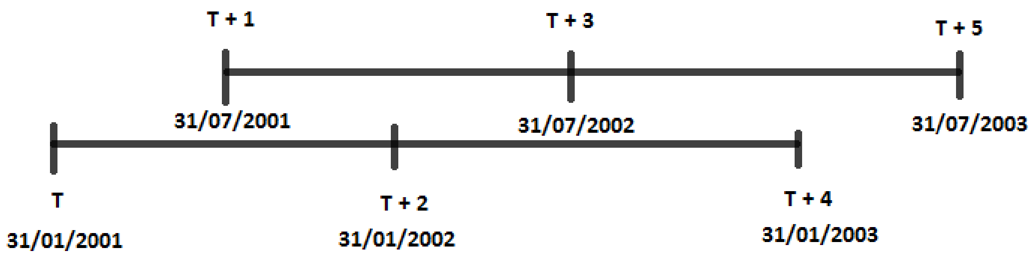

Figure 2. Timeline for the calculations of the annualized returns on semi-annual basis.

When calculating annualized returns on semi-annual basis, the data used for calculating the annual return on 31/01/2001 is partially the same as the data used for calculating the annual return on 37/07/2001. This is also true for the three year return. Therefore the returns and inflation contains a lot of information from their lagged values. Therefore it is needed that the standard errors of the coefficients are corrected for serial correlation in every regression analysis. With the Newey-West heteroskedasticity and autocorrelation consistent test the econometric effects of autocorrelation could be removed.

Another point of attention is the seasonal patterns that could exist in the inflation data series. The inflation rate often has some seasonal patterns which occur year after year. By taking the annual inflation rate all seasonal patterns are incorporated.

The second approach used to measure the hedging capabilities of different assets is the Pearson correlation test, as in Hoevernaars et al. (2008). While the OLS tells the form or the goodness of fit of the linear association between two variables, the Pearson correlation gives the strength of the relation. The correlation coefficient is calculated as follows:

14) $$\boldsymbol{\rho} = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}}$$

, where x_t and y_t are the values of the returns of an asset and inflation at time *t*. While $\bar{x}$ and $\bar{y}$ are the mean of the variables *x* and *y*. *Rho* could take the value of $-1 \geq \rho \geq 1$. A value of -1 means a perfect negative relation and 1 means a perfectly positive relation between the variables. When *rho* is 0 there is no relationship at all. In finance it is very rare to find a correlation of 1 or -1, but often there is some degree of correlation. Therefore it is necessary to test whether a correlation is significantly different from zero or not. The lower the p-value the more significant the relation is, however the higher the correlation the stronger the relation is. To test if the correlation is significant equation 15 will be used,

15) $p = \rho \sqrt{\frac{n-2}{1-r^2}}$,

where ρ is the correlation coefficient and n is the number of observations. The corresponding t-value will be translated into a p-value which makes it better to interpret if the coefficient is statistically different from zero or not.

Chapter 4: Dataset

The data is collected on a monthly basis. This is because the time series of the Dutch CPI level is not available on a daily basis. Even if it was available on a daily basis the inflation rate would be almost the same as yesterday and therefore the correlation and regression analysis would not give clear results about the relation between the variables. The monthly data is required via Thomson Reuters DataStream. The research period is from the beginning of 1973 till the end of 2011. The Dutch consumer price index is used as a measurement of the Dutch inflation, which is published monthly by the CBS. The inflation rate through this period is not constant as can be seen in figure 2 below. The seventies and early eighties are characterized by high levels of inflation. In 1973 there was the famous oil crisis which raised the inflation during this period. The more recent periods have a steady level of inflation, this is mainly due to the inflation rate targeting by central banks and nowadays the ECB. Therefore it is interesting to investigate what the relation is between

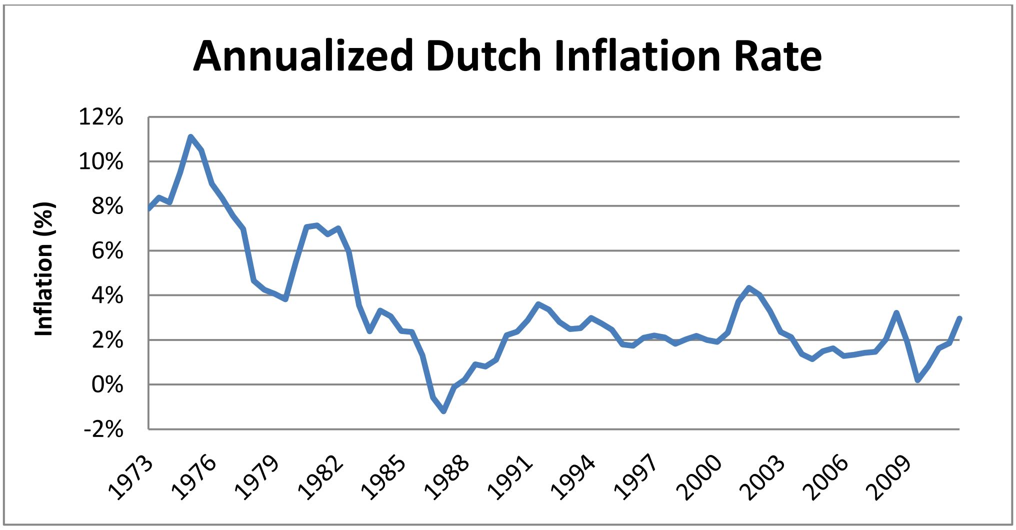

Figure 3. Yearly inflation on a monthly basis from 1973 to 2011.

inflation and an asset return over the whole period. This period is characterized by low and high inflation and therefore it is probably a good representative period to examine inflation hedging. In the table below are the descriptive statistics of the expected and unexpected inflation rate at different time horizons. The average inflation yearly is 3.49%. The one month inflation rate is 0.27%, due to the volatility it could be hard to measure the effect of inflation on asset returns. The expected inflation which is the inflation level at *t-1* has a minimum on a yearly basis of -1.21% and a maximum of 11.11%. For the unexpected inflation rate the mean is around zero for the one year rate. The three years unexpected inflation rate has a mean of -0.98%. This negative mean of the unexpected inflation rate can be explained by the starting point of the dataset. In 1973 the inflation rate is high compared to the whole sample

Descriptive statistics of inflation	Expected Inflation			Unexpected Inflation		
	1 Month return	*1 Year return*	*3 Year return*	*1 Month return*	*1 Year return*	*3 Year return*
Mean	0.27%	3.49%	12.00%	0.00%	-0.14%	-0.98%
Median	0.23%	2.42%	8.94%	-0.02%	-0.05%	-0.49%
Standard Deviation	0.45%	2.74%	8.42%	0.50%	1.38%	6.49%
Minimum	-1.31%	-1.21%	-0.20%	-1.87%	-3.58%	-15.36%
Maximum	2.17%	11.11%	31.13%	1.56%	3.25%	11.43%
Kurtosis	0.85	0.23	-0.30	0.37	0.39	-0.41
Skewness	0.32	1.01	0.84	0.20	-0.37	-0.35
Observations	468	78	78	468	78	78
Time series start at:	31/01/1973	31/01/1973	31/01/1973	31/01/1973	31/01/1973	31/01/1973

Table 9. Descriptive statistics of the expected and unexpected Dutch inflation rate changes at different time horizons. Dutch inflation rate is measured by the CBS. Expected inflation is measured as the period of inflation one period ago. Unexpected inflation is the difference between one period and two periods ago.

period of 1973 till 2011; because of the steady lower inflation rate after 1990 the mean is negative.

The EMU inflation rate is also investigated for a comparison approach. The time-series is collected from the website of the European Central Bank, which gathers all kinds of inflation rates across Europe. The period is investigated from October 2002 till December 2011. The mean inflation during this period is lower than the Dutch inflation rates displayed in table 9. Also the standard deviation is significantly lower for the EMU inflation. This observation makes sense from the fact that in the last decade the inflation rate was substantially lower and more or less constant. Additional descriptive statistics are displayed in appendix A.

For Dutch real estate three indices are used, the Netherlands-Datastream Real Estate Investment Trusts, Euronext AEX real estate and S&P Netherlands REITs which are all constituent equity indices (see table 10 for the descriptive statistics of real estate indices).

The return from gold is obtained from the S&P GSCI total gold index which is a commodity index and from The London Bullion Bank which physically trades golden bars (see table 11 for the descriptive statistics of gold indices).

For measuring the relation between inflation and stock returns, the following indices are used: S&P 500, Euronext AEX, MSCI World Index, MSCI Europe index and MSCI Europe energy index. Because return indices are used for the stock returns, the data is not available for all indices from 1973 (see table 12 for the descriptive statistics of the equity indices).

For the inflation-linked bonds there are several possibilities available. As stated earlier Dutch inflation linked-bonds do not exist. However, national inflation linked bonds as German and French bonds do exist, but next to this there are also European inflation-linked bond indices. Therefore 3 different inflation-linked bond indices are used which are managed by the MTS group. The inflation-linked bonds indices are linked to the harmonised index of consumer prices (HICPxT) ex-tobacco (see table 13 for the descriptive statistics of inflation linked-bonds indices). The HICPxT is expected to be one of the most representative inflation rates for the Dutch inflation rate. Each bond index has a different maturity. The inflation-linked bond indices also have three fixing moments. For research purposes the time series of latest fixings of the day are used, because they represent the closing prices best. The starting dates are between 2005 and 2007. For inflation-linked bonds only the yearly returns are investigated, because the dataset is too small for investigating the three year return. Also the Barclays Capital all Markets EMU HICP-Linked index is used for comparison purposes.

To determine the relation between inflation and inflation-linked swaps, the swaps of Bank of America Merrill Lynch are used with different maturities. Data of swaps with maturities of 5 till 50 years, with 5 year intervals are required from DataStream. All swaps have the same issue date of 1 August 2007. Again, due to the issue date only the one year return is examined (see table 14 for the descriptive statistics of inflation linked-swaps).

The S&P GSCI total return index, S&P GSCI total energy return index and the Dow Jones UBS Commodities index are used for commodities (see table 15 for the descriptive statistics of the commodities indices).

To investigate the hedging characteristics of cash, interest rates from the "*De Nederlandsche Bank''* (DNB) are used. Depending on the assets horizon under investigation a corresponding interest rate will be used (see table 16 for the descriptive statistics of the interest rates).

When calculating the return of all the assets it is important to add dividend yield to the price return of bonds, real estate and stocks. Of these assets the underlying value could rise, but it is also possible that stocks pay-out dividend and bonds pay-out coupons, which is both a return component. For real estate, as stated before rental income is some sort of dividend. Therefore, these kinds of returns have to be taken into account when calculating the hedging possibilities of the assets. For bond, real estate and stock returns a return index is used which replicates an index with a daily dividend yield. In other words the daily dividend is included as an incremental amount next to the daily price changes. The formula to get to the total return index is,

$$15)\ RI_t = RI_{t-1} \times \frac{PI_t}{PI_{t-1}} \times \left(1 + \frac{DY}{100 \times n}\right)$$

where, *RI* stands for the total return, *PI* is the price index, *DY* is the dividend yield and *n* is the number of days in a financial year (most of the time 260 trading days a year).

Descriptive statistics of real estate indices	1 Month return			1 Year return			3 Year return		
	AEX real estate	*NLD REITS DS*	*S&P NLS REITS*	*AEX real estate*	*NLD REITS DS*	*S&P NLS REITS*	*AEX real estate*	*NLD REITS DS*	*S&P NLS REITS*
Mean	0.86%	0.68%	0.42%	13.35%	9.74%	7.34%	44.15%	33.46%	25.50%
Median	1.16%	0.57%	0.40%	15.27%	7.04%	6.30%	41.17%	25.81%	19.87%
Standard Deviation	5.20%	4.89%	4.52%	21.23%	19.62%	20.55%	51.26%	40.66%	40.81%
Minimum	-17.98%	-20.08%	-20.30%	-34.65%	-39.78%	-33.09%	-24.14%	-36.08%	-45.24%
Maximum	14.61%	33.01%	14.98%	48.75%	79.26%	49.91%	129.11%	145.07%	128.70%
Kurtosis	1.19	6.85	1.72	0.06	1.36	-0.64	-1.37	0.35	0.22
Skewness	-0.48	0.80	-0.32	-0.54	0.45	0.11	0.15	0.69	0.67
Observations	131	467	269	20	76	43	16	72	39
Time series start at:	28/02/2001	28/02/1973	31/08/1989	31/01/2002	31/01/1974	31/07/1990	30/01/2004	30/01/1976	31/07/1992

Table 10. Descriptive statistics of real estate indices returns of three different time horizons.

Descriptive statistics of gold indices	1 Month return		1 Year return		3 Year return	
	Gold Bullion	*S&P GSCI GOLD*	*Gold Bullion*	*S&P GSCI GOLD*	*Gold Bullion*	*S&P GSCI GOLD*
Mean	0.91%	0.70%	12.32%	9.34%	44.38%	20.68%
Median	0.18%	0.14%	4.32%	1.70%	18.87%	12.85%
Standard Deviation	6.08%	5.48%	30.33%	30.09%	76.51%	42.23%
Minimum	-18.36%	-18.35%	-22.48%	-21.20%	-31.61%	-31.47%
Maximum	35.81%	29.41%	164.39%	178.14%	325.82%	189.18%
Kurtosis	5.15	3.70	8.54	15.98	3.14	4.17
Skewness	1.23	0.91	2.43	3.42	1.85	1.77
Observations	468	407	78	66	78	62
Time series start at:	31/01/1973	28/02/1978	31/01/1973	31/01/1979	31/01/1973	30/01/1981

Table 11. Descriptive statistics of gold indices returns of three different time horizons.

Descriptive statistics of stocks indices	Monthly returns					1 Year returns					3 Year returns				
	AEX	*S&P 500*	*MSCI World*	*MSCI Europe*	*MSCI EU Energy*	*AEX*	*S&P 500*	*MSCI World*	*MSCI Europe*	*MSCI EU Energy*	*AEX*	*S&P 500*	*MSCI World*	*MSCI Europe*	*MSCI EU Energy*
Mean	1.01%	0.87%	0.87%	0.97%	0.97%	13.44%	11.24%	12.13%	13.05%	12.67%	43.19%	37.79%	40.84%	44.93%	36.52%
Median	1.46%	1.10%	1.15%	1.69%	1.36%	14.15%	13.11%	11.59%	14.93%	13.22%	35.16%	31.52%	35.90%	42.43%	35.91%
Standard Deviation	5.99%	5.00%	4.56%	4.70%	5.56%	26.75%	22.67%	21.83%	20.73%	23.23%	61.19%	59.01%	47.56%	47.43%	49.26%
Minimum	-27.49%	-15.14%	-21.26%	-23.17%	-14.67%	-41.21%	-38.26%	-35.47%	-38.13%	-26.07%	-48.43%	-41.69%	-45.16%	-43.47%	-27.37%
Maximum	17.52%	14.09%	14.30%	22.07%	20.16%	88.54%	86.79%	72.05%	69.80%	82.60%	189.95%	167.54%	155.55%	148.21%	136.07%
Kurtosis	2.44	0.08	1.29	2.55	0.86	0.80	1.67	0.11	0.22	1.25	-0.20	0.00	-0.46	-0.47	-0.81
Skewness	-0.78	-0.18	-0.49	-0.56	-0.01	0.42	0.36	0.17	-0.10	0.73	0.60	0.80	0.30	0.25	0.48
Observations	347	287	468	468	204	56	46	78	78	32	52	42	78	78	28
Time series start at:	02/1983	02/1988	01/1973	01/1973	01/1995	01/1984	01/1989	01/1973	01/1973	01/1996	01/1986	01/1991	01/1973	01/1973	01/1998

Table 12. Descriptive statistics of stock indices returns of three different time horizons.

Descriptive statistics of ILB's	One month			One year		
	1-10Y	*1-15Y*	*10+*	*1-10Y*	*1-15Y*	*10+*
Mean	0,31%	0,12%	-0,22%	3,78%	2,11%	-0,70%
Median	0,34%	0,34%	0,19%	4,22%	2,18%	-1,52%
Standard Deviation	1,67%	2,10%	3,11%	3,24%	5,38%	8,88%
Minimum	-5,88%	-6,27%	-8,16%	-5,04%	-9,39%	-18,22%
Maximum	6,39%	6,11%	5,50%	11,17%	14,36%	18,65%
Kurtosis	6,55	2,41	0,56	0,70	-0,05	-0,20
Skewness	-0,17	-0,42	-0,61	-0,05	0,27	0,24
Observations	50	50	50	39	39	39
Time series start at:	30-11-2007	30-11-2007	30-11-2007	31-10-2008	31-10-2008	31-10-2008

Table 13. Descriptive statistics of inflation-linked bond returns of two different time horizons.

Descriptive statistic swap indices	1 Month return									
	Swap 5-Year	*Swap 10-Year*	*Swap 15-Year*	*Swap 20-Year*	*Swap 25-Year*	*Swap 30-Year*	*Swap 35-Year*	*Swap 40-Year*	*Swap 45-Year*	*Swap 50-Year*
Mean	0.15%	0.13%	0.14%	0.14%	0.11%	0.09%	0.08%	0.08%	0.06%	0.05%
Median	0.27%	0.37%	0.40%	0.38%	0.45%	0.54%	0.49%	0.58%	0.66%	0.73%
Standard Deviation	1.18%	1.52%	2.06%	2.74%	3.42%	4.08%	4.83%	5.62%	6.47%	7.35%
Minimum	-4.39%	-5.96%	-7.14%	-8.92%	-11.00%	-13.24%	-15.77%	-18.19%	-21.77%	-25.74%
Maximum	3.95%	4.87%	6.34%	7.88%	7.92%	8.47%	9.80%	11.19%	13.59%	16.42%
Kurtosis	5.20	5.27	3.30	2.71	2.60	2.62	2.88	3.13	3.28	3.44
Skewness	-0.73	-0.85	-0.64	-0.74	-1.00	-1.08	-1.14	-1.19	-1.20	-1.19
Observations	53	53	53	53	53	53	53	53	53	53
Time series start at:	31/08/2007	31/08/2007	31/08/2007	31/08/2007	31/08/2007	31/08/2007	31/08/2007	31/08/2007	31/08/2007	31/08/2007
Descriptive statistic swap indices	**1 Year return**									
	Swap 5-Year	*Swap 10-Year*	*Swap 15-Year*	*Swap 20-Year*	*Swap 25-Year*	*Swap 30-Year*	*Swap 35-Year*	*Swap 40-Year*	*Swap 45-Year*	*Swap 50-Year*
Mean	1.11%	0.64%	0.40%	-0.01%	-0.81%	-1.58%	-2.29%	-3.09%	-4.22%	-5.43%
Median	0.92%	1.08%	0.84%	-0.42%	-0.63%	-1.77%	-2.19%	-2.82%	-3.55%	-4.33%
Standard Deviation	2.95%	3.99%	4.99%	6.44%	8.41%	10.19%	12.28%	14.53%	16.83%	19.13%
Minimum	-3.20%	-6.66%	-8.94%	-11.16%	-14.86%	-19.28%	-24.17%	-29.17%	-34.11%	-38.82%
Maximum	8.26%	9.62%	10.65%	14.42%	18.58%	21.46%	25.12%	29.05%	32.98%	36.81%
Kurtosis	0.24	-0.06	-0.28	-0.57	-0.77	-0.74	-0.74	-0.74	-0.74	-0.74
Skewness	0.73	0.34	0.16	0.24	0.36	0.41	0.35	0.31	0.28	0.28
Observations	42	42	42	42	42	42	42	42	42	42
Time series start at:	31/07/2008	31/07/2008	31/07/2008	31/07/2008	31/07/2008	31/07/2008	31/07/2008	31/07/2008	31/07/2008	31/07/2008

Table 14. Descriptive statistics of inflation-linked swap returns of two different time horizons.

Descriptive statistics of commodities indices	**1 Month return**			**1 Year return**			**3 Year return**		
	S&P GSCI	*S&P GSCI Energy*	*DJ UBS Comm Index*	*S&P GSCI*	*S&P GSCI Energy*	*DJ UBS Comm Index*	*S&P GSCI*	*S&P GSCI Energy*	*DJ UBS Comm Index*
Mean	0.92%	1.04%	0.56%	13.03%	14.35%	7.65%	41.83%	36.11%	19.95%
Median	1.09%	1.10%	0.71%	11.55%	12.65%	7.34%	39.45%	23.32%	19.48%
Standard Deviation	6.15%	9.12%	4.37%	26.20%	39.99%	19.63%	52.11%	66.02%	26.77%
Minimum	-20.88%	-27.63%	-12.81%	-49.22%	-57.37%	-32.50%	-50.15%	-60.35%	-32.79%
Maximum	26.23%	37.25%	14.45%	89.71%	144.79%	54.35%	216.01%	197.95%	74.30%
Kurtosis	1.58	1.88	0.53	1.11	0.94	0.28	1.55	-0.18	-0.31
Skewness	0.15	0.38	-0.11	0.34	0.64	-0.05	0.95	0.73	0.03
Observations	468	348	251	78	56	40	78	52	36
Time series start at	31/01/1973	31/01/1983	28/02/1991	31/01/1973	31/01/1984	31/01/1992	31/01/1973	31/01/1986	31/01/1994

Table 15. Descriptive statistics of commodities indices returns of three different time horizons

Descriptive statistics of interest rates	**1 Month return**	**1 Year return**	**3 Year return**
	Dutch interest rate	*Dutch interest rate*	*Dutch interest rate*
Mean	0.43%	5.46%	18.02%
Median	0.40%	5.17%	17.52%
Standard Deviation	0.25%	2.66%	7.76%
Minimum	0.03%	1.12%	6.92%
Maximum	1.60%	12.69%	35.15%
Kurtosis	1.060	-0.330	-0.775
Skewness	0.858	0.553	0.486
Observations	445	74	68
Time series start at:	31/12/1974	31/01/1975	31/01/1978

Table 16. Descriptive statistics of interest rates of three different time horizon.

Chapter 5: Results

In this chapter the inflation hedging characteristics of the seven asset classes will be discussed. The regression results will be analysed on the one year and three year horizon. From the regression analysis it is to be expected that the alpha (intercept) in both formulas is closely around zero. For the first equation which separates inflation into expected inflation and unexpected inflation, the coefficients β & γ should be both positive. If the β-coefficient is significant, than inflation has some predictive power in forecasting future asset returns due to the lag in the variable expected inflation. If the gamma variable is significant then the asset return has a relation with the inflationary shocks. When both coefficients are significant then the asset return could provide an effective hedge against inflation (depending on the signs of the coefficients), because the expected and unexpected inflation equals the realized inflation. For the second equation, the variable realized inflation should also be positive. A statistically significant coefficient means that asset return and inflation is a direct hedge. Another important statistic is the adjusted R^2. A normal R^2 represents the percentage of the variation in the asset return that can be explained by the explanatory variable(s). A drawback of the normal R^2 is that it increases with the number of explanatory variables in a linear regression. Therefore the adjusted R^2 is used, which only increases if the added explanatory variable improves the model more than it would be expected by average chance. For pension funds it is to be expected that hedging against unexpected inflation is more important than the expected inflation. Unexpected inflation causes inflationary shocks, which is responsible for the greatest part of inflation risk.

In appendix B are the results of hedging inflation over a one month horizon. Almost everything on the one month basis is insignificant, because on such a short term other effects dominate more, therefore the explanatory variables could not explain any of the variance in the dependent variables. Noteworthy results on the one month horizon are discussed if present.

The inflation hedging properties of real estate, gold, stocks, inflation-linked bonds, inflation-linked swaps, commodities and cash are discussed in section 2 till 7 respectively. Section 8 will give a conclusion in which there is a summary of the inflation risk-return relationship based on the coefficients, p-values and correlations.

5.1 Real estate

For testing the hedging capabilities of real estate, three different indices are used; the AEX real estate index, Datastream Dutch REITs index and the S&P Netherlands REITs. For the one year real estate returns the hedging results against Dutch inflation are disappointing (see table 17). Only the intercept variables in equation one and two and the expected inflation coefficient for the AEX real estate index are statistically significant. The coefficients for this expected inflation variable is negative, -8.74, which implies that it is negatively significant. The negative coefficient indicates that hedging against expected inflation could be done with creating a short position in the AEX real estate index. The relation between expected and unexpected inflation and the AEX real estate return could be interpreted as:

Return = 30% - 8.47 * Expected inflation (%) – 5.31 * Unexpected inflation (%)

On average the unexpected inflation is around 0.00% and the expected yearly inflation on average is 3.49%. This results into a yearly return of 0.40%, which is different when compared to the real mean of the yearly AEX real estate return of 13.35%. This large deviation from the real mean could also be explained with the adjusted R^2 which is zero. The

1 Year Real Estate	AEX Real Estate Index		REITS		S&P NL REITS	
	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1						
Intercept (α)	0.30	0.01	0.13	0.00	0.29	0.01
Expected (β)	-8.47	0.04	-1.01	0.16	-1.00	0.06
Unexpected (γ)	-5.31	0.28	-3.81	0.09	-4.04	0.32
Adjusted R2	0.00		0.04		0.08	
Variable eq. 2						
Intercept (α)	0.26	0.02	0.14	0.00	0.21	0.05
realized infl.	-6.68	0.09	-1.30	0.10	-6.05	0.16
Adjusted R2	0.03		0.02		0.04	
Correlation						
Expected	-0.25	0.29	-0.05	0.69	-0.31	0.05
Unexpected	0.01	0.97	-0.22	0.05	0.05	0.75
Inflation	-0.29	0.22	-0.17	0.14	-0.25	0.10

Table 17. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test for the one year real estate returns. The time-series from the AEX Real Estate starts in January 2002, the REITS start at January 1974 and the S&P NL REITS is from July 1990. All time-series end at December 2011.

explanatory variables cannot explain any variation in the AEX real estate return on a yearly basis and therefore the regression fails in determining the real estate prices from the expected and unexpected inflation. The relation, as stated in the regression, does not have any explanatory power as seen by the R^2.

The negative sign of the coefficient means that it is a negative hedge. If the regression was statistical significant it implies that a short position in the AEX real estate index would partially hedge your position against inflation risk. For such a short position in real estate is no economic rationale. A short position would imply that that you would lose the expected return on real estate on average, but gain to some extent protection against inflation. Such a short position is to costly because the returns are historically negative. The other indices cannot provide a hedge against Dutch inflation. The coefficients for both equations are not statistically significant and the adjusted R^2s are low. The correlation statistics are also not significant as it can be expected from the regression equations. However, the correlation statistics are almost significant for the expected inflation of the S&P REITS and the unexpected inflation of REITS. Nonetheless, it can be concluded that the three indices do not provide an effective hedge against inflation on a one year horizon. The results for the short-term horizon (one year) are in line with the conclusions summarized in table 2. Martin (2010) has a possible explanation for the negative coefficients on a short-horizon. He states that during normal times, it is to be expected that real estate prices experience negative effects from changes in the macro-economic environment that are linked with increases in inflation.

3 Year Real Estate	AEX Real Estate Index		REITS		S&P NL REITS	
	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1						
Intercept (α)	-0.17	0.64	0.25	0.02	-0.19	0.67
Expected (β)	5.69	0.33	0.12	0.86	6.43	0.35
Unexpected (γ)	-1.28	0.03	-3.98	0.00	-5.51	0.25
Adjusted R2	0.81		0.34		0.48	
Variable eq. 2						
Intercept (α)	1.15	0.20	0.38	0.01	0.84	0.10
realized infl.	-1.37	0.38	-0.44	0.57	-8.66	0.19
Adjusted R2	0.00		-0.01		0.16	
Correlation						
Expected	0.88	0.00	0.35	0.00	0.66	0.00
Unexpected	-0.91	0.00	-0.60	0.00	-0.69	0.00
Inflation	-0.26	0.32	-0.08	0.51	-0.40	0.01

Table 18. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test for the three year real estate returns. The time-series from the AEX Real Estate starts in January 2004, the REITS start at January 1976 and the S&P NL REITS is from July 1992. All time-series end at December 2011.

The results of hedging inflation over a three year period are displayed in table 18. The correlations of expected and unexpected inflation are all statistically significant. The expected inflation coefficients have a positive effect on returns and the unexpected inflation has a negative impact on real estate returns. The signs of the correlations of expected and unexpected inflation correspond to the coefficients. The sign for the expected inflation correlations are positive and for the unexpected component negative (only exception is for

REITS). In the regression analysis only the unexpected components are mostly negatively significant. Another important finding is the high adjusted R^2 for the multivariate regressions. The AEX real estate index has a R^2 of 0.81, which means that more than eighty percent of the variation in the return is explained by expected and unexpected inflation. The adjusted R^2 is remarkable, because only the unexpected variable is significant. The R^2 of the univariate regression is zero, but that regression only uses one variable. When splitting realized inflation into two components the explanatory power of the equation is much higher. The 0.81 could also be explained from the correlations which are 0.88 and -0.91 respectively for the multivariate regression of the AEX real estate index. The correlation of the realized inflation is only -0.26, that is why the R^2 for that regression is zero. It can be concluded that for the AEX real estate index realized inflation as a variable cannot explain real estate returns, but when split up into; expected and unexpected inflation the explanatory power increases. REITs and S&P have an adjusted R^2 of 0.34 and 0.48 respectively. The results of the univariate regression, where returns are regressed on the real inflation rate are inconclusive. The adjusted R^2 for these three indices are very low and the coefficients and correlations are not significant.

Overall, real estate returns measured over a three year horizon is significantly correlated and has some significant regression coefficients. For all three indices the unexpected inflation correlation is negatively significant. These results strongly indicate that it is possible to hedge against unexpected inflation with a short position in listed real estate, which is in line with Gyorko and Linneman (1988) and Hoesli et al. (2008). The evidence for hedging against expected inflation is somewhat thinner. Therefore the results for expected inflation are at best mixed. Real estate returns do not provide a hedge against the realized inflation, because of the adjusted R^2 of zero. Also, the coefficients and correlations are insignificant. A possible reason could be the opposite signs of the expected and unexpected inflation.

Implications for a pension fund which focuses more on a long-term investment strategy, could partially hedge inflation risk with a short position is listed real estate. However, this is not practical, because than they would earn a negative return. Therefore it can be concluded that real estate cannot hedge Dutch inflation.

5.2 Gold

The hedging characteristics of gold are measured on the basis of two indices. The first index is the London bullion market, where gold is traded in an over-the-counter market. The index quotes the price of gold per troy ounce. The second index that is used is the GSCI gold commodity index. The price of gold is collected from the futures contracts on gold, just as with commodities. The relation between gold returns and inflation is not noticeable on the one month horizon (appendix B).

The one year results of hedging inflation with gold returns are displayed in table 19. The adjusted R^2 is low for both the univariate and multivariate regressions. This indicates that little of the variance is explained by the explanatory variable. However, the realized inflation correlations are for both indices statistically and economical significant. There is evidence that gold provides a hedge against inflation on the short term one year. The strength of the realized inflation is significant, but gold returns and realized inflation are not highly correlated (0.30 for a one year horizon). The coefficients from the regression analysis are not statistically significant and the R^2 is not high.

Therefore the results are mixed for the one year horizon. It can be stated though that the relation is positive as all coefficients and correlations have positive signs.

1 Year Gold	Gold Bullion		GSCI Gold index	
	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1				
Intercept (α)	0.02	0.69	0.00	0.90
Expected (β)	3.09	0.13	4.17	0.27
Unexpected (γ)	5.88	0.14	6.54	0.28
Adjusted R2	0.07		0.05	
Variable eq. 2				
Intercept (α)	0.01	0.85	-0.03	0.75
realized infl.	3.38	0.11	4.81	0.26
Adjusted R2	0.08		0.06	
Correlation				
Expected	0.20	0.09	0.13	0.30
Unexpected	0.18	0.11	0.18	0.14
Inflation	0.30	0.00	0.27	0.03

Table 19. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test for the one year gold returns. The time-series of the prices from the Gold Bullion starts in January m1973 and time-series of the GSCI Gold Index starts at January 1979. The time-series ends in December 2011.

The hedging results over a three year horizon are shown in table 20. For both indices the expected inflation component, just as the realized inflation is significant. The coefficients have a positive sign which makes them economic significant, because from economic theory it can be expected that when gold prices increase, inflation also increases. For the GSCI the unexpected inflation component is also significant and has a positive sign. The adjusted R^2 is between 0.23 and 0.30 for both indices and both regression equations. This is higher than those of the one year horizon.

The correlation coefficients are also positively significant, except for both the unexpected inflation. The latter one has correlation coefficients of 0.05 and 0.06 respectively. Therefore the strength of the realized inflation variable for this asset class consists mostly out of expected inflation. On the three year term gold can provide partially a hedge against inflation, however it does not respond well to inflationary shocks. As stated earlier, the already existing literature is at best mixed. For instance, Ghosh et al. (2004) founds no evidence for a short term horizon hedge, on the other hand the authors found evidence that on the long-term there is a positive relation between inflation and gold returns.

3 Year gold	Gold Bullion		GSCI Gold index	
	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1				
Intercept (α)	-0.19	0.33	-0.18	0.37
Expected (β)	5.59	0.02	4.91	0.05
Unexpected (γ)	3.33	0.17	3.80	0.03
Adjusted R2	0.30		0.23	
Variable eq. 2				
Intercept (α)	-0.10	0.54	-0.13	0.40
realized infl.	4.92	0.01	4.46	0.03
Adjusted R2	0.28		0.23	
Correlation				
Expected	0.51	0.00	0.35	0.00
Unexpected	0.05	0.69	0.06	0.64
Inflation	0.54	0.00	0.49	0.00

Table 20. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test of gold indices returns over a three year horizon. The time-series of the prices from the Gold Bullion starts in January 1973 and time-series of the GSCI Gold Index starts at January 1981. The time-series ends in December 2011.

Overall it could be stated that, the longer the investment horizon the better the asset serves as a hedge against inflation. Gold does not provide security for the one year variation in the inflation rate, but it certainly provides hedging possibilities over a three year horizon. Gold cannot purely hedge inflationary shocks in the form of unexpected inflation, but gold is more than suitable to hedge against realized inflation. For pension funds it is therefore recommended to invest at least some proportion of their portfolio into gold for inflation risk purposes. It is not clear to what extent a pension fund should invest, because it depends on many things like the average age of the participants, risk profiles, return, and market environment.

5.3 Stocks

The results of hedging inflation risk with equity returns are assessed on the following five indices, Euronext AEX, MSCI World, MSCI Europe, MSCI Europe Energy and the American S&P 500.

The results for the one year investment horizon are mixed (see table 21). Almost all intercept variables are significant, but some other variables are as well. The returns for the MSCI Europe provide a negatively significant hedge against unexpected inflation. For the MSCI Europe Energy and the S&P 500 index the expected inflation correlations are significant. However, their correlations of the unexpected inflation are not significant, 0.41 and 0.50 respectively. Furthermore the correlation coefficient of the MSCI World and the MSCI Europe are significant at the 10% level. The adjusted R2 is for all regression analyses is low, therefore little variance is explained by the explanatory variables on the one year horizon and it can be concluded that inflation has a minor influence on stock returns.

The signs of most variables are negative. This is according to economic theory. When the inflation increases, the interest rate should also increase. If in the Gordon-growth model *r* increases (ceteris paribus) then the price of equity should decrease. But it is more likely that the dividend also rises as a result of a rising inflation rate. Therefore it depends on which factor dominates. Through low adjusted R^2's and few significant coefficients it can be concluded that on the one year investment horizon stock returns do not hedge against inflation.

1 Year equity	AEX		MSCI WORLD		MSCI EUROPE		MSCI EUROPE ENERGY		S&P 500	
	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1										
Intercept (α)	0.17	0.12	0.13	0.00	0.17	0.00	0.34	0.00	0.31	0.00
Expected (β)	-1.83	0.76	-0.42	0.67	-1.16	0.13	-10.21	0.01	-9.12	0.06
Unexpected (γ)	-1.16	0.72	-3.67	0.15	-3.90	0.04	-1.70	0.41	2.69	0.37
Adjusted R2	-0.03		0.02		0.04		0.06		0.06	
Variable eq. 2										
Intercept (α)	0.16	0.04	0.15	0.00	0.18	0.00	0.21	0.03	0.23	0.01
realized infl.	-1.50	0.71	-0.75	0.50	-1.44	0.85	-4.13	0.21	-5.43	0.14
Adjusted R2	-0.01		0.00		0.02		0.00		0.02	
Correlation										
Expected	-0.05	0.71	0.02	0.86	-0.07	0.53	-0.34	0.05	-0.31	0.04
Unexpected	0.00	0.95	-0.22	0.06	-0.21	0.06	0.15	0.41	0.10	0.50
Inflation	-0.06	0.65	-0.09	0.42	-0.18	0.11	-0.16	0.38	-0.21	0.16

Table 21. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test of stock indices returns over a one year horizon. The time-series from the AEX begins in January 1984, the S&P 500 starts at January 1989, the MSCI World and MSCI Europe are both from January 1973 and the MSCI EU Europe starts in January 1996 and ends in December 2011.

3 Year equity	AEX		MSCI WORLD		MSCI EUROPE		MSCI EUROPE ENERGY		S&P 500	
	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1										
Intercept (α)	-0.06	0.87	0.31	0.02	0.40	0.00	-0.19	0.75	0.26	0.70
Expected (β)	7.09	0.23	0.60	0.51	0.06	0.94	8.04	0.42	1.96	0.84
Unexpected (γ)	0.48	0.91	-2.80	0.01	-3.71	0.00	-2.74	0.57	-0.78	0.92
Adjusted R2	0.11		0.17		0.24		0.13		-0.03	
Variable eq. 2										
Intercept (α)	0.53	0.04	0.45	0.00	0.57	0.00	0.63	0.12	0.49	0.35
realized infl.	-1.59	0.70	-0.41	0.63	-1.06	0.17	-4.15	0.44	-1.68	0.80
Adjusted R2	-0.02		0.00		0.02		0.00		-0.02	
Correlation										
Expected	0.38	0.00	0.25	0.02	0.20	0.07	0.42	0.02	0.13	0.41
Unexpected	-0.32	0.02	-0.42	0.00	-0.51	0.00	-0.39	0.04	-0.12	0.43
Inflation	-0.06	0.64	-0.07	0.53	-0.19	0.10	-0.17	0.40	-0.05	0.73

Table 22. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test of stock indices returns over a three year horizon. The time-series from the AEX begins in January 1986, the S&P 500 starts at January 1991, the MSCI World and MSCI Europe are both from January 1973 and the MSCI EU Europe starts in January 1998 and ends in December 2011.

The results from the three year investment horizon are different from those of the one year horizon (see table 22). The large diversified indices, MSCI World and MSCI Europe, have negatively significant unexpected inflation variables. In these regression analyses the R^2 is 0.17 and 0.24 respectively. The expected and unexpected inflation correlations are significant (only exception is S&P 500 index). The corresponding p-values of the realized inflation correlations are on the other hand far from significant. Also, this is implied by the low R^2s of the regression analyses, which are around 0.00. The correlation analyses indicate that there is some sort of relation between inflation and stock returns on a three year horizon. However this relation is only present in the lagged inflation variable and the unexpected inflation part. These two variables also have opposite signs which imply that it is only possible to hedge against one component. Most correlations are significant, though the regression coefficients are not. The adjusted R^2's of the regression analyses also indicate that stock returns are not much influenced by inflation.

Overall stocks do not provide any hedging possibilities against real inflation. When inflation is split up in expected and unexpected inflation, on the long term it could be that one of these inflation components could be hedged. The longer the investment horizon the stronger or higher the correlation is, however the adjusted R^2 for stock returns over all the horizons is low. Also the opposite signs between expected and unexpected inflation at the three year horizon indicates that a complete hedge against inflation is not likely. The conclusion on the short-term hedging possibilities is in line with the findings in section 2.3. All articles from that section conclude that stocks cannot provide a hedge against inflation risk on the short term. Only Martin (2010) states that energy stocks could have some hedging possibilities, however, I do not find any particular relationship. For the three year horizon, which is the long-term, the literature states that stocks are not capable of hedging inflation risk, but some researches show that it depends on country specific elements. The results that I found indicate that stock returns cannot hedge Dutch inflation risk.

5.4 Index-related bonds

The one year results of hedging inflation with European HICPxT inflation-linked bonds are displayed in table 23. The first column, *1-10Y,* stands for a constituent list of inflation-linked bonds with a maturity from at least one till a maximum of 10 years. The second index, *1-15Y*, consists of bonds which have a maturity of at least of one year and a maximum of 15 years. The third index only has inflation-linked bonds within its list that have at least a maturity of 10 years. The three different indices also have different durations due to the minimum and maximum of the maturities that are in the index. The first index has approximately a duration of 4-6, the second index of 8-10 and the index *10+Y* has an approximate duration of around 14-16. For pension funds higher duration bonds are more important, because most of their liabilities are far ahead in the future.

1 Year Inflation-linked Bonds	1-10Y		1-15Y		10Y	
	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1						
Intercept (α)	0.10	0.00	0.12	0.00	0.17	0.00
Expected (β)	-3.58	0.00	-5.87	0.00	-10.71	0.00
Unexpected (γ)	-3.52	0.00	-5.90	0.00	-10.05	0.00
Adjusted R2	0.60		0.63		0.63	
Variable eq. 2						
Intercept (α)	0.10	0.00	0.12	0.00	0.15	0.00
realized infl.	-3.50	0.00	-5.92	0.00	-9.75	0.00
Adjusted R2	0.61		0.64		0.63	
Correlation						
Expected	0.34	0.00	0.36	0.02	0.31	0.05
Unexpected	-0.66	0.00	-0.68	0.00	-0.65	0.00
Inflation	-0.79	0.00	-0.80	0.00	-0.80	0.00

Table 23. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test of inflation-linked bond returns over a one year horizon. The time-series of the 1-10Y bonds, the 1-15Y bonds and the 10Y+ bonds start at October 2008. The series end in December 2011.

Over a one year horizon all the regression coefficients and the correlations are statistically significant. The explanatory variables explain at least 60% of the variance in the dependent variable. The signs of the coefficients and correlations indicate that there is a negative relationship between inflation and index-linked bonds. The statistics indicate that this relation is significant, but this means that if inflation increases the returns of inflation-linked bonds decreases and vice versa. Also the correlation statistics indicate the same. The expected component has a slightly positive relation, but the unexpected and realized inflation have a negative relation with inflation-linked bonds. No economic theory or rationale expects a negative relation between these variables. A pension fund will not go short in inflation-linked bonds. This result of a negative hedge is surprising, because inflation-linked bonds are issued with the intention of inflation hedging. Therefore it is interesting to look at possible causes, which led to these shocking results.

The ILB's are linked to the HICPxT inflation rate and consist of multiple bonds which changes continuously over time. Only four countries issue inflation-linked bonds in the Euro-zone. These four countries are Germany, France, Italy and Greece and therefore the inflation-linked bonds could be not so representative for the European inflation rate. The indices can only obtain investment grade bonds, therefore on the 27th of April 2010, when Greece was downgraded from investment grade to the category of high-yield bonds, the Greece ILB's were excluded from the indices. The dataset is from October 2008 till December 2011 and contains the financial crises and the sovereign debt crisis. In this period, prices are volatile and the market participants are becoming more risk averse. The ILB's investigated are linked to the above mentioned countries, representing the European inflation rate. The discrepancy between the European and the Dutch inflation rate could be a possible cause of the shocking results found earlier, also known as mismatch risk. However, investigating the relation between the two inflation rates during the sample period gives a correlation of 0.77, which indicates that the two inflation rates are highly correlated, although not perfect (see also figure 3). Therefore the Dutch inflation is not likely the cause of the negative relationship between the Dutch inflation rate and inflation-linked bonds returns.

To compare between ILB's, I also investigated the Barclays Capital all Markets EMU HICP-linked index (for results see table 24). This index is almost perfectly correlated with the ILB's used in table 23 and is negatively correlated with the European inflation rate. When the sample period is expanded to October 2002 till December 2011, then the correlation decreases to zero.

Index	Euro 1Y	1-15Y	1-10Y	10Y	Sample period
BarCap	-0,1485	0,9880	0,9771	0,9825	31-10-2008 - 31-12-2011
,,	-0,0099				31-10-2002 / 31-12-2011
,,	-0,3115				31-01-2007 / 31-12-2011

Table 24. Correlation statistics of the BarclaysCapital all Markets EMU HICP-linked index, the EMU inflation rate and the three ILB's that are used for the investigation. The correlation between the BarCap and the EMU inflation rate is divided into three different subsamples.

In figure 4, it is clearly visible that during the sample period the Dutch and the European inflation rate have a negative relation with the ILB's return. When the inflation rate decreases, the returns of ILB's went up and vice versa, which is in line with the conclusion made above that ILB's do not provide a hedge against Dutch inflation during the sample period.

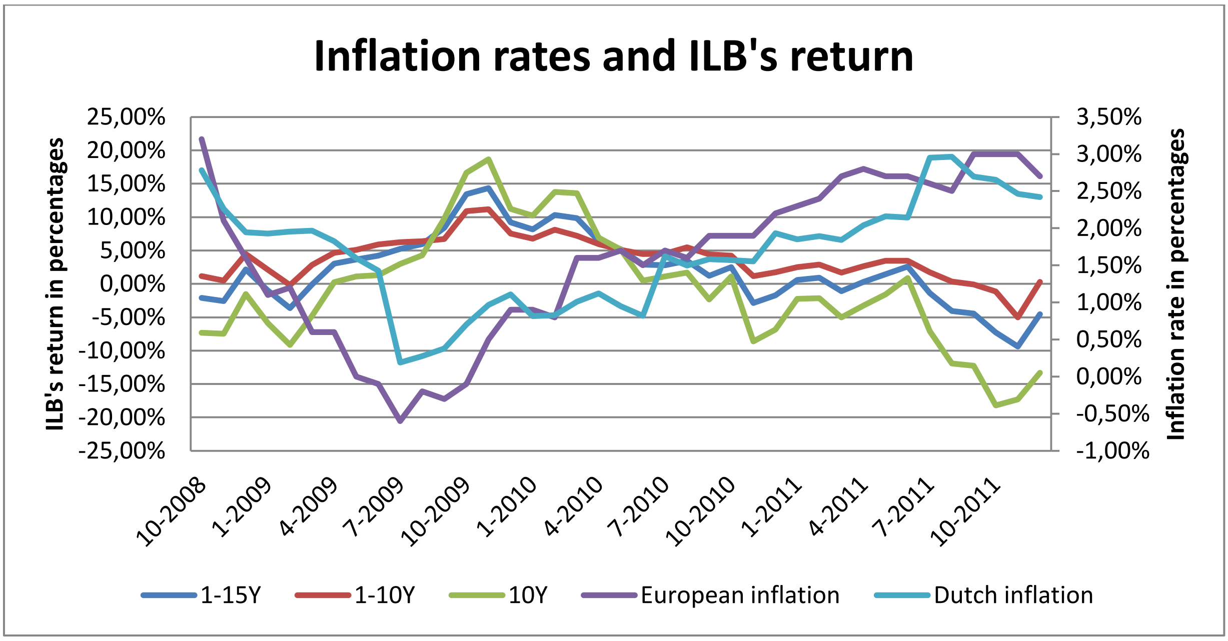

Figure 4. A chart of the Dutch and European inflation rate (vertical axis on the right-hand side). Also the three different inflation-linked bonds indices are displayed (vertical axis on the left-hand side). The percentages display annualized rates and returns on a monthly basis. The sample period is from October 2008 till December 2011.

The negative relation found could also be explained with the euro swap rate curve. When these rates rise (parallel shift), the yield on the investment goes up. This lead to a fall in the prices of ILB's. When the euro swap curve decreases, the price of the ILB's will go up. The euro swap curve is determined by the market. The relation between the average swap rates over the associated horizon of the index and the ILB's returns are plotted in figure 5.

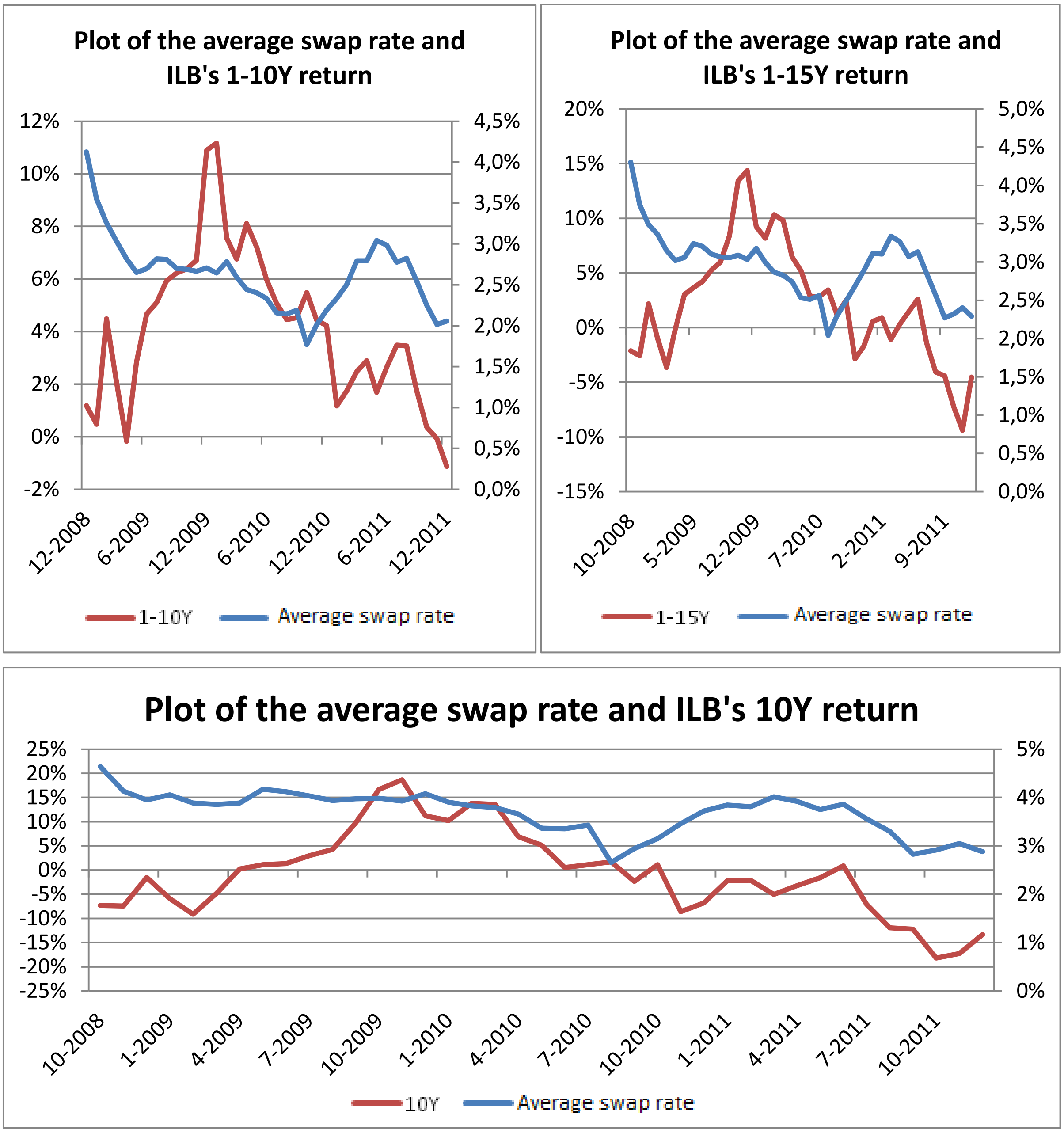

Figure 5. Plots of the average euro swap rate, based on the term structure of the euro swap rates, and the ILB's index return. The average swap rate is measured over the average horizon of the ILB index. The average swap rates represents the interest demanded by investors. The sample period start in October 2008 and ends on December 2011. The term structure is collected from the DNB. The return of the ILB uses the left axis, the average swap rate is displayed on the right axis.

From figure 5, it can be concluded that ILB's return do not move negatively one-on-one with the average swap rates. This implies that the yield as stated in economic theory has not a perfect negative relation with the price of the asset. This is a remarkable result, because ILB's pay out inflation adjusted coupons. The coupons and the principal are often the largest income of such a bond and therefore interest rate risk is expected to be dominant. However, the plots in figure 5 cannot support this view. The correlations between the returns and the euro swap rates are for the 1-10Y, 1-15Y and 10Y index, 0.03, 0.14 and 0.38 respectively.

Instead of an expected negative relation between the average swap rates and the ILB's return, the results show a slightly positive relation.

Interest rate risk and mismatch risk cannot explain the negative relation between the Dutch inflation rate and the inflation-linked bonds. In total there are three main factors that can cause this negative relation of which two are already excluded. The last reason is credit spread risk within the inflation-linked bonds indices, which makes the ILB's return deviate from the inflation rate. In the last couple of years the interest rate on nominal bonds increased substantial for countries like France, Italy and Greece. As stated before Greece was excluded from ILB's indices, because there creditworthiness was decreased to junk status. But for France and Italy this is not the case. However both countries experience high interest rates, because they were downgraded over the last years. France and Italy dominate in the ILB's indices in percentages, Germany (is not downgraded) is only represented for a minor part in these indices. The enlargement of the credit spread for a great part of the underlying bonds in the indices probably dominates the pricing of the ILB's indices. Therefore, the relation between the Dutch inflation rate and these ILB's indices is not positively related.

In May 2012, TKP investments also found a negative correlation between EMU-ILB's (also used the indices from Barclays) and the Dutch inflation rate, between the period 2001 and 2011.[18] This investment company however did not researched the causes of this negative relation and also did not look at the expected and unexpected inflation rate.
Bekaert and Wang (2010) are believers of inflation-linked bonds and argue that it is hard to neglect the potential and the benefits of such bonds, unless the market in which they trade is highly deficient. Bekaert and Wang draw the wrong conclusion. The ILB's returns were not positively related with the European inflation rate; therefore the hedging properties of ILB's are vanished during the sample period.

Overall it could be stated that the ILB's could not provide a hedge against Dutch inflation. Although the statistics indicate a statistical significant negative relation, no pension fund will go short on ILB's. The conclusion that ILB's do not provide a hedge against Dutch inflation and even European inflation is shocking. Therefore it can be concluded that the negative relation has nothing to do with the mismatch in inflation rates. Also, the term structure of the euro swap rates does not influence the prices of the inflation-linked bonds enough to explain the negative relationship between the return and Dutch inflation. Therefore it is expected that

[18] TKP investments is a company which manages portfolios and researches relations between economic variables and assets. Their results are not publicly available.

the increased credit spread over the last couple of years has influenced the market value of ILB's. The highly negative correlation of unexpected inflation indicates strongly that ILB's are useless for inflation risk hedging during the period October 2008 and December 2011. I expect that in the future, when the capital markets are more serene, the ILB's will provide a hedge against inflation risk as stated by Bekaert and Wang (2010).

5.5 Index-related swaps

For investigating whether index-related swaps or inflation-linked swaps are a hedge against Dutch inflation ten different swaps with different maturities are used. These swaps with different maturities are issued by the Bank of America Merrill Lynch. The results on the one month horizon are published in appendix B. The results of the annualized inflation-linked swap returns are displayed in table 25. The one year results are discussed below and are interesting, because these swaps are related to the European and not to the Dutch inflation rate. Therefore the relation between both variables is important and affects the effectiveness of the hedge.

The statistics of the inflation-linked swaps with a maturity of 5, 10, 15 and 20 years are mostly significant. The coefficients, but also the correlations have a positive sign, which is in line with economic theory. It is expected that when inflation increases, the returns on inflation-linked swaps also increase. The adjusted R^2 for the five year swap is 0.49 and decreases with maturity. The correlations also get lower as the maturity increases. For the swaps longer than 25 years, the coefficients and correlations are insignificant and the adjusted R^2 is around zero. It can be concluded that for these swaps there is not a relation between the returns and the Dutch inflation rate. Though, the shorter maturities do have a relation, the longer maturities have not, which is a bit surprising. There are several reasons which could explain the results. The first possibility is the use of the Dutch inflation rate. As stated earlier, the swaps are linked to the EMU inflation rate. Therefore the significance could be not so persistent over all the maturities. The second reason could be that on the short term inflationary shocks are more pronounced in the price index of these swaps. Large inflationary shocks have a great influence on the pricing of a 5 year swap. The same shock could have a minor effect on the price of a swap with a holding period to maturity of 50 years. Due to an averaging out effect these inflation shocks are not persistent over such a long time.

In appendix C, are the results of the EMU inflation rate analysed on the inflation-linked swap returns. The EMU inflation rate provides better results on the swaps as it is expected. The coefficients and correlations are significant for almost all inflation-linked swaps, except for the swaps with a holding period to maturity of 45 and 50 years. An interesting observation is that the correlation increases from the holding maturity of 5 years to the holding period of 10 and 15 year swap, after that the correlation decreases.
Another observation is that the coefficients are around one and consistent over time, especially for the longer maturities. In contrast to the EMU inflation rate coefficients, the Dutch inflation coefficients are not that consistent and not around one. This finding is logical, because the inflation-linked swaps are linked to the EMU inflation rate and not the Dutch inflation rate and differs in level. The difference in both inflation rates causes the mismatch risk (Mahieu and de Roode, 2011). Therefore the swaps cannot be a perfect hedge against the Dutch inflation. The Dutch inflation rates are however positively correlated and significant.

Overall it can be concluded that EMU inflation-linked swaps can provide a hedge against the Dutch inflation rate. This is true for the 5, 10, 15 and perhaps the 20 year swap. Especially the short-horizon swaps provide a hedge against the realized Dutch inflation rate, which is shown in the univariate regression and the realized inflation correlation. In comparison with the ILB's, which were considered in the previous section, the inflation-linked swaps can be used by pension funds to hedge their inflation risk. Therefore it can be recommended to switch the ILB's for swaps, because during crises swaps seem to be the best hedging asset. The best solution to hedge inflation would be to hedge the inflation risk with a swap that is linked to the Dutch inflation rate instead of the EMU inflation rate.

1 Year Swaps	5 Year		10 Year		15 Year		20 Year		25 Year	
	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1										
Intercept (α)	-0,06	0,01	-0,11	0,00	-0,12	0,00	-0,12	0,05	0,05	0,28
Expected (β)	3,83	0,00	6,52	0,00	7,30	0,00	6,75	0,04	0,04	0,30
Unexpected (γ)	2,89	0,00	3,92	0,00	4,09	0,00	3,64	0,05	0,05	0,34
Adjusted R2	0,49		0,49		0,35		0,15		0,00	
Variable eq. 2										
Intercept (α)	-0,03	0,02	-0,04	0,04	-0,05	0,13	-0,04	0,30	-0,04	0,49
realized infl.	2,50	0,00	2,86	0,01	2,78	0,03	2,37	0,18	1,70	0,49
Adjusted R2	0,45		0,32		0,18		0,07		0,02	
Correlation										
Expected	-0,05	0,46	0,13	0,42	0,18	0,26	0,15	0,33	0,07	0,64
Unexpected	0,48	0,00	0,28	0,07	0,17	0,55	0,10	0,55	0,06	0,72
Inflation	0,68	0,00	0,58	0,00	0,45	0,00	0,30	0,06	0,16	0,30
1 Year Swaps	30 Year		35 Year		40 Year		45 Year		50 Year	
	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1										
Intercept (α)	-0,05	0,59	0,79	0,79	-0,02	0,91	-0,01	0,93	-0,02	0,93
Expected (β)	2,20	0,70	0,94	0,94	-0,95	0,91	-1,72	0,85	-2,31	0,83
Unexpected (γ)	1,42	0,68	0,82	0,82	0,58	0,90	0,59	0,92	0,71	0,91
Adjusted R2	-0,04		-0,05		-0,04		-0,04		-0,03	
Variable eq. 2										
Intercept (α)	-0,04	0,61	-0,04	0,61	-0,05	0,60	-0,07	0,55	-0,09	0,50
realized infl.	1,10	0,72	1,11	0,77	1,21	0,78	1,53	0,76	1,95	0,73
Adjusted R2	-0,02		-0,02		-0,02		-0,02		-0,02	
Correlation										
Expected	0,01	0,97	-0,05	0,74	-0,09	0,56	-0,11	0,47	-0,13	0,41
Unexpected	0,05	0,76	0,07	0,64	0,09	0,56	0,11	0,49	0,12	0,44
Inflation	0,09	0,59	0,07	0,65	0,07	0,67	0,07	0,64	0,08	0,60

Table 25. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test of inflation-linked swaps returns with different maturities over a one year horizon. The time-series of all the swaps start at August 2008 and end in December 2011.

5.6 Commodities

In this section commodities are investigated as a whole, which also includes gold returns. Three different indices are used for investigating commodity returns as a hedge against inflation. The three indices are the Dow Jones Commodities index, the S&P GSCI Energy and the S&P GSCI.

On the one month horizon, commodities can be a hedge against unexpected inflation (see appendix B). For the one year investment horizon the results have slightly changed compared to the one month returns. The unexpected component is again significant in the multivariate regression analyses, however the adjusted R^2 for the three indices are not convincing (see table 26). Little of the variation is explained by the expected and unexpected inflation variables. The univariate regression where realized inflation is the explanatory variable could also not provide significant results. The coefficient is not statistically significant and also here the adjusted R^2 is low. For the Dow Jones Commodities Index the R^2 is even negative.

All the signs of the variables and correlations (only exception is the Dow Jones index, expected inflation component) are positive. This makes sense from economic theory (see table 2). As with stocks, commodities prices could be explained with the Gordon-growth model. When the prices of commodities increase it is expected that inflation would also increase.

1 Year commodities	Dow Jones Commodities index		S&P GSCI Energy		S&P GSCI	
	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1						
Intercept (α)	0.15	0.06	0.15	0.10	0.07	0.19
Expected (β)	-3.20	0.20	-0.40	0.92	1.85	0.27
Unexpected (γ)	4.64	0.07	12.51	0.00	5.82	0.03
Adjusted R2	0.07		0.09		0.07	
Variable eq. 2						
Intercept (α)	0.04	0.67	0.03	0.82	0.05	0.37
realized infl.	1.79	0.60	5.94	0.19	2.26	0.22
Adjusted R2	-0.02		0.00		0.04	
Correlation						
Expected	-0.28	0.08	-0.18	0.17	0.10	0.39
Unexpected	0.32	0.05	0.35	0.00	0.25	0.03
Inflation	0.08	0.63	0.16	0.23	0.23	0.04

Table 26. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test of commodities indices returns over a one year horizon. The time-series of the Dow Jones Commodities index start at January 1973, the S&P GSCI Energy begins in January 1984 and the S&P GSCI is from January 1992.

Most products that are used in the consumer price index have a direct or indirect link with commodities; therefore it is expected that there is a stronger relationship on a longer investment horizon due to the persistence of shocks (Martin 2010). The correlation coefficients are significant for unexpected inflation. This is something, which makes sense from the results of the regression analyses. For the S&P GSCI also the realized inflation correlation is statistical and economic significant.

On the one year horizon, commodities could hedge against inflation. Most effective is hedging against unexpected inflation, which is not specially indicated from the literature review in section 2.6. Earlier researches also indicated that commodities provide an effective hedge against inflation. Bodie and Rosansky (1980) and Martin (2010) both state that on the short-term commodities returns provide hedging opportunities against inflation.

3 Year commodities	Dow Jones Commodities index		S&P GSCI Energy		S&P GSCI	
	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1						
Intercept (α)	-0.67	0.01	0.42	0.46	0.09	0.55
Expected (β)	12.59	0.00	-0.32	0.97	3.03	0.04
Unexpected (γ)	5.19	0.08	4.40	0.39	4.06	0.01
Adjusted R2	0.32		0.08		0.29	
Variable eq. 2						
Intercept (α)	-0.10	0.69	0.01	0.98	0.05	0.72
realized infl.	4.61	0.20	5.87	0.23	3.34	0.02
Adjusted R2	0.08		0.03		0.28	
Correlation						
Expected	0.48	0.00	-0.30	0.03	0.29	0.00
Unexpected	-0.10	0.54	0.34	0.01	0.32	0.00
Inflation	0.32	0.06	0.23	0.10	0.54	0.00

Table 27. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test of commodities indices returns over a three year horizon. The time-series of the Dow Jones Commodities index start at January 1973, the S&P GSCI Energy begins in January 1986 and the S&P GSCI is from January 1994.

Commodity returns over a three year period provide hedging possibilities against inflation, especially the S&P GSCI performs well (see table 27). The correlations of the energy index and the corresponding p-values show that there is a relationship between the expected and unexpected inflation and the GSCI Energy returns. Unfortunately the variables have opposite signs and a low R^2 next to the insignificant coefficients. But still a long position in commodities could hedge inflationary shocks as expressed by the unexpected inflation correlation. Therefore Energy commodities can be used to hedge inflation risk.

The Dow Jones Commodities Index has mixed results. The expected inflation variable is the only coefficient that is statistically significant, next to the intercept. Unexpected and the realized inflation are both not significant. The Dow Jones index cannot hedge against unexpected inflation, as indicated by the p-values in the table. Therefore this index is not the most effective hedge against the Dutch inflation rate.

The last index, the S&P GSCI, has the characteristics of an index which can hedge against inflation. All correlations and coefficients of the controlled variables are statistic and economic significant. The signs of these are all positive, which is in line with economic theory. The correlations all have a p-value of 0.00 which makes them highly significant. The S&P GSCI also has an adjusted R^2 of 0.29 and 0.28 respectively, which indicates that commodities return of the S&P GSCI can hedge against inflation rate movements.

Commodities on the one year investment horizon could provide a hedge against inflation, mainly against unexpected inflation. Although the indices have some positively significant input variables, it cannot explain a large proportion of the variance in the experimental variable. For the three year horizon the results differ. The energy index is suitable for hedging unexpected inflation risk, as indicated by the correlation statistic. The Dow Jones index does not give very clear results whether it can or cannot hedge. Therefore it is not recommended to use this index for hedging purposes. The S&P GSCI index gives clear results and can definitely serve as a hedge against inflation, which corresponds with earlier research of Gorton and Rouwenhorst (2006) and Hoevenaars et al. (2008). Greer (2000) found a low positive correlation between inflation and commodity returns, which is in line with the findings presented in this paper.

Both the S&P GSCI and the Dow Jones Commodity index are large indices which consists of a large variety of futures contracts on different commodities. Therefore it is odd that the results are different. One reason is that the S&P GSCI is a collateralized commodities index and the Dow Jones not. The underlying of the collateral are bonds which could be the reason why the S&P is more significant. A second reason could be the composition of the index and the constituent list of commodities. The Dow Jones uses different commodities and put different weights on each class than the S&P GSCI, therefore both indices give different results. The last reason could be the time period of the time series. For the three year horizon the GSCI started in 1973, but the Dow Jones commodities Index starts in 1994. Still, the S&P GSCI provides an effective hedge against inflation. Next to this index energy commodities can hedge against unexpected inflation.

5.7 Cash

In times of high volatility and troubled economic markets more investors tend to hold a higher proportion of their portfolio in cash. The return on money depends on the interest rate, which has changed severely over the last decades. Holding cash and earn interest is seen as one of the safest asset classes among investors. From the Fischer-equation it can be expected that the interest rate and the inflation rate are related. The equation assumes that the nominal interest rate depends on the real interest rate plus the inflation rate.

The one month interest returns have a positively significant relation with inflation. Noteworthy, though the unexpected coefficients are positively significant, its correlation is not. Overall the one month interest return can hedge against inflation risk. See appendix B for the results.

Interest rate returns	One year		Three year	
	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1				
Intercept (α)	3.79	0.00	11.05	0.00
Expected (β)	55.10	0.02	84.90	0.00
Unexpected (γ)	67.15	0.02	94.65	0.03
Adjusted R2	0.25		0.33	
Variable eq. 2				
Intercept (α)	3.73	0.00	10.85	0.00
realized infl.	56.21	0.02	84.64	0.00
Adjusted R2	0.25		0.33	
Correlation				
Expected	0.40	0.00	0.35	0.00
Unexpected	0.14	0.22	0.06	0.63
Inflation	0.51	0.00	0.59	0.00

Table 28. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test of interest returns over a one year and three year horizon. The one year and three year time-series starts at January 1975 and January 1978 respectively.

The results of hedging inflation with cash on a one year and three year horizon are displayed in table 28. Holding cash over a twelve months period is an effective way to hedge inflation. All the coefficients are statistical significant and evenly important the adjusted R^2 of the regressions is 0.25. Even though the coefficient of the unexpected inflation component is significant its correlation is not. All the signs of the correlations and coefficients are positive; therefore a long position in cash (i.e. a deposit account) can hedge to some extent inflation risk.

Hedging against inflation over a three year horizon with cash provides even better results. Again all results are significant except for the unexpected inflation correlation. The input variables explain more of the variance than on the one year horizon, namely 33%. The strength of the relationship, which is shown through the correlations, is about the same.

Overall, on a one year horizon or longer it can be concluded that holding cash, which earns the interest rate can hedge against inflation. More specifically it can protect against the realized inflation and the expected inflation. The unexpected inflation correlation is not significant, but the coefficient is. When measuring the relation of unexpected inflation it is best to take the expected inflation into account as in the regression analysis. Eventually both sum up to the realized inflation. The results show that the interest rate can provide a hedge against Dutch inflation.

From Fisher's (1930) theory of the interest rate it is expected that the relation between interest and inflation should be highly positive. The results show a positive relation between inflation and interest returns; however the relation could be better. One possibility is that the ECB and the DNB set interest rates, which are followed by the market. Another reason could be that inflation shocks do not change the interest rates immediately.

5.8 Conclusion

The previously discussed results are summarized in figure 4. This figure represents a common trade-off, but in a different setting, the inflation risk-return trade-off. Inflation risk is measured in terms of the unexpected inflation correlation over the one- and three year horizon. As stated earlier inflation risk is represented mainly in the unexpected component, because this causes inflationary shocks. Overall it can be concluded that only two assets can provide a good hedge against the Dutch inflation rate.

The first asset is commodities, which are represented by the S&P GSCI and the S&P GSCI Energy. A lot of goods and services use commodities as an input, think of oil, copper and wood. Therefore it is expected that these goods and services reflect the relative prices of commodities to some extent. The CPI is measured in terms of the price differential between goods and services, therefore an economic rationale for commodities being an inflation hedge exists. The correlation between commodities expected return and unexpected inflation is reflected in the adjusted correlation and has a value of approximately 0.28.[19] The expected returns for the near future estimated by Towers Watson are around 5% for commodity

[19] The adjusted correlation is measured as the correlation times one minus the p-value, therefore it is expected that the correlation calculated is in fact lower than in reality. Also true for the other adjusted correlations in figure 4.

hedged returns. The conclusion that commodity returns can serve as a hedge against the inflation is in line with Greer (2000), Gorton and Rouwenhorst (2006) and Hoevenaars et al. (2008). The second assets that can provide a hedge against the Dutch inflation rate are the inflation-linked swaps. Inflation-linked swaps are especially designed for inflation hedging

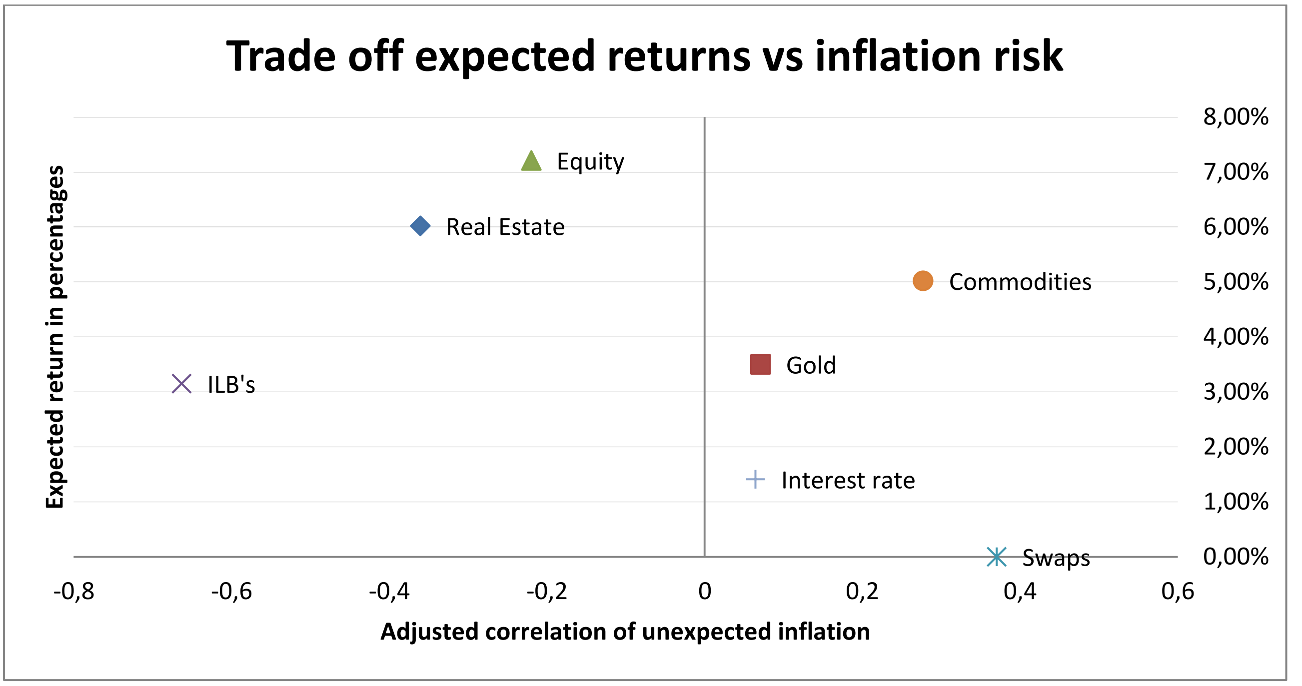

Figure 6. Summary of expected asset class returns versus the Dutch inflation rate. The correlation on the x-axis is measured as a function of the one year and three year correlation of the unexpected inflation rate.[20] The expected returns, which are displayed on the vertical axis are acquired from Towers Watson and represents the returns which are expected in the future.

purposes. However there is a difference between the EMU inflation rate and the Dutch inflation rate which causes an imperfect relation between the Dutch inflation and the swap returns. Although the swaps are linked to the EMU inflation rate, they still provide a more than sufficient hedge against Dutch inflation. The adjusted correlation measured as a proxy for the relation with the unexpected inflation rate is 0.37. The corresponding expected return is expected to be zero or slightly negative, due to transaction costs.

Equities and real estate returns both have an insignificant relation with the Dutch inflation rate. These assets cannot hedge inflation risk. As in Fama and Schwert (1977), Kaul (1987) and Ely and Robinson (1997) equity returns are not suitable for hedging inflation risk. Also the findings in this paper are in line with Gultekin (1983), which finds a negative relation.

Fama and Schwert (1977) and Gyourko and Linneman (1988) found negative results for listed real estate as a hedge against inflation risk. Hoesli et al. (2008) also found an

[20] $\boldsymbol{Adj.correlation} = \frac{[\boldsymbol{Correlation\ 1Y*(1-Pvalue)+correlation\ 3Y*(1-Pvalue)}]}{\boldsymbol{2}}$, where the p-value corresponds to the correlation founded in the Pearson correlation tests. For equity, real estate, ILB's, gold, commodities and swaps multiple indices are used. Therefore the adjusted correlations are added and divided by the number of indices used.

insignificant relation, but only for U.S. data. Overall it can be stated that listed real estate cannot hedge Dutch inflation risk.

Dempster and Artigas (2010) found negative results for gold. Also, Blose (2010) and Chua and Woodward (1982) find mixed results for the relation between gold and inflation. The latter one states that the effectiveness of gold as a hedge depends on the market and the timing, which is also noticed by Wang et al. (2008). In this paper, the results are slightly positive. From the results it is expected that gold can hedge against the realized inflation, however it does not adjust significantly to unexpected inflation. Overall gold should provide to some extent a hedge against Dutch inflation.

Holding cash and earning interest can hedge inflation. Fisher (1930) states, that there should be a relation between inflation and the interest rate. The results show that there is an economic and statistical significant relation.

The most shocking conclusion about the results in chapter 5 is about the ILB’s. The results from the inflation-linked bonds show that in times of crisis, the hedging capabilities of ILB’s are negative. This is in line with the findings of TKP Investments. For pension funds this negative relation indicates that it should short ILB’s which is far from practical and should not even be considered. ILB’s are therefore not able to provide a hedge against Dutch inflation in times of crisis.

Overall it is recommended for pension funds to use swaps as the main tool to minimize the inflation risks. However, pension funds most likely want to earn a return for maintaining a certain coverage ratio. Therefore it is recommended that pension funds also invest a proportion of their assets in commodities. As it provides a relatively good hedge and provides an expected return of 5%.

Chapter 6: Recommendation and Conclusion

In this article the hedging characteristics of different assets are discussed. Seven asset classes are investigated whether they provide a hedge against the Dutch inflation rate or not. The examined asset classes are listed real estate, gold, equities, inflation-linked bonds, inflation-linked swaps, commodities and cash (interest earnings). The main focus has been on the relationship between the one year and three year asset returns and the Dutch realized, expected and unexpected inflation rate. The relation between the unexpected inflation and the return of an asset is the most important one, because this inflation component measures inflationary shocks, which represents most of the inflation risk. For pension funds it will become more and more important to take inflation risk hedging into account. To understand the relation between these variables one must first investigate the properties of the assets and how return is generated. Two statistical tools have been used for determining this relation. First an univariate and multivariate equation, with asset return as output variable. Secondly, the Pearson correlation test has been used for indicating the strength of the relationship between the Dutch inflation rate and the asset's return. For every asset class multiple indices are investigated and the category bonds and swaps use different maturities. In this article, the effectiveness of different asset classes is reviewed and multiple methodologies are examined. Most of the already existing researches are on U.S. and U.K data, none on the Dutch inflation rate.

The results in this article are in line with previous articles, which also conclude that equity and listed real estate could not provide an effective hedge against Dutch inflation. On the other hand, gold can hedge inflation risk. However, the results are a bit mixed, because the results show it provides a hedge against expected and realized inflation and to some extent to unexpected inflation. Also, cash as an asset class to earn interest can provide to some extent inflation protection. Inflation-linked swaps and commodities are suitable as inflation hedge. For pension funds commodities could be a good asset, because it provides a positive expected return, which could be necessary for guaranteeing their outgoing cash flows and are a positive hedge against inflation risk. The other asset mentioned, inflation-linked swaps (EMU-linked), are a better asset class for providing protection against inflationary shocks. However, these swaps do not provide any expected return. The findings on the relation between ILB's and the Dutch inflation rate are surprising. To summarize, ILB's are not appropriate for hedging inflationary movements, because the relation between the two variables is negative and therefore it can be concluded that ILB's cannot provide a hedge against inflation in times of the current crisis.

My recommendation for pension funds is to investigate what the added value is of having ILB's in their current portfolios and look if these bonds could be replaced with swaps to

hedge their inflation risk exposure. Also these ILB's create interest rate exposure, which is one of the main risks of a pension fund. Therefore the relation between ILB's, inflation risk and interest rate risk could be investigated as well in future research.
The Dutch pension system grows and grows and therefore it is recommended that the Dutch government and Central Bank issue inflation-linked bonds that are linked to the Dutch inflation rate. My expectation is that these ILB's will have a strongly positive relation with the unexpected inflation rate in the future when the markets become more serene. These ILB's will provide a positive hedge against Dutch inflation, because two of the three risks could be discarded. The Netherlands is not exposed much to credit risk and secondly there will be no mismatch risk. The market demand for the Dutch ILB's will be sufficient, due to the size of the pension market.

The field of inflation hedging with traditional assets has been researched extensively, but not for the Dutch inflation rate. Also the relation between EMU-linked inflation derivatives and other inflation rates have not been researched on a large scale. Further investigation in the areas of derivatives like the indexed-linked swaps and bonds could give additional insights. Especially for bonds it is interesting to know what the impact of the relation is between volatility of the inflation rate and the hedging capabilities of the returns. Also, investigating ILB's for different time periods could give an explanation why the relation in the recent crisis is negative. Furthermore, investigating the introduction of Dutch ILB's on the asset allocation decision of pension funds could have great value to portfolio management.

Literature

Adrangi, B., Chatrath, A., & Raffiee. (2003). Economic activity, inflation, and hedging: The case of gold and silver investments.*The Journal of Wealth Management*, *6*, 60–77.

Amenc, N., Martellini, L., & Ziemann, V. (2009). Inflation-Hedging Properties of Real Assets and Implications for Asset–Liability Management Decisions. *The Journal of Portfolio Management*, *35*(4), 94-110.

Barnes, M., Boyd, J.H., & Smith, B. D. (1999), Theories of Money, Credit and Aggregate Demand Inflation and Asset Returns. *European Economic Review, Vol. 43*, 737-754.

Bekaert, G., & Wang, X. (2010). Inflation Risk and the Inflation Risk Premium. *Economic Policy*, *25*(64), 755–806.

Bodie, Z. (1976). Common Stocks as a Hedge against Inflation. *Journal of Finance, Vol. 31*, 459–470.

Bodie, Z. (1988). Inflation, Index-Linked Bonds, and Asset Allocation. *National Bureau of Economic Research, Working Paper No. 2793*.

Bodie, Z., & Rosansky, V. I. (1980). Risk and Return in Commodity Futures. *Financial Analysts Journal*, *36*(3), 27-39.

Bikker, J. A., Broeders, D. W. G. A., & Dreu, J. D. (2010). Stock Market Performance and Pension Fund Investment Policy : Rebalancing , Free Float , or Market Timing?. *International Journal of central Banking, 6(3),* 53-79.

Blose, L. E. (2010). Gold prices, cost of carry, and expected inflation. *Journal of Economics and Business, 62(1),* 35-47.

Boudoukh, J., & Richardson, M, (1993). Stock returns and inflation: A long-horizon perspective. *American Economic Review, 83(5),* 1346–1355.

Campbell, J. Y. (2009). The Changing Role of Nominal Government Bonds in Asset Allocation. *Geneva Risk Insur Rev, 34(2)*, 89. PALGRAVE MACMILLAN LTD

Campbell, J. Y., Shiller, R. J., & Viceira, L. M. (2009). Understanding Inflation-Indexed Bond Markets. *Brookings Papers on Economic Activity. 2009(1)*, 79-120.

Cecchetti, S. G., Chu, R. S., & Steindel, C. (2000). The unrealiability of inflation indicators. *Current Issues in Economics & Finance*,*6*, 1–6.

Chua, J., and Woodward, R. (1982). Gold as an Inflation Hedge: A Comparative Study of Six Major Industrial Countries. *Journal of Business Finance and Accounting, Vol. 9*, 191-197.

Christie-David, R., Chaudhry, M., & Koch, T. W. (2000). Do macroeconomics news releases affect gold and silver prices? *Journal of Economics and Business*, *52*, 405–421.

Deacon, A., & Derry, A. (2004). *Inflation-Indexed Securities (Prentice Hall Europe). [Second edition: A. Deacon, A. Derry and D. Mirfendereski (2004) Inflation-Indexed Securities: Bonds, Swaps and other Derivatives (John Wiley & Sons, Ltd)]*

Dempster, N., & Artigas, J. C. (2010). Gold: Inflation Hedge and Long-Term Strategic Asset. *The Journal of Wealth Management, 13(2),* 69–75.

Ely, D. P., & Robinson, K. J, (1997). Are stocks a hedge against inflation? International evidence using a long-run approach. *Journal of International Money and Finance, 16(1),* 141–167.

Fama, E.F., & Schwert, G.W. (1977). Asset Returns and Inflation. *Journal of Financial Economics, Vol. 5*, 115-146.
Fama, E. F. (1981). Stock Returns, Real Activity, Inflation, and Money. *American Economic Review, 71(4)*, 545-565.

Fisher, I. (1930). The Theory of Interest. *The MacMillan Company, New York*.

Froot, K. A. (1995). Hedging Portfolios with Real Assets. *The Journal of Portfolio Management*, *21*(4), 60-77

Furlong, F. T., & Ingenito, R. (1996). Commodity Prices and Inflation. *Federal Reserve Bank of San Francisco Economic Review, No. 2*, 27-47.

Garner, C. A. (1995). How useful are leading indicators of inflation? *Economic Review (01612387)*, *80*, 5–18.

Ghosh, D., Levin, E.J., Macmillan, P., & Wright, R.E. (2004). Gold as an inflation hedge? *Studies in Economics and Finance, 22*, 1–25.

Gorton, G., & Rouwenhorst, K. G. (2006). Facts and Fantasies about Commodity Futures. *Financial Analysts Journal*, *62(2),* 47-68.

Greer, R. J. (2000). The Nature of Commodity Index Returns. *The Journal of Alternative Investments, Vol. 3 No.1*, 45-52.

Gultekin, N. B., (1983). Stock Market Returns and Inflation: Evidence from Other Countries. *Journal of Finance, 38(1),* 49.

Gyourko, J., & Linneman, P. (1988). Owner-occupied homes, income-producing properties, and REITs as inflation hedges: empirical findings. *Journal of real estate finance and economics, Vol. 1*, 347-372.

Hoesli, M., Lizieri, C., & MacGregor, B. (2008). The Inflation Hedging Characteristics of U.S. and U.K. Investments: A Multi-Factor Error Correction Approach. *Journal of real estate finance and economics, Vol. 36, No. 2*, 183-206

Hoevenaars, R., Molenaar, R., Schotman, P., & Steenkamp, T. (2008). Strategic asset allocation with liabilities: Beyond stocks and bonds. *Journal of Economic Dynamics and Control, Vol.32, No.9.*

Huang, H., & Hudson-Wilson. S. (2007). Private Commercial Real Estate Equity Returns and Inflation. *Journal of Portfolio Management, Vol. 33, No. 5*, 63-73.

Jaffe, J. F. (1989). Gold and gold stocks as investments for institutional portfolios. *Financial Analysts Journal*, *45*, 53.

Kat, H. M., & Oomen, R. C. A. (2007). What Every Investor Should Know about Commodities Part II: Multivariate Return Analysis. *Journal of Investment Management*, *5*(3), 16

Kaul, G. (1987). Stock returns and inflation: The role of the monetary sector. *Journal of Financial Economics, 18(2),* 253–276.

Kothari, S. P., & Shanken, J. (2004). Asset allocation with inflation-protected bonds. *Financial Analysts Journal, Vol. 60, No. 1*, 54–70.

Larsen, A. B., & McQueen, G. R. (1995). REITs, real estate, and inflation: Lessons from the gold market. *Journal of Real Estate Finance & Economics*, *10*, 285–297.

Lawrence, C. (2003). Why is gold different from other assets? An empirical investigation*. In Research manuscript*. London, UK: World Gold Council.

Le Moigne, C., & Viveiros. E. (2008). Private Real Estate as an Inflation Hedge: An Updated Look with a Global Perspective. *Journal of Real Estate Portfolio Management, Vol. 14, No. 4*, 263-285.

Lintner, J. (1975). Inflation and Security Return. *Journal of Finance, Vol. 30,* 259–280.

Mahdavi, S., & Zhou, S. (1997). Gold and commodity prices as leading indicators of inflation: Tests of long-run relationship. *Journal of Economics & Business*, *49*, 475–489.

Mahieu, S. J., & de Roode, F.A. (2011). Inflation Matching in Europe with a Special Focus on the Dutch Case, *Netspar, September 7, 2011.*

Martin, A. G. (2010). The Long-Horizon benefits of Traditional and New Real Assets in the Institutional Portfolios. *Journal of Alternative Investments, Vol. 13, No. 1*, 6-29.

Moore, G. H. (1990). Gold prices and a leading index of inflation. *Challenge*, *33*, 52–56.

Park, J., Mullineaux, D.J. & Chew, I.K. (1990). Are REITs inflation hedges? *Journal of Real Estate Finance and Economics, Vol. 3*, 91-103.

Rauh, J. D. (2008). Risk Shifting versus Risk Management: Investment Policy in Corporate Pension Plans. *Review of Financial Studies, 22(7), 2487. Soc Financial Studies.*

Schotman, P.C., & Schweitzer, M. (2000). Horizon sensitivity of the inflation hedge of stocks. *Journal of Empirical Finance* 7, 301-315.

Scott, L.O. (1990). Do prices reflect market fundamentals in real estate markets. *The Journal of Real Estate Finance and Economics, Vol. 3*, 5-23.

Sharpe, W. F. (1994). The Sharpe Ratio. *The Journal of Portfolio Management*, *21*(1), 49-58.

Sherman, E. J. (1983). A gold pricing model. *Journal of Portfolio Management*, *9*, 68–70.

Spierdijk, L., & Umar, Z. (2010). Are commodities a good hedge against inflation, a comperative approach. *Netspar, 2010.*

Swinkels, L. A. P. (2012). Emerging Markets Inflation-Linked Bonds (February 12, 2012). *Financial Analysts Journal, Forthcoming.*

Tkacz, G. (2007). Gold prices and inflation, *Bank of Canada Working Paper 2007-35*.

Wang, K.-M., Lee Y.-M., & Thi, T.-B. N. (2010). Time and place where gold acts as an inflation hedge: An application of long-run and short-run threshold model. *Economic Modelling, Vol. 28, No. 4*, 806-819.

Appendix A

Descriptive statistics of inflation	Expected inflation	Unexpected inflation
	1 Year inflation	
Mean	2,05%	0,06%
Median	2,10%	0,10%
Standard Deviation	0,82%	1,36%
Minimum	-0,60%	-4,60%
Maximum	4,00%	2,30%
Kurtosis	2,04	2,40
Skewness	-0,70	-1,28
Observations	116	116
Time series start at:	31-10-2002	31-10-2002

Tabel A. Descriptive statistics of the EMU inflation rate. Inflation is divided into expected and unexpected inflation.

When comparing the EMU inflation rate in the time period October 2002 till December 2011 it is easy to recognize that the mean and standard deviation are significantly lower than the Dutch inflation rate over the period 1973 till 2011. This is also to be expected, because the last decade the inflation rate is lower than over the last 40 years and the inflation rate is relatively constant.

Appendix B

In this section the results of the one month asset class returns will be briefly discussed.
In table B are the results of the analysis between inflation and real estate returns. These results do not differ significantly from the one year horizon.

1 Month Real Estate	AEX Real Estate Index		REITS		S&P NL REITs	
	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1						
Intercept (α)	0.01	0.14	0.01	0.00	0.01	0.08
Expected (β)	-0.59	0.61	-1.46	0.02	-1.54	0.05
Unexpected (γ)	0.34	0.76	0.24	0.67	-0.35	0.62
Adjusted R2	-0.01		0.02		0.01	
Variable eq. 2						
Intercept (α)	0.01	0.18	0.01	0.01	0.18	0.15
realized infl.	-0.01	0.99	-0.43	0.42	0.69	0.27
Adjusted R2	-0.01		0.00		0.00	
Correlation						
Expected	-0.07	0.41	-0.15	0.00	-0.12	0.05
Unexpected	0.06	0.46	0.10	0.03	0.05	0.45
Inflation	0.00	0.99	-0.04	0.40	-0.06	0.29

Table B. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test for the one month real estate returns.

The one month gold returns (Table C) differ much from the one and three year horizon. One month gold returns do not provide a hedge against inflation, while the three year gold returns can hedge against the realized inflation.

1 Month Gold	Gold Bullion		GSCI Gold index	
	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1				
Intercept (α)	0.00	0.03	0.00	0.01
Expected (β)	0.89	0.33	-0.38	0.68
Unexpected (γ)	0.41	0.46	0.50	0.39
Adjusted R2	0.00		0.00	
Variable eq. 2				
Intercept (α)	0.00	0.00	0.00	0.02
realized infl.	0.60	0.31	0.23	0.70
Adjusted R2	0.00		0.00	
Correlation				
Expected	0.05	0.31	-0.05	0.31
Unexpected	0.00	0.96	0.06	0.24
Inflation	0.04	0.34	0.02	0.73

Table C. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test for one month real gold returns.

1 Month equity	AEX		MSCI WORLD		MSCI EUROPE		MSCI EUROPE ENERGY		S&P 500	
	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1										
Intercept (α)	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.11	0.00	0.01
Expected (β)	-1.20	0.13	-0.80	0.15	-0.67	0.21	1.71	0.11	-0.73	0.36
Unexpected (γ)	-1.54	0.08	-0.90	0.07	-0.70	0.21	0.56	0.55	-1.19	0.12
Adjusted R2	0.00		0.00		0.00		0.00		0.00	
Variable eq. 2										
Intercept (α)	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.04	0.01	0.00
realized infl.	-1.44	0.06	-0.87	0.06	-0.69	0.15	0.91	0.31	-1.06	0.13
Adjusted R2	0.00		0.00		0.00		0.00		0.00	
Correlation										
Expected	0.00	0.88	-0.02	0.59	-0.02	0.60	0.10	0.14	0.01	0.85
Unexpected	-0.08	0.16	-0.06	0.23	-0.04	0.41	-0.03	0.69	-0.08	0.16
Inflation	-0.10	0.07	-0.09	0.06	-0.07	0.15	0.07	0.31	-0.09	0.14

Table D. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test of stock indices returns over a one month horizon.

The equity one month returns (Table D) cannot provide an effective hedge against inflation. This is in line with the results of the one year and three year returns.

Over a one month horizon the three inflation-linked bond indices could not provide a hedge against inflation risk (Table E). The adjusted R^2 of all regressions is close to zero and none of the coefficients is significant. The correlation statistics also indicate that on a one month horizon it is not possible to hedge Dutch inflation risk with European inflation rate linked bonds.

1 Month inflation-linked bonds	1-10Y		1-15Y		10Y	
	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1						
Intercept (α)	0,00	0,07	0,00	0,54	0,00	0,74
Expected (β)	-0,28	0,56	-0,31	0,65	-0,40	0,70
Unexpected (γ)	0,51	0,20	0,56	0,32	0,60	0,49
Adjusted R2	0,01		0,00		-0,02	
Variable eq. 2						
Intercept (α)	0,00	0,17	0,00	0,76	0,00	0,60
realized infl.	0,20	0,57	0,22	0,67	0,20	0,79
Adjusted R2	-0,02		-0,02		-0,02	
Correlation						
Expected	-0,17	0,24	-0,15	0,31	-0,12	0,42
Unexpected	0,21	0,15	0,18	0,21	0,14	0,35
Inflation	0,06	0,90	0,05	0,73	0,03	0,83

Table E. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test of inflation-linked bonds returns over a one month horizon.

The one month inflation-linked swaps as a hedge against the Dutch inflation are displayed in table F. These short-term returns cannot provide a hedge.

1 Month Swap return	5 Year		10 Year		15 Year		20 Year		25 Year	
	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1										
Intercept (α)	0,00	0,33	0,33	0,47	0,00	0,59	0,00	0,71	0,00	0,84
Expected (β)	-0,09	0,79	0,79	0,65	-0,24	0,70	-0,16	0,84	-0,02	0,98
Unexpected (γ)	0,11	0,74	0,74	0,97	-0,12	0,84	-0,14	0,85	-0,16	0,87
Adjusted R2	-0,30		-0,04		-0,04		-0,04		-0,04	
Variable eq. 2										
Intercept (α)	0,00	0,39	0,00	0,53	0,00	0,61	0,00	0,72	0,00	0,82
realized infl.	0,03	0,91	-0,09	0,82	-0,17	0,75	-0,15	0,82	-0,11	0,90
Adjusted R2	-0,02		-0,02		-0,02		-0,02		-0,02	
Correlation										
Expected	-0,06	0,64	-0,06	0,66	-0,04	0,78	-0,01	0,93	0,01	0,94
Unexpected	0,07	0,61	0,03	0,82	0,00	1,00	-0,01	0,93	-0,02	0,87
Inflation	0,01	0,92	-0,03	0,84	-0,04	0,79	-0,03	0,85	-0,01	0,92

1 Month Swap return	30 Year		35 Year		40 Year		45 Year		50 Year	
	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1										
Intercept (α)	0,00	0,87	0,00	0,91	0,00	0,93	0,00	0,96	0,00	0,98
Expected (β)	-0,13	0,90	-0,08	0,95	-0,01	0,99	0,06	0,97	0,12	0,95
Unexpected (γ)	-0,29	0,79	-0,26	0,84	-0,25	0,87	-0,26	0,88	-0,30	0,88
Adjusted R2	-0,04		-0,04		-0,04		-0,04		-0,04	
Variable eq. 2										
Intercept (α)	0,00	0,86	0,00	0,89	0,00	0,92	0,00	0,94	0,00	0,95
realized infl.	-0,23	0,81	-0,20	0,86	-0,16	0,91	-0,14	0,93	-0,14	0,94
Adjusted R2	-0,02		-0,02		-0,02		-0,02		-0,02	
Correlation										
Expected	0,00	0,97	0,01	0,96	0,01	0,93	0,02	0,91	0,02	0,89
Unexpected	-0,03	0,84	-0,02	0,86	-0,02	0,87	-0,02	0,97	-0,03	0,85
Inflation	-0,03	0,85	-0,02	0,89	-0,01	0,83	-0,01	0,94	-0,01	0,95

Table FCoefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test for one month swap returns (all with different maturity).

1 Month commodities	Dow Jones Commodities index		S&P GSCI Energy		S&P GSCI	
	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
Variable eq. 1						
Intercept (α)	0.00	0.20	0.00	0.56	0.01	0.20
Expected (β)	0.51	0.52	3.99	0.01	1.49	0.07
Unexpected (γ)	1.35	0.07	4.59	0.00	2.06	0.01
Adjusted R2	0.01		0.03		0.02	
Variable eq. 2						
Intercept (α)	0.00	0.32	0.00	0.62	0.00	0.27
realized infl.	1.11	0.12	4.41	0.00	1.83	0.01
Adjusted R2	0.01		0.04		0.02	
Correlation						
Expected	-0.04	0.48	0.03	0.53	0.02	0.71
Unexpected	0.13	0.04	0.14	0.01	0.11	0.02
Inflation	0.11	0.08	0.20	0.00	0.13	0.00

Table G. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test of commodities indices returns over a one month horizon.

The one month commodities returns (Table G) show some significant results. The variables unexpected and realized inflation are often economic and statistical significant. The adjusted R^2s of the regression analyses are low, but it seems that on the very short-run commodities return could hedge against inflation (the inflationary shocks as well as the realized inflation).

Interest rate returns	One month	
	Coefficient	P-Value
Variable eq. 1		
Intercept (α)	0,39	0,00
Expected (β)	15,77	0,01
Unexpected (γ)	8,63	0,00
Adjusted R2	0,05	
Variable eq. 2		
Intercept (α)	0,41	0,00
realized infl.	11,12	0,01
Adjusted R2	0,04	
Correlation		
Expected	0,18	0,00
Unexpected	0,01	0,75
Inflation	0,20	0,00

Table H. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test of commodities indices returns over a one month horizon.

Over a one month period, interest rate returns (Table H) could provide a hedge against inflation. Although, interest rates do not provides a good hedge against the unexpected inflation. On a one month basis a lots of other variables influence interest rate returns as well, that is why the adjusted R^2 is low.

Appendix C

1 Month Swap returns	5 Year		10 Year		15 Year		20 Year		25 Year		30 Year		35 Year		40 Year		45 Year		50 Year	
	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value
Variable																				
Intercept (α)	0,00	0,10	0,00	0,24	0,00	0,36	0,00	0,48	0,00	0,63	0,00	0,70	0,00	0,74	0,00	0,76	0,00	0,79	0,00	0,81
HICP inflation	0,33	0,05	0,43	0,03	0,56	0,03	0,72	0,03	0,78	0,04	0,86	0,05	1,00	0,05	1,14	0,06	1,27	0,06	1,39	0,07
Adjusted R2	0,17		0,17		0,16		0,14		0,10		0,09		0,08		0,08		0,07		0,07	
Correlation																				
HICP inflation	0,43	0,00	0,43	0,00	0,42	0,00	0,40	0,00	0,35	0,01	0,32	0,02	0,32	0,02	0,31	0,02	0,30	0,03	0,29	0,04
1 Year Swap returns	5 Year		10 Year		15 Year		20 Year		25 Year		30 Year		35 Year		40 Year		45 Year		50 Year	
	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value
Variable																				
Intercept (α)	0,02	0,02	0,02	0,02	0,02	0,03	0,02	0,15	0,01	0,58	0,00	0,93	0,00	0,89	-0,01	0,77	-0,02	0,64	-0,03	0,55
HICP inflation	0,37	0,00	0,61	0,00	0,75	0,00	0,86	0,00	0,88	0,00	0,82	0,02	0,83	0,04	0,85	0,08	0,91	0,10	0,97	0,12
Adjusted R2	0,37		0,57		0,56		0,44		0,25		0,14		0,09		0,06		0,05		0,04	
Correlation																				
HICP inflation	0,62	0,00	0,76	0,00	0,76	0,00	0,67	0,00	0,52	0,00	0,40	0,01	0,34	0,03	0,29	0,06	0,27	0,08	0,25	0,10

Table I. Coefficients, p-values, adjusted R^2 and correlations of the regression analysis and Pearson correlation test of inflation-linked swap returns over a one month horizon (swaps have different maturities).

The European inflation rate or EMU inflation rate provides an effective hedge against the European inflation-linked swaps. Over a one month horizon all the correlation statistics are positively significant. The coefficient of the realized inflation is for all swaps almost significant. Just as the correlations, these coefficients also have positive signs. Although the intercept is not significant, the coefficient of the intercept of the one month returns is zero. This is expected from economic theory that the intercept is close to zero. Overall the European inflation-linked swaps provide a hedge against the European inflation rate. One remark though, the definition of European inflation can be measured in several ways. Therefore the results could be better if the European inflation from the swaps is exactly the same as the inflation used as the dependent variable.

The one year swap returns provide more or less the same results as the one month horizon. The biggest difference is the effectiveness of the hedge. At the one year horizon the adjusted R^2 is much higher than for the one month returns. This also means automatically that the correlation is higher too.