SWEDISH REAL ESTATE AS A HEDGE AGAINST INFLATION

- With comparison to stocks, bonds and gold
Master of Science thesis

Title                  SWEDISH REAL ESTATE AS A HEDGE AGAINST INFLATION
                      - With comparison to stocks, bonds and gold
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Master Thesis number     174
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Keywords          Inflation, Inflation Hedge, Inflation Protection, Real Estate, Gold, Stocks, Bonds

Abstract

The objective of this research is to analyze residential, unsecuritized and securitized real estate’s ability to hedge inflation in Sweden and compare it to stocks’, bonds’ and gold’s ability to hedge inflation.

This research is based on both descriptive statistical and econometric analysis methodology with use of both quarterly and annual data series. First are the correlations between assets and actual, expected and unexpected inflation analyzed. Inflation betas are then estimated for all assets based on an ordinary least square model. The results indicate that, during the researched period 1993-2011, none of the studied exposures of real estate are a hedge against actual, expected nor unexpected inflation. As expected the results also indicate that both stocks and bonds have a negative relation to inflation, while gold seems to be a partial hedge against inflation. However, all inflation betas have a low R square and low statistical significance in general. Real estate in Sweden is not a hedge against inflation as it traditionally is perceived to be and real estate returns might be driven by business cycles, accessibility to financing and expectations of interest rates rather than inflation.
Acknowledgement

First we would like to thank IPD, Carnegie, EPRA and Handelsbanken who have provided us with necessary data. Secondly we would like to thank our friends and families who have patently listened to our theories around inflation hedging and given us their support.

Above all, we would like to thank our supervisor Han-Suck Song who has contributed with constructive criticism and valuable advice.

Stockholm, May 2012.
Odinn Arnason and Krister Persson
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1. Introduction

1.1 Background

There is an ongoing debate among long-term investors about what types of assets that best protects investors against inflation. For institutional investors it is very important to keep up with inflation since their obligations most times in some way are inflation-linked.

Inflation hedging\(^1\) was a hot topic in the 1970s among researchers when inflation was considerably higher than what it is today. So why is inflation once again a hot topic when it has been both low and stable in most evolved markets over the last decade? Policy makers and central banks around the world started their attempt to stabilize output and stave off deflation by introducing enormous amount of liquidity operations after the recent financial crises. Due to those liquidity operations investors have started to fear that inflation is likely to be unpredictable and unusually high within a few years. On top of this is inflation already at high levels in countries like the United Kingdom and United States (Kelleher, 2011).

The conventional academic view of real estate investments is that real estates offer a better hedge against inflation than other assets such as stocks and bonds. However, the conclusions of previous literature regarding real estate’s ability to serve as an inflation hedge, is inconsistent. Real estate seems to provide a good hedge against expected inflation in most studies but not a hedge against unexpected inflation. Because of different behavior regarding the characteristics of different properties, exposures, different markets and/or economic situations, real estate as an inflation hedge continues to be a crucial research topic.

Real estate capability to hedge inflation has not just been a debate among academics but also among professional investors. Real estate is perceived as a hedge against inflation among investors mainly due to the advantages of inflation linked leases, which institutional investors with fixed liabilities appreciate (Thomas, 2011).

Another problem is that inflation rates in emerging markets are already high and are likely to hit western economies. Since western countries the last decades have imported goods from emerging markets it is likely that the inflation rates in those western countries might have been protected through imports of low-cost production. When the emerging markets demand

\(^1\)Assets whose value moves, adjusts and correlates with inflation are considered an inflation hedge (Hull, 2003).
goods for their own uses, it is likely that inflation will rise in the western part of the world too. Many western countries, on top of everything, are also doing their best to weaken its currencies to be able to keep up the competiveness with developing countries, which also could result in high unexpected inflation in the near future (Kelleher, 2011).

Nagy et al. (2011) point to another relatively recent issue for institutional investors. The burst of the dot-com bubble in 2001 made investors realize that the traditional equity/bond asset allocation did not serve as the risk diversifier it once was due to the fact that correlation between those asset types had changed over time. This led institutional investors to increase their allocation to alternative investments such as unsecuritized real estate\(^2\), private equity, hedge funds, infrastructure and commodities.

This brings the question of whether and how correlations and behaviors between different asset classes change over time and what effects it will have on portfolio strategies.

In response to a considerably loud alert in 2008, despondent institutional investors realized once again that their asset risk was driven largely by their equity exposure. In particular, many so-called “alternatives” turned out to be equities in disguise. Furthermore, interest in active management of assets against liabilities has been revived. Pension funds and insurance companies worry about their surplus relative to their liabilities instead of the risk of underperforming compared to their benchmarks (Nagy, et al., 2011).

This has led investors to classify their assets in a new ways. Assets are now being categorized along investment objectives; for example, growth, income generating, inflation protection and liquidity (Nagy, et al., 2011).

Since inflation-linked bonds today have a low expected return, investors have started to move away from inflation-linked bonds and started allocate to other assets like real estate, industrial metals, timberland, energy stocks, commodities and gold (Kelleher, 2011).

### 1.2 Objective

The objective of this thesis is to analyze Swedish real estate’s and other Swedish financial asset’s capability to hedge inflation.

\(^2\)Unsecuritized real estate is also referred to as private real estate, real property or directly owned real estate. Unsecuritized real estate includes the interests, benefits and rights inherent in the ownership of physical real estate (Appraisal Institute, 2008).
1.2.1 Research Questions

Since it is possible to have different types of exposure to real estates and since the nature of them is also very different, real estates are divided into different groups and subgroups.

- Is real estate a hedge against actual, expected and/or unexpected\(^3\) inflation in Sweden?
  - Is private residential\(^4\) real estate a hedge against actual, expected and/or unexpected inflation?
  - Is securitized\(^5\) real estate a hedge against actual, expected and/or unexpected inflation?
  - Is unsecuritized real estate a hedge against actual, expected and/or unexpected inflation?
- Is real estate a better hedge against actual, expected and unexpected inflation than stocks, bonds and gold?

1.3 Method

This paper is mainly based on a quantitative research. The research area was nevertheless first reviewed to understand the topic, which methods as have been used and what areas were left out. The trustworthiness of each source has been carefully scrutinized, and as a result, only academic papers, articles from reliable business papers and data from well know banks and organizations have been accepted. Two different statistical methods were used: a descriptive statistics approach and econometric analysis based on ordinary least squared regression analysis. These two methods are better described in the methodology chapter.

1.4 Thesis Structure

This research is set up in the way that a literature overview comes after this introduction to the researched issue, and goes through what academics have been researching in this field as well as their biggest conclusions.

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\(^1\)See method and data chapter for a description of the different types of inflation.

\(^2\)Dwellings for permanent living.

\(^3\)Securitized real estate is normally listed real estate companies or investment funds like REITs, which could be both tradable on a secondary market and as over-the-counter products (Bodie, Kane, & Marcus, 2011; Geltner, et al., 2001).
Then there is an overview of our research methodology where the three analytical tools used are introduced and discussed. There is a data introduction after that followed by a result summary for all of these analyses of the data.

The results are then scrutinized and analyzed in the analysis chapter.

In the end of the paper is concluded followed by a reference list and an appendix with the statistical tests performed.
2. Literature Review

Inflation was a main topic due to investors’ expectations of a growing inflationary pressure at Morgan Stanley’s real estate conference in December 2011. Due to expectations of growing inflation investors also had an optimistic view about real estate the coming years. However investors have started to challenge real estate investments’ ability to hedge inflation. A research program initiated by Investment Property Forum found that UK real estate is in most cases not a hedge against inflation; they even found that equities are a better hedge against inflation than real estate. HSBC points out that rents struggle to keep up the pace with inflation, and real estate capital growth are closer related to the availability of finance, changes in interest rate expectations and the general economic condition rather than inflation (Thomas, 2011).

Although the Investment Property Forum found that real estate, together with gold, commodities and equities, can give investors a partial hedge against inflation (Thomas, 2011). The literature usually categorizes real estate investments into unsecuritized, securitized and residential real estate. The general conclusion is that unsecuritized and residential real estate might constitute a hedge, or at least a partial hedge against inflation. Nevertheless there are large differences in unsecuritized real estate’s capability of hedging against expected and unexpected inflation depending on sectors, markets and timeframes (Rubens, et al., 1989; Zhou, et al., 2005; Matysiak, et al., 1996; Newell, 1996; Huang & Hudson-Wilson, 2007).

Due to the mixed results of different assets ability to hedge inflation, an overview of different researchers’ results is presented in table 1 below.

The first and most obvious impression is that the literature is inconsistent and using different exposure to real estate. Unsecuritized real estate are most likely to be an inflation hedge while securitized real estate are most times closer related to stocks and therefore not a hedge. The literature is more consistent with gold’s capability of hedging expected and unexpected inflation. The literature seems also to be consistent about that both stocks and bonds are poor inflation hedges.

An apparent evidence of the different natures of real estate exposures is found by Hoesli et al. (2008) where they found that inflation hedging capability of real estate depends on what type of exposures investors have on real estate. Exposure to real estate securities does not offer an inflation hedge and, in fact, fluctuates more like stocks than the underlying real estate.
Exposure to unsecuritized real estate on the other hand offers a different behavior compared to other publicly traded assets and seems to have stronger correlation with both expected and unexpected inflation thus making it a better inflation hedge. Nevertheless, the hedging capability of unsecuritized real estate seems to change over time and be different between markets.

Other researcher that have concluded securitized real estate to be a adverse hedge against inflation and have a higher correlation with stocks than the underlying property market and inflation are: Matysiak et al. (1996), Bekaert and Wang (2010), Crocker et al. (1997) and Attié and Roache (2009).

Table 1 - Overview of literature on inflation hedging capability of different assets

<table>
<thead>
<tr>
<th></th>
<th>Not a Hedge Against Inflation</th>
<th>Hedge Against Expected Inflation</th>
<th>Hedge Against Unexpected Inflation</th>
<th>Hedge Against Both Expected and Unexpected Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Residential Real Estate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Hamelink &amp; Hoesli, 1996)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Securitized Real Estate</strong></td>
<td>(Crocker, et al., 1997; Hoesli, et al., 2008; Bekaert &amp; Wang, 2010; Attié &amp; Roache, 2009)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gold</strong></td>
<td></td>
<td></td>
<td></td>
<td>(Bekaert &amp; Wang, 2010; Worthington &amp; Pahlavani, 2007; Attié &amp; Roache, 2009)</td>
</tr>
</tbody>
</table>

(Zhou, et al., 2005; Bond & Seiler, 1998; Fama & Schwert, 1977)

(Huang & Hudson-Wilson, 2007; Bekaert & Wang, 2010)

The results seem to be highly dependent on the data type and method used. Since most of the data for unsecuritized real estate suffers from appraisal smoothing, the researches using results from transaction based data are highly interesting and perhaps more trustworthy, see Hoesli et al. (2008) and Hamelink and Hoesli (1996).

Other studies find that even if real estate investments do not seem to offer a hedge against inflation, as it traditionally is preserved to offer, real estate still offers a better protection than stocks and bonds (Tarbert, 1996; Zhou, et al., 2005; Rubens, et al., 1989). Stocks and bonds are neither a hedge against expected nor unexpected inflation in the short-run nor the long-run. Moreover, it seems that gold is the best hedge against both expected and unexpected inflation in the long-run.

Some researchers also conclude that assets’ capability of hedging inflation may change over time, depending on the existing economic environment (Hoesli, et al., 2008; Tarbert, 1996; Hoesli, et al., 1995; Attié & Roache, 2009).

In parts 2.1-2.6, detailed results of the literature review regarding the capability to serve as an inflation hedge will be presented for different asset types.

### 2.1 Unsecuritized Real Estate

Hoesli et al. (1995) investigated the short-term inflation hedge of UK real estate compared to other assets between 1963-1993. They found that in the short-term UK stocks seem to have better hedging characteristics than UK real estate, but UK real estate is a better short-term hedge than bonds. However, real estate might provide a long-term hedge against inflation.

Rubens et al. (1989) found that commercial real estate was a complete hedge against expected inflation. Furthermore farmland and residential real estate provided a complete hedge against unexpected inflation between 1960 and 1986.

Zhou et al. (2005) concluded that the returns of residential, commercial, industrial buildings and farms in New Zealand, under the period 1979-2003, had a positive coefficient significantly different from zero when regressed against inflation. This means that real estate in New Zealand provided partial hedge against actual inflation. Commercial, industrial and farm buildings were a better hedge than residential buildings where the residential inflation beta was about 50% lower than betas for commercial buildings, industrial buildings and farms.
Tarbert (1996) found that directly owned commercial properties in UK provided a hedge against both expected and unexpected inflation in the long-run. Their results also indicated that securitized real estate may not be as effective long-term hedge against inflation as unsecuritized real estate.

Newell (1996) found that office, retail and industrial properties during 1984-1995 in Australia offered an inflation hedge against actual, expected and unexpected inflation. Newell used an appraisal based index called the BOMA-index which is commonly used as a performance benchmark in the Australian commercial property market.

Huang and Hudson-Wilson (2007) used annual total return series during 1978-2006 from the Council of Real Estate Investment Fiduciaries (NCREIF) and the Property Index (NPI) to test the hedging capability of private commercial real estate equity. According to them the NPI database is recognized as one of the best date sources of private equity of commercial real estate returns, but nevertheless it suffers from appraisal smoothing since it is partly based on appraisals. The authors found that the office sector is the best hedge against inflation, with coefficients of 1.47 and 1.48 against expected and unexpected inflation. Furthermore, offices not only hedges inflation, it also gains from inflation. Apartments are the second best hedge against inflation in their research with a coefficient of 1.08 and 1.19 against expected and unexpected inflation, while industrials and retail properties do not provide a hedge against inflation.

Based on a cointegration model Tarbert (1996) found that commercial real estate returns had not been a consistent hedge against inflation during 1977-1994. Tarbert used two different indices to test the inflation hedging capability of real estate in UK, the JLW index and the Hillier Parker index. The JLW index represents a typical portfolio of real estate, where the returns should reflect rent reviews, vacancies, management and obsolescence. The Hillier Parker index is based on a hypothetical prime real estate with no allowances for obsolescence. Tarbert found that commercial real estate had some short-run inflation hedging characteristics.

Tarbert (1996) also tested unsecuritized real estate capability to hedge inflation with the same model as Fama and Schwert (1977) and found that unsecuritized real estate was a partial hedge against inflation and stocks and bonds were negative hedge against inflation, which to a certain extent contradicts Tarbert’s results based on the cointegration model (see above).
The indices for unsecuritized real estate prices used in the Hoesli et al. (2008) research were indices from NCREIF for US (between 1977 and 2003) and from IPD for UK (between 1979 and 2003). Since those indices suffer of first order serial correlation, which is common for appraisal indices, and also has strong second serial correlation, the authors further investigated the hedging characteristics of unsecuritized real estate using the MIT transaction based index, published by the MIT Center for Real Estate. Since the MIT index started in 1985, a shorter time period (1985 to 2003) was used for the comparison of the NCREIF and MIT indices. The difference in the coefficient was significant when comparing those two indices. The coefficient for expected inflation over this shorter period was -1.14 in the NCREIF index and -2.60 in the MIT index while being -0.33 and -5.59, respectively, for unexpected inflation. This shows that when using the MIT transaction based index, real estate seems to be an inferior hedge against both expected and unexpected inflation than when using the NCREIF index. Hoesli et al. conclude that real estate is different – both in long run relationships and in the adjustment processes to inflation compared to equities and bonds, although it is most evident for unsecuritized real estate and that further investigations of transactions based indices with longer time series has to be done (Hoesli, et al., 2008).

Although, the hedging advantages of commercial real estate appeared to be small, commercial property seemed to have a superior hedging capability against inflation compared to both stocks and governmental bonds. All tests made on stocks and governmental bonds correlation with inflation appeared to demonstrate either no relation or negative relation. The fact that the response to inflation was negative for stocks and bonds confirms the advantage of including real estate in a portfolio of assets (Tarbert, 1996).

### 2.2 Securitized Real Estate

Crockeret al. (1997) found that securitized real estate in most markets seem to have a low correlation with both expected and unexpected inflation and thus making it a bad inflation hedge. The exception from this is the Swiss and the French real estate securities that seem to offer a slight inflation hedge. In fact some evidence shows that real estate securities, in some countries, are perverse hedges and respond more like stocks. One reason behind the low correlation between inflation and securitized real estate could be due to high leverage which makes securitized real estate more exposed to interest rate changes and other financial market movements rather than the underlying assets behavior.
In UK both securitized and unsecuritized real estate seem to be a hedge against both expected and unexpected inflation during the period 1977-2003. During 1977-2003, real estate in US seemed to be a partial hedge against expected inflation (0.56 for securitized, 0.95 for unsecuritized) but a negative hedge against unexpected inflation for both securitized (-7.14) and unsecuritized (-3.51). Furthermore, during a shorter period between 1984 and 2003 the coefficient for unsecuritized real estate in US turned negative from 0.56 to -1.14 for expected inflation and the coefficient for unexpected inflation changed from -3.51 to -0.33. This implies that the real estate’s ability to hedge inflation seems to change over time, and consequently the timing of purchases and exits, as well as the duration of real estate holdings, might therefore have important implications whether real estate provide hedge against inflation (Hoesli, et al., 2008).

Attié and Roache (2009) found that between 1973 and 2008 US REITs were negatively correlated to actual inflation. However after a formal analysis of the breakpoints the authors concludes that is difficult to draw a strong conclusion since inflation sensitivity for all those asset classes seemed to be instable over time.

Bekaert and Wang (2010) used data from the European Public Traded Real Estate Association (EPRA) when analyzing real estate returns. The inflation betas\(^6\) for securitized real estate in all markets were negative for both expected and unexpected inflation apart from North America, that had a positive beta for both expected and unexpected inflation and Asia that had a positive beta for unexpected inflation, see table 2.

### Table 2 - Inflation betas for real estate with one year horizon from Bekaert and Wang (2010), with standard deviations in brackets

<table>
<thead>
<tr>
<th></th>
<th>Expected Inflation Beta</th>
<th>Unexpected Inflation Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed</td>
<td>-2.46 (0.91)</td>
<td>-0.43 (1.01)</td>
</tr>
<tr>
<td>Emerging</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>North America</td>
<td>2.04 (4.58)</td>
<td>2.19 (4.18)</td>
</tr>
<tr>
<td>EU</td>
<td>-4.33 (1.34)</td>
<td>-1.42 (1.36)</td>
</tr>
</tbody>
</table>

\(^6\)Inflation beta is also referred to as the inflation beta coefficient. This measures the inflation risk of an asset. The tendency of an asset’s returns to respond to swings in inflation or the extent to which returns on the asset and inflation move together (Bodie, Kane, & Marcus, 2011).
2.3 Residential Real Estate

The results from Bond’s and Seiler’s (1998) research indicated that residential real estate in United States during 1969-1994 was a hedge against both expected and unexpected inflation.

Fama and Schwert (1977) tested a range of assets capability to hedge inflation between 1953 and 1971. They found that private residential real estate was a complete hedge against both expected and unexpected inflation.

Hamelink and Hoesli (1996) tested the hedging capability of residential real estate in Switzerland using a transaction-based index constructed by a hedonic approach; this type of index tries to erase all problems concerning appraisal smoothing. Their result show that Swiss residential real estate, stocks and bonds were positively correlated with expected inflation and negatively correlated with unexpected inflation. Based on this approach Swiss residential real estate was not a better hedge against unexpected inflation than stocks and bonds. Annual returns were used in this study and because real estate returns normally lagging in adjusting to inflation, the hedging capability should be tested over a longer time period in order to show any real results.

2.4 Stocks

Stocks do not provide a hedge against any type of inflation according to Fama and Schwert (1977), Rubens et al. (1989), Tarbert (1996), Zhou et al. (2005) and Attié and Roache (2009).

Bekaert and Wang (2010) showed that emerging markets on average have positive inflation betas, driven by Latin America since Asia and Africa had negative betas while the inflation betas for stocks in all developed markets are negative. They found that stocks in emerging markets protect the investor against both expected and unexpected inflation much better than in developed markets. Table 3 summarizes the results of the Bekaert and Wang study.

<table>
<thead>
<tr>
<th></th>
<th>Expected Inflation Beta</th>
<th>Unexpected Inflation Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed</td>
<td>-0.25 (0.29)</td>
<td>-0.44 (0.40)</td>
</tr>
<tr>
<td>Emerging</td>
<td>1.01 (0.07)</td>
<td>0.97 (0.09)</td>
</tr>
<tr>
<td>North America</td>
<td>-0.42 (0.81)</td>
<td>-0.99 (1.26)</td>
</tr>
<tr>
<td>EU</td>
<td>0.27 (0.43)</td>
<td>-0.24 (0.63)</td>
</tr>
</tbody>
</table>
2.5 Bonds

Bonds do not provide a hedge against any type of inflation according to Fama and Schwert (1977), Rubens et al. (1989), Tarbert (1996), Zhou et al. (2005) and Attié and Roache (2009).

Bekaert and Wang (2010) found that bonds have a statistically significant (at the 10 % level) beta below one in 19 out of 48 countries and further 5 countries had a negative beta which was not statistically significant. Since expected inflation should be priced in the required rate of return of bonds, betas for bonds against expected inflation should be around unity. Since bonds are not able to adjust to unexpected inflation, returns of bonds will be sensitive to inflation shocks. The remaining halves of the 48 countries have a positive inflation beta for bonds. However, none of them are statistically significant and 8 of them have a beta below 0.5. Table 4 summarizes the results of the Bekaert and Wang study.

Table 4 - Inflation betas for bonds with one year horizon from Bekaert and Wang (2010), with standard deviations in brackets

<table>
<thead>
<tr>
<th>Region</th>
<th>Expected Inflation Beta</th>
<th>Unexpected Inflation Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed</td>
<td>0.28 (0.13)</td>
<td>-0.58 (0.19)</td>
</tr>
<tr>
<td>Emerging</td>
<td>0.98 (0.34)</td>
<td>0.92 (0.33)</td>
</tr>
<tr>
<td>North America</td>
<td>0.27 (0.36)</td>
<td>-0.44 (0.48)</td>
</tr>
<tr>
<td>EU</td>
<td>0.30 (0.15)</td>
<td>-0.53 (0.19)</td>
</tr>
</tbody>
</table>

2.6 Gold

Gold is traditionally perceived as a hedge against inflation in a similar way as real estate. Gold’s capability of hedging inflation are supported by Attié and Roache (2009), Bekaert and Wang (2010) and Worthington and Pahlavani (2007).

Worthington and Pahlavani (2007) tested gold’s capability to hedge inflation during two periods 1945-2006 and 1973-2006, as they tested the long-run relationship between changes of inflation and gold prices. Their research supports the general view that gold is a hedge against inflation. They also concluded that both direct and indirect exposure to gold is an effective hedge against inflation.

Bekaert and Wang (2010) analyzed the real return of holding physical gold and found that the inflation betas for both expected and unexpected inflation are consistently positive for all markets, making it a good inflation hedge. Since gold prices are in dollars they needed to be converted to the local currencies and the hedging capability of gold might therefore partly be
due to movements of the local currencies against the dollar and not only due to changes in gold prices.

Table 5 - Inflation betas for gold with one year horizon from Bekaert and Wang (2010), with standard deviations in brackets

<table>
<thead>
<tr>
<th>Region</th>
<th>Expected Inflation Beta</th>
<th>Unexpected Inflation Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed</td>
<td>1.25 (0.40)</td>
<td>2.30 (0.45)</td>
</tr>
<tr>
<td>Emerging</td>
<td>0.91 (0.03)</td>
<td>1.06 (0.03)</td>
</tr>
<tr>
<td>North America</td>
<td>1.45 (1.67)</td>
<td>3.96 (2.01)</td>
</tr>
<tr>
<td>EU</td>
<td>0.99 (0.11)</td>
<td>1.17 (0.07)</td>
</tr>
</tbody>
</table>

2.7 Inflation-linked bonds

Inflation linked bonds protects investors against inflation by linking the returns to actual inflation, the return of an inflation linked bond is based on a predefined real rate plus actual inflation. Inflation-linked bonds are typical issued by governments (Bekaert & Wang, 2010). The returns of inflation-linked bonds are typical low; an analysis of the return of inflation-linked bonds compared to other investments is made in the analysis chapter.
3. Methodology

Two statistical approaches are applied in this thesis. The first approach which is descriptive in nature focuses on correlation analysis of the data sample while linear regression analysis is the second approach used.

3.1 Measuring Inflation

Three types of inflation is used in this research, actual inflation, expected inflation and unexpected inflation.

The actual inflation used is simply the headline consumer price index (CPI) published by Statistics Sweden and typically measures the change in CPI over the last twelve months. The publications of these numbers always lag one month and investors therefore have to use their own forecasts of inflation when investing. This forecast is referred to as the expected inflation. The difference between the expected inflation and the actual inflation, when published, is referred to as the unexpected inflation.

There is no standard method of estimating expected inflation but a broadly used method is to use three-month government bonds as substitute of expected inflation. This method implies that the real returns are constant over time which would probably not be a good estimate in this case since the real rate of Swedish government bonds have not been constant over the researched period. Another method used to estimate expected inflation is to use an integrated moving-average process; which allows the real rate of return to be irregular over time and is done by calculating the difference between the nominal rate of return and the expected real rate of return, also referred to as the ex-ante return (Tarbert, 1996). In a paper written by Tarbert (1996) a third method is used to estimate expected inflation; the difference between yields of index-linked government bonds and conventional government bonds is used to derive expected inflation.

The fourth method of estimating expected inflation is to use surveys to understand peoples´ expectations of inflation over the coming year. There are two institutions that perform survey of this kind in Sweden, Prospera and National Institute of Economic research. The survey method will be used here since the quality of the data is perceived to be highly reliable and perhaps the best approximation of investors´ expectations on the Swedish market.
The unexpected inflation is simply the difference between actual and expected inflation for the given period, like mentioned before.

### 3.2 Correlation Analysis

When using a descriptive method to analyze the data, sample statistics such as the means, medians, correlations and standard deviations explain the statistical nature of the observed data pools.

This research focuses on the relationship between inflation and the return of different assets, with special emphasis on real estate. The most relevant sample statistics is therefore the sample correlation coefficient.

In order to compute the sample correlation coefficient to estimate the correlation between inflation rate and different asset returns (here denoted as \(X\) and \(Y\) for simplicity), equation 1 is used.

**Equation 1 - Sample correlation coefficient**

\[
Corr(X, Y) = r_{xy} = \frac{\sum_{i=1}^{T} (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{T} (X_i - \bar{X})^2 \sum_{i=1}^{T} (Y_i - \bar{Y})^2}}
\]

A perfect correlation (one) is when the two move in perfect harmony (Kashyna & Sotnyk, 2010; Brière & Signori, 2009; Hoenig, 2012).

### 3.3 Econometric Analysis

The inconsistency of assets ability to hedge inflation seems not just to be due to different time frames, geographical areas or nature of the exposure but also due to the type of regression models used. There are a range of different methods to test the inflation hedging capability of assets and it seems that the results are dependent on the method. Table 6 reveals a sample selection of econometric methods.
Table 6 - Econometric methods

<table>
<thead>
<tr>
<th>Author</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zhou, et al., 2005; Fama &amp; Schwert, 1977</td>
<td>A linear regression model to test the correlation</td>
</tr>
<tr>
<td>Tarbert, 1996; Worthington &amp; Pahlavani, 2007</td>
<td>Cointegration approach</td>
</tr>
<tr>
<td>Bond &amp; Seiler, 1998</td>
<td>Added variable regression method</td>
</tr>
<tr>
<td>Attié &amp; Roache, 2009</td>
<td>Multiple regression model</td>
</tr>
</tbody>
</table>

The most widely used method to assess assets effectiveness to hedge inflation is the method first used by Fama and Schwert (1977) which assumes that the so called Fisher hypothesis holds. The Fisher hypothesis assumes that the real interest is equal to the nominal interest rate minus inflation (Tarbert, 1996). The Fama and Schwert model tests the correlation between the movements of an asset’s returns and the movements of the inflation rate. The nearer to one the covariance divided by the variance of the inflation is, the more effective is the asset as a hedge against inflation (Bond & Seiler, 1998).

The model used by Fama and Schwert (1977) to test assets ability to hedge inflation is presented in equation 2:

Equation 2 - OLS regression model

\[ R_{xt} = \alpha_x + \beta_x I_t + \varepsilon_{xt} \]

Where \( R_{xt} \) is the nominal return of asset x and \( I_t \) is the inflation rate at time t (expected, unexpected or actual inflation depending on the emphasis). \( \varepsilon_{xt} \) is error term in the regression which is assumed to be normally distributed. The sign on the regression coefficient (also referred to as the inflation beta), \( \beta_x \), explains if an asset is a positive or a negative hedge against inflation. If the inflation beta is significantly different from zero, but less than one, the asset is said to be a partial hedge. If the beta is equal to one it is a perfect hedge against inflation and if the inflation beta is significantly large than one, the asset offers a larger hedge than one to one (Zhou, et al., 2005).

One problem with the static regression model like the Fama and Schwert (1977) is that real estate returns are unlikely to adjust immediately to changes in inflation and would therefore have difficulties to capture the nature of real estates´ lagging adjustment to inflation in a satisfactory way. Static regressions, like the Fama & Schwert relationship, are not capable of distinguishing between adjustments to a long-run equilibrium and short-run dynamic movements. Hence, a method of separating the long-run movements from any short-run adjustments mechanism might be required. One way of capturing the long-run relationships
could be to use a cointegration approach. Verification of a cointegration relationship between real estate returns and inflation would entail that real estate are a long-term hedge against inflation; if such relation exists, variables can be added to explain the short-term dynamics of the adjustments.

A third approach could be to use an added variable approach like Bond and Seiler (1998) did in their research. By dividing the returns from the asset into different components, it is possible to divide the return into inflation and noninflationary components; where the noninflationary component is preserved as the real rate of return. Then the inflation component would further be divided into expected and unexpected inflation.

Yet another model to test assets ability to hedge inflation is the error correction model used by Hoesli et al. (2008). The error correction model captures the long term relationship of the components.

The regression model used in this research is based on the first method, the Fama and Schwert (1977) model. The reason that this method was chosen is that it is the most widely used and of a more basic nature which facilitates the receiver to better understand the methodology and questions related to the deployment of the model is also minimized. However, this method comes with a few side effects that need to be taken into considerations, see appendix and results for statistical tests.
4. Data

All the data on inflation and on return series of different exposures are collected for the period 1993-2011, except for securitized real estate growth (CREX) and bond return series that start in 1994 and 1995, respectively. 1993 is selected as a starting point since the Swedish Central Bank switched from a fixed exchange rate policy to a flexible exchange rate policy in 1992, hence, making the inflationary environment different before 1993 and therefore not comparable with figures after the change to flexible exchange rate.

Sweden changed to a floating exchange rate in 1993 after an unsuccessful attempt to defend the currency with a marginal rate of over 500%. The Swedish central bank has had an inflation target of 2% [+/- 1%] since 1993 (Sveriges Riksbank, 2011).

4.1 Inflation

Inflation can be calculated in many different ways and using many different compositions of the inflation index. The inflation will be divided into three different types; actual, expected and unexpected inflation.

4.1.1 Actual Inflation

The actual inflation is based on the consumer price index (CPI) and gives a measurement of changes in the cost of living in the society. The data of CPI is collect from Statistics Sweden (SCB).

4.1.2 Expected Inflation

It is always difficult to find a satisfying measure of expected inflation, especially in Sweden, since the real rate has not been stable over time and the actual inflation usually fluctuates more than the expected inflation. There are two institutions in Sweden that investigate expected inflation, the Swedish National Institute of Economics and Prospera. Their results are usually very similar (Lagerwall, 2008).

The expected inflation is collected from the Swedish National Institute of Economics (Konjunktursinstitutet) and their survey of Consumer Indicators (Hushällsbarometern) which contains expected inflation in the next twelve months.
4.1.3 Unexpected Inflation

The unexpected inflation is derived by subtracting actual inflation from expected inflation and therefore measures how actual inflation varies from what market participants had expected.

4.2 Assets

4.2.1 Unsecuritized Real Estate

Data of returns from unsecuritized real estate (referred to as Unsecuritized R.E. in the research) are collected from IPD Sweden annual property index. This index measures unleveraged total returns of directly owned properties based on an annual market valuations. The index consisted of 1 105 properties with a capital value of SEK 226 785 million within all sectors in 2010. Contributors of this index are the largest institutional investors in the Swedish market as well as the largest private equity funds (IPD, 2010).

Five different index compositions are analyzed, namely:

- The residential total returns (Unsecuritized Residential R.E. Total), which is the total return (income plus growth) from residential property.
- Residential income returns (Unsecuritized Residential R.E. Income), which only is the income component of residential property return.
- All property total returns (Unsecuritized All R.E. Total), which is the total return from all sectors.
- All property income returns (Unsecuritized All R.E. Income), which only is the income component of property return within all sectors.
- All property growth returns (Unsecuritized All R.E. Growth), which is only the growth or price appreciation component of property returns within all sectors.

Data from the price development of the present stock of one or two dwelling buildings from Statistics Sweden are also used. This index (referred to as Residential R.E. (SCB) in this paper) is based on the average prices of all registered market transactions during each quarter and does not take into account of seasonal variations and size and so forth.

4.2.2 Securitized Real Estate

The returns series from securitized real estate (publicly listed real estate companies) in Sweden are collected from two sources, the Carnegie Real Estate Index (referred to as
Securitized R.E. Growth or CREX) and the European Public Real Estate Association Index (referred to as Securitized R.E. Total or EPRA).

CREX is based on the daily closing price of all listed real estate companies on OMX Stockholm. The index is adjusted for different types of splits, redemptions and other structural changes, but not adjusted for dividend. The index has tracked the price development of all publicly listed real estate companies in Sweden since 1994 (Carnegie, 1993; Bernström, 2003). CREX is the most commonly used index when tracking the Swedish listed property sector’s performance according to Leimdörfer (2012). This dataset starts at 1994 and the research period begins a year earlier.

EPRA is based on daily closing prices of the following listed real estate companies on the OMX Stockholm stock exchange; Whilborgs, Hufvudstaden, Castellum, Fabege, Kungsleden, Wallenstam, Balder and Klövern. The index is a gross index and is adjusted for dividends (EPRA, 2012).

4.2.3 Stocks
The returns of stocks are based on Nasdaq Stockholm OMX’s stock price index which is not adjusted for dividend. The index is collected from the Nasdaq OMX webpage, and is referred as stocks in this paper.

4.2.4 Bonds
The returns series of bonds are represented by two indices from Handelsbanken. Both indices start 1995, unfortunately it is not obtainable to get indices of total returns for bonds further back in time.

One index measures total returns of Swedish mortgage bonds with a duration of three to five years (referred to as mortgage bonds) and the second index measures total returns of Swedish government bonds (referred to as government bonds) and have the same duration as the mortgage bonds (Handelbanken, 2012).

4.2.5 Gold
The gold spot price is collected from Barchart.com in US dollars per ounce and is based on the monthly closing price.
To track the gold price development in SEK, historical monthly average exchange rates between the USD and SEK from the Swedish Central Bank is used to convert the gold price into SEK. The gold price development is then converted to grams instead of ounces (31.1g in 1oz) for an easier understanding for the European readers and then converted into annual and quarterly prices.

The mismatch between closing prices of gold and the average exchange rate of the currency used to convert is perceived to only have a trivial effect on the price development.
5. Results

This chapter covers the findings in terms of descriptive statistics, correlation analysis and an ordinary least square regression model as well as from the rolling window analysis. The results in this research are then summed up in the end of the chapter.

5.1 Descriptive Statistics

The evolution of each asset is presented in diagram 1 and 2, with the annual data in diagram 1 and with quarterly data in diagram 2. All the indices start of with 100 in 1993, except for securitized real estate growth (CREX) that starts in 1994 and mortgage and government bonds that starts in 1995. A few unsecuritized real estate indices included in the research are omitted in the annual diagram to make it more readable.

Diagram 1 - Evolution of different index series based on annual data
All researched assets have a positive real mean return compared to actual inflation over the whole researched period, as is illustrated in diagrams 1 and 2.

When taking into account that the securitized real estate data in this research is an index of listed real estate companies it is revealed that listed real estate stocks (EPRA) as a whole have the highest mean return, and also the highest standard deviation, as popular theories promote.

A detailed statistical description of the assembled data is presented in table 7. The focus in correlations is on actual inflation since investors are most interested in having a hedge against actual inflation and to make an ex-post real return.
### Table 7 - Descriptive data 1993-2011

<table>
<thead>
<tr>
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<td><strong>Quarterly data</strong></td>
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<td></td>
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<td></td>
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<tr>
<td>Inflation</td>
<td>0.4%</td>
<td>0.4%</td>
<td>3.3%</td>
<td>-2.0%</td>
<td>0.7%</td>
<td>0.64</td>
<td>6.21</td>
<td>1.00</td>
<td>76</td>
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<td>Expected</td>
<td>0.5%</td>
<td>0.5%</td>
<td>0.8%</td>
<td>0.2%</td>
<td>0.1%</td>
<td>-0.02</td>
<td>-0.39</td>
<td>0.38</td>
<td>76</td>
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<td>Unexpected</td>
<td>-0.1%</td>
<td>-0.1%</td>
<td>2.7%</td>
<td>-2.5%</td>
<td>0.6%</td>
<td>0.54</td>
<td>6.99</td>
<td>0.98</td>
<td>76</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res SCB</td>
<td>1.4%</td>
<td>1.5%</td>
<td>5.4%</td>
<td>-4.4%</td>
<td>1.9%</td>
<td>-0.60</td>
<td>0.67</td>
<td>0.02</td>
<td>76</td>
</tr>
<tr>
<td>EPRA</td>
<td>3.8%</td>
<td>3.7%</td>
<td>33.9%</td>
<td>-23.7%</td>
<td>12.0%</td>
<td>-0.06</td>
<td>-0.11</td>
<td>-0.19</td>
<td>76</td>
</tr>
<tr>
<td>CREX$^2$</td>
<td>3.0%</td>
<td>2.8%</td>
<td>28.1%</td>
<td>-17.4%</td>
<td>11.3%</td>
<td>0.14</td>
<td>-0.80</td>
<td>-0.25</td>
<td>72</td>
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<tr>
<td><strong>Alternatives</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gold</td>
<td>2.2%</td>
<td>-0.1%</td>
<td>22.1%</td>
<td>-12.6%</td>
<td>7.0%</td>
<td>0.69</td>
<td>0.30</td>
<td>-0.03</td>
<td>76</td>
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<tr>
<td>Stocks</td>
<td>3.0%</td>
<td>5.9%</td>
<td>40.8%</td>
<td>-26.5%</td>
<td>11.9%</td>
<td>-0.24</td>
<td>0.83</td>
<td>-0.12</td>
<td>76</td>
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<tr>
<td>Mortgage Bonds$^3$</td>
<td>1.8%</td>
<td>1.7%</td>
<td>9.5%</td>
<td>-2.5%</td>
<td>2.1%</td>
<td>0.66</td>
<td>1.90</td>
<td>-0.48</td>
<td>68</td>
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<tr>
<td>Government Bonds$^4$</td>
<td>1.7%</td>
<td>1.6%</td>
<td>8.0%</td>
<td>-2.4%</td>
<td>2.1%</td>
<td>0.46</td>
<td>0.68</td>
<td>-0.41</td>
<td>68</td>
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<td><strong>Annual data</strong></td>
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<tr>
<td>Inflation</td>
<td>1.6%</td>
<td>1.6%</td>
<td>4.0%</td>
<td>-1.1%</td>
<td>1.2%</td>
<td>-0.19</td>
<td>0.45</td>
<td>1.00</td>
<td>19</td>
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<tr>
<td>Expected</td>
<td>2.0%</td>
<td>1.9%</td>
<td>2.9%</td>
<td>1.1%</td>
<td>0.5%</td>
<td>-0.25</td>
<td>-0.52</td>
<td>0.49</td>
<td>19</td>
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<tr>
<td>Unexpected</td>
<td>-0.5%</td>
<td>-0.3%</td>
<td>1.9%</td>
<td>-2.4%</td>
<td>1.1%</td>
<td>0.10</td>
<td>0.12</td>
<td>0.92</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res SCB</td>
<td>5.9%</td>
<td>7.1%</td>
<td>12.0%</td>
<td>-3.8%</td>
<td>5.1%</td>
<td>-0.72</td>
<td>-0.69</td>
<td>-0.34</td>
<td>19</td>
</tr>
<tr>
<td>Res Total IPD</td>
<td>11.3%</td>
<td>11.4%</td>
<td>18.2%</td>
<td>-3.6%</td>
<td>4.7%</td>
<td>-1.49</td>
<td>5.06</td>
<td>-0.09</td>
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<tr>
<td>Res Income IPD</td>
<td>5.0%</td>
<td>4.9%</td>
<td>7.2%</td>
<td>2.8%</td>
<td>1.4%</td>
<td>-0.01</td>
<td>1.46</td>
<td>-0.11</td>
<td>19</td>
</tr>
<tr>
<td>All Total IPD</td>
<td>8.6%</td>
<td>8.0%</td>
<td>21.9%</td>
<td>-3.3%</td>
<td>6.6%</td>
<td>0.13</td>
<td>-0.56</td>
<td>-0.14</td>
<td>19</td>
</tr>
<tr>
<td>All Income IPD</td>
<td>5.9%</td>
<td>5.8%</td>
<td>7.6%</td>
<td>4.8%</td>
<td>0.8%</td>
<td>0.59</td>
<td>-0.72</td>
<td>0.05</td>
<td>19</td>
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<tr>
<td>All Growth IPD</td>
<td>2.5%</td>
<td>1.1%</td>
<td>15.6%</td>
<td>-7.8%</td>
<td>6.5%</td>
<td>0.26</td>
<td>-0.72</td>
<td>-0.14</td>
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<tr>
<td>EPRA</td>
<td>15.0%</td>
<td>20.6%</td>
<td>48.1%</td>
<td>-22.0%</td>
<td>22.8%</td>
<td>-0.10</td>
<td>-1.33</td>
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<tr>
<td>CREX$^2$</td>
<td>12.2%</td>
<td>11.9%</td>
<td>43.2%</td>
<td>-27.4%</td>
<td>22.0%</td>
<td>-0.31</td>
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<td><strong>Alternatives</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gold</td>
<td>9.1%</td>
<td>5.9%</td>
<td>39.9%</td>
<td>-11.8%</td>
<td>15.4%</td>
<td>0.58</td>
<td>-0.50</td>
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<tr>
<td>Stocks</td>
<td>13.7%</td>
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<td>-42.0%</td>
<td>29.6%</td>
<td>-0.28</td>
<td>-0.47</td>
<td>-0.10</td>
<td>19</td>
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<tr>
<td>Mortgage Bonds$^3$</td>
<td>7.4%</td>
<td>6.1%</td>
<td>18.6%</td>
<td>0.3%</td>
<td>5.2%</td>
<td>0.83</td>
<td>0.31</td>
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<tr>
<td>Government Bonds$^4$</td>
<td>6.9%</td>
<td>6.1%</td>
<td>17.5%</td>
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<td>5.4%</td>
<td>0.66</td>
<td>-0.30</td>
<td>-0.39</td>
<td>17</td>
</tr>
</tbody>
</table>

$^1$Correlation with actual inflation; $^2$Sample starts 1994; $^3$Sample starts 1995

**Inflation** – Actual inflation
**Expected** – Expected inflation according to Swedish National Institute of Economics
**Unexpected** – Unexpected inflation

**Res SCB** – One or two dwelling residential properties from Statistics Sweden (Residential R.E. (SCB))
**Res Total IPD** – Total returns of residential properties from IPD (Unsecuritized Residential R.E. Total)
**Res Income IPD** – Income returns of residential properties from IPD (Unsecuritized Residential R.E. Income)
**All Total IPD** – Total returns of all properties from IPD (Unsecuritized All R.E. Total)
**All Income IPD** – Income return of all properties from IPD (Unsecuritized All R.E. Income)
**All Growth IPD** – Growth return of all properties from IPD (Unsecuritized All R.E. Growth)
**CREX** – Carnegie Real Estate Index
**EPRA** – European Public Real Estate Association Index
**Gold** – Gold spot price in SEK
**Stocks** – Price index of OMX-SE from the Stockholm stock exchange
**Mortgage Bonds** – Three to five year mortgage bond index from Handelsbanken
**Government Bonds** – Three to five year government bond index from Handelsbanken
The highest mean returns in the sample are the stock index and the two securitized real estate indices with an annual mean return of 12.2-15.0%, followed by the total return of unsecuritized real estate (8.6-11.3% p.a.) and gold (9.1% p.a.). It makes sense that the total return of securitized real estate gives a higher return than the unsecuritized real estate, because the securitized real estate is typically highly leveraged. Lowest mean returns in the period is the growth return of unsecuritized real estate (2.5% p.a.).

As expected, the highest standard deviations have the assets with the highest mean returns but it is interesting to see a comparatively low standard deviation in the unsecuritized real estate assets. This might be due to appraisal smoothing which is covered in the analysis chapter.

A few surprises are discovered when viewing correlations. Overall there seems to be very low correlation with actual inflation among all assets classes. Only gold has a positive correlation with actual inflation on an annual basis, with a correlation of 0.27. There are no assets in the sample that have a positive correlation with actual inflation in quarterly return except for Residential R.E. (SCB) who has only a very small positive correlation (0.02) while gold has a small negative correlation (-0.03).

All real estate returns, except of the quarterly Residential R.E. (SCB), have a negative correlation to actual inflation but there is a risk of underestimation of this correlation because of potential problems in the data sampling of real estate returns which is again covered in the analysis chapter.

All the return series seem relatively normally distributed with both skewness and kurtosis between -1 and 1 for both annual and quarterly return with the exception of the quarterly actual and unexpected inflation as well as the residential total return from IPD which have a very high kurtosis, meaning that the shape of the probability distributions are very peaked and have very few extreme deviations.

5.2 Correlations

The most interesting descriptive statistics for this research is how the correlation is between these different assets and inflation.

The quarterly and annual correlations of the assets with all three kinds of inflation, i.e. actual, expected and unexpected, are presented in this part. Since many consider that real estate tend
to lag inflation it is also interesting to see the correlations between inflation and these assets lagging one period.

Quarterly correlations are portrait in diagram 3 while the annual correlations are portrait in diagram 4.

Diagram 3 - Correlations with inflation with quarterly data
Most assets show a negative correlation with all three kinds of inflation over the entire research period measured in quarterly returns. Annual returns show some more positive correlation with inflation types over the whole research period compared to the quarterly returns although a similar pattern can be identified.

- **Is private residential real estate a hedge against actual, expected and/or unexpected inflation?**

Private residential real estate does not seem to be a hedge against any kind of inflation according to both quarterly and annually correlation data. In fact, private real estates seem to be an adverse inflation hedge since it has a negative correlation with all inflation kinds over this period with the exception of quarterly unexpected inflation.
Interestingly, private real estate show a more negative correlation with all inflation kinds when lagged one period which contradicts the notion that real estate typically lag inflation. This is at least evident in quarterly and annually lagged residential real estate.

- *Is securitized real estate a hedge against actual, expected and/or unexpected inflation?*

Securitized real estates show no inflation hedging ability of any kind. This asset class has a negative correlation with all inflation kinds, both lagged and non-lagged.

It is a popular view that securitized real estate actually behaves more in line with stocks than the underlying assets and this outcome only supports that view as similarities with the stock correlation can be identified.

It is interesting that both researched securitized real estate assets show a less negative correlation when lagging one quarter which might here support the notion that real estate returns typically lag inflation. Private residential returns from Statistics Sweden do not fit into that theory, like mentioned above and a possible explanation for that might be that since that index is transaction based is should faster respond to changes in inflation compared the other appraisal based real estate indices. A shorter lag period would therefore be needed to discover that lagging tendency.

It has to be kept in mind though, that real estate return sampling might underestimate the correlations, more on that in the analysis chapter.

- *Is unsecuritized real estate a hedge against actual, expected and/or unexpected inflation?*

Unsecuritized real estate does not either seem to be a strong inflation hedge. This exposure to real estate also seems to be an adverse inflation hedge to actual and expected inflation since correlations to those inflation kinds are negative.

It could be stated, though, that unsecuritized real estate shows a hedging capability against unexpected inflation according to these outcomes with unsecuritized residential real estate exposure a stronger hedge (with a correlation of 0.21).

- *Is real estate a better hedge against actual, expected and unexpected inflation than stocks, bonds and gold?*
Like expected, stocks do not seem to hedge any kind of inflation, with the exception of annual unexpected inflation. The strongest negative correlation stocks have is with expected inflation which is in line with popular views as investors typically invest in this asset when inflation is low.

Both mortgage and government bonds show some tendencies in moving positively with some inflation types. Interestingly, both bond types have a very big negative correlation with both actual and unexpected inflation when not lagged (with correlations of -0.39 to -0.61) but a significant positive correlation with the same entities when lagged one year (with correlations of 0.54 to 0.69).

Gold is the only asset in this research to show hedging ability to all kinds of inflation. This hedging ability is best viewed in the annual data and indicates that gold reacts with all inflation types within a year since it has a positive correlation to all non-lagged annual inflation types (with correlations ranging from 0.14 to 0.27). Gold, on the other hand, becomes an adverse hedge to those same inflation types when lagging one year (with correlations of -0.10 to -0.13). This hedging ability is not as evident when quarterly returns are viewed.

5.3 Inflation Betas

The outcome of the regression modeling is presented in this part.

The quarterly inflation betas of the assets with actual inflation are portrayed in diagram 5 and table 8 on the next page while the annual inflation betas are portrayed in diagram 6 and table 9.

The focus is on actual inflation since most investors tend to focus on that relationship like previously mentioned.

Statistical tests such as autocorrelation test and stationarity test to inspect the healthiness of the data are performed and presented in the appendix.
Table 8 - Regression results for quarterly data

<table>
<thead>
<tr>
<th></th>
<th>Actual Inflation</th>
<th></th>
<th>Expected Inflation</th>
<th></th>
<th>Unexpected Inflation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beta</td>
<td>( R^2 )</td>
<td>Beta</td>
<td>( R^2 )</td>
<td>Beta</td>
<td>( R^2 )</td>
</tr>
<tr>
<td>Residential R.E (SCB)</td>
<td>-0.07</td>
<td>0.00</td>
<td>-4.84***</td>
<td>0.11</td>
<td>0.14</td>
<td>0.00</td>
</tr>
<tr>
<td>Securitized R.E Total (EPRA)</td>
<td>-3.46</td>
<td>0.04</td>
<td>-18.83*</td>
<td>0.04</td>
<td>-3.04</td>
<td>0.02</td>
</tr>
<tr>
<td>Securitized R.E Growth (CREX)</td>
<td>-4.95**</td>
<td>0.06</td>
<td>-20.26**</td>
<td>0.06</td>
<td>-4.36*</td>
<td>0.04</td>
</tr>
<tr>
<td>Gold</td>
<td>-0.27</td>
<td>0.00</td>
<td>1.99</td>
<td>0.00</td>
<td>-0.39</td>
<td>0.00</td>
</tr>
<tr>
<td>Stocks</td>
<td>-2.22</td>
<td>0.02</td>
<td>-23.88**</td>
<td>0.07</td>
<td>-1.42</td>
<td>0.01</td>
</tr>
<tr>
<td>Mortgage Bonds</td>
<td>-1.76***</td>
<td>0.23</td>
<td>-0.48</td>
<td>0.00</td>
<td>-2.00***</td>
<td>0.26</td>
</tr>
<tr>
<td>Government Bonds</td>
<td>-1.47***</td>
<td>0.17</td>
<td>0.80</td>
<td>0.00</td>
<td>-1.75***</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Significance at the 1, 5, and 10 per cent levels is denoted by ***, **, and * respectively.
Diagram 6 - Inflation betas for annual data

Table 9 - Regression results for annual data

<table>
<thead>
<tr>
<th></th>
<th>Actual Inflation</th>
<th>Expected Inflation</th>
<th>Unexpected Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beta R²</td>
<td>Beta R²</td>
<td>Beta R²</td>
</tr>
<tr>
<td>Residential R.E (SCB)</td>
<td>-1.41 0.12</td>
<td>-6.37*** 0.38</td>
<td>-0.53 0.01</td>
</tr>
<tr>
<td>Unsecuritized Residential R.E. Total</td>
<td>-0.33 0.01</td>
<td>-6.67*** 0.48</td>
<td>0.92 0.04</td>
</tr>
<tr>
<td>Unsecuritized Residential R.E. Income</td>
<td>-0.12 0.01</td>
<td>-1.49*** 0.27</td>
<td>0.15 0.01</td>
</tr>
<tr>
<td>Unsecuritized All R.E. Total</td>
<td>-0.76 0.02</td>
<td>-6.38** 0.22</td>
<td>0.30 0.00</td>
</tr>
<tr>
<td>Unsecuritized All R.E. Income</td>
<td>0.04 0.00</td>
<td>-0.30 0.03</td>
<td>0.11 0.02</td>
</tr>
<tr>
<td>Unsecuritized All R.E. Growth</td>
<td>-0.74 0.02</td>
<td>-5.76* 0.19</td>
<td>0.21 0.00</td>
</tr>
<tr>
<td>Securitized R.E Total (EPRA)</td>
<td>-3.39 0.03</td>
<td>-16.34 0.14</td>
<td>-1.09 0.00</td>
</tr>
<tr>
<td>Securitized R.E Growth (CREX)</td>
<td>-6.16 0.10</td>
<td>-16.51 0.14</td>
<td>-3.88 0.03</td>
</tr>
<tr>
<td>Gold</td>
<td>3.39 0.07</td>
<td>4.39 0.02</td>
<td>3.51 0.06</td>
</tr>
<tr>
<td>Stocks</td>
<td>-2.34 0.01</td>
<td>-33.02*** 0.30</td>
<td>3.65 0.02</td>
</tr>
<tr>
<td>Mortgage Bonds</td>
<td>-2.05* 0.19</td>
<td>2.09 0.04</td>
<td>-3.31*** 0.38</td>
</tr>
<tr>
<td>Government Bonds</td>
<td>-1.89 0.15</td>
<td>3.09 0.08</td>
<td>-3.36** 0.36</td>
</tr>
</tbody>
</table>

Significance at the 1, 5, and 10 percent levels is denoted by ***,**, and * respectively.
• Is private residential real estate a hedge against actual, expected and/or unexpected inflation?

Based on quarterly data during the measuring period private residential real estate is not a hedge against actual nor expected inflation with an inflation beta of -0.07 for actual and -4.84. Residential real estate has a positive unexpected inflation beta of 0.14.

Based on the annual data private residential real estate is an inferior hedge against inflation with betas of -1.41, -6.37 and -0.53 by actual, expected and unexpected inflation respectively. However, with the exception of the expected inflation the statistical significance for residential real estate is very low and the explanatory power in terms of R squared is extremely low for all types of inflation.

• Is securitized real estate a hedge against actual, expected and/or unexpected inflation?

Based on both quarterly and annual data securitized real estate is not a hedge against any type of inflation (i.e. actual, expected and unexpected). Securitized real estate has actually a higher negative beta of actual inflation than stocks. With a negative beta of -4.95 for CREX and -3.46 for EPRA in terms of actual inflation compared to stocks that has a beta of -2.22 based on quarterly data. The CREX index has a more negative beta than EPRA in all types of inflation based on both quarterly and annual data. The statistical significance is strong for CREX on the quarterly data but weak based on the annual data and both on the quarterly and annual data for EPRA. However, the explanatory power is still very low for both the CREX and EPRA for all types of inflation.

• Is unsecuritized real estate a hedge against actual, expected and/or unexpected inflation?

Unsecuritized real estate seems not to be a hedge against actual inflation both in the all sector index and within the residential sector, but it seems that securitized real estate has much more negative betas than unsecuritized real estate. The total return has a stronger negative beta for both residential and all real estate than the income component for all types of inflation. This may give a clue on which component of the return could possibly generate an inflation hedge,
and since most leases are linked to inflation it makes sense that the income component should be the strongest hedging component in unsecuritized real estate.

However, with the exception of the expected inflation the statistical significance for unsecuritized real estate is very low and the explanatory power in terms of $R^2$ squared is low for all the investigated sectors of unsecuritized real estate and types of inflation.

- *Is real estate a better hedge against actual, expected and unexpected inflation than stocks, bonds and gold?*

During this time frame and based on this data and methods it seems that gold is the only asset that is close to be considered a hedge against actual inflation. Based on the annual data gold has a positive beta for all types of inflation, with betas of 3.39, 4.39 and 3.51 for actual, expected and unexpected inflation respectively. Interestingly, gold has negative betas based on quarterly data for actual and unexpected inflation.

Stocks have negative betas for all types of inflation based on both annual and quarterly data except for unexpected annual inflation. Mortgage bonds and government bonds are an adverse hedge against actual and unexpected inflation while they seem to offer some hedge against expected inflation with some positive betas.

Hence, none of the real estate asset classes (i.e. residential from SCB, securitized from CREX and EPRA and unsecuritized from IPD) seem to protect the investor against actual inflation, expected inflation nor unexpected inflation based on both quarterly and annual return series with the exception of a small hedging ability against unexpected inflation in unsecuritized real estate.

Gold seems to offer a partial hedge against actual, expected and unexpected annual inflation. All regressions have a low $R^2$ square which means that the explanatory power of the regressions is low. None of the assets with positive betas are statistically significant.

### 5.4 Rolling Windows

The whole researched period between 1993 till 2011 has been used in computing both the descriptive statistics and the inflation betas until this point in the research.

But have these behavioral patterns been constant over the whole period or do they vary depending on market situations? It is therefore of interest to look at how correlation between actual inflation and these different assets has evolved over the researched period.
Rolling window approach will be used to investigate behavioral changes in correlation, both for lagged and non-lagged returns. Quarterly returns are used to have a sufficient sample size.

The researched period is divided into five year periods and correlation is examined by moving this period one year forward at a time.

Some interesting patterns are revealed when examining how correlation between the given non-lagged assets and actual inflation.

There seem to have been changes in the market dynamics at least three times over the researched period.

- The first change is around 1998-1999 when gold becomes negatively correlated with inflation and residential real estate becomes positively correlated with inflation (blue shaded area in diagram 7).
- The second change happened shortly afterwards when gold becomes positively correlated with inflation again in around the years 2000-2001. Bonds, stocks and securitized real estate begin on increasingly negative correlation trend and residential
real estate tops the positive correlation trend and starts to reverse few years later (non-shaded area in diagram 7).

- Third change came around 2008 when gold becomes negatively correlated with inflation and trends to an increasingly negative correlation along with bonds while stocks, securitized real estate and residential real estate reverse to a less negative correlation with inflation and residential real estate becomes increasingly positively correlated (red shaded area in diagram 7).

The rolling correlation between quarter lagged assets and actual inflation was also examined.

![Diagram 8 - Rolling window correlation with actual inflation lagged one quarter](image)

Less obvious patterns are revealed for lagged assets correlation with inflation. What is most noticeable is that there are some shifts in those correlations around the same periods mentioned above.

It is also interesting to see that lagged bond returns have been positively correlated with inflation since 2004 while lagged gold’s correlation with inflation became negative again (green and red shaded area in diagram 8).

The potential changing factors in the market dynamics will be discussed in the analysis chapter.
5.5 Summary of Results

Below is a summary of the results from the correlation and regression models presented to get an overview of the results. The last years correlations according to the rolling windows analysis are also taking into account.

- Is private residential real estate a hedge against actual, expected and/or unexpected inflation?

No, private residential real estate seems to be an adverse hedge against all types of inflation. Although, according to the rolling window analysis, private residential real estate has been the strongest hedge against actual inflation since 2008.

- Is securitized real estate a hedge against actual, expected and/or unexpected inflation?

No, securitized real estate seems to be an adverse hedge against all types of inflation.

- Is unsecuritized real estate a hedge against actual, expected and/or unexpected inflation?

No, unsecuritized real estate seems to be an adverse hedge against actual and expected inflation. Although, unsecuritized real estate seems to be a partial hedge against unexpected inflation.

- Is real estate a better hedge against actual, expected and unexpected inflation than stocks, bonds and gold?

In most cases, real estate does not seem to offer any hedge against inflation so this statement has to be rejected.

Stocks show more tendencies being an adverse hedge against all types of inflation, although with the possible exception of the annually unexpected inflation.

Bonds show some hedging ability against expected inflation but an adverse hedging ability against both actual and unexpected inflation.

Gold is the only asset class showing some hedging ability against all types of inflation. Interestingly, this hedging capability seems to have disappeared according to the rolling windows analysis.
Table 10 shows the findings of this research summed up in a table similar to table 1 presented in the literature review.

**Table 10 - Overview of inflation hedging capability of different assets according to this research**

<table>
<thead>
<tr>
<th></th>
<th>An Adverse Hedge Against Inflation</th>
<th>Hedge Against Actual Inflation</th>
<th>Hedge Against Expected Inflation</th>
<th>Hedge Against Unexpected Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Residential Real Estate</strong></td>
<td>According to correlation and regression analysis</td>
<td>According to rolling window analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Securitized Real Estate</strong></td>
<td>According to correlation, regression and rolling window analysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Unsecuritized Real Estate</strong></td>
<td>According to correlation and regression analysis</td>
<td></td>
<td></td>
<td>According to correlation and regression analysis</td>
</tr>
<tr>
<td><strong>Stocks</strong></td>
<td>According to correlation and regression analysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bonds</strong></td>
<td>According to correlation, regression and rolling window analysis</td>
<td>According to correlation and regression analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gold</strong></td>
<td>According to rolling window analysis</td>
<td>According to correlation and regression analysis</td>
<td>According to correlation and regression analysis</td>
<td>According to correlation and regression analysis</td>
</tr>
</tbody>
</table>
6. Analysis

Our results reveal that gold seems to be the only asset class to offer a hedge against inflation, all exposures against real estate, stocks and bonds do not offer any significant hedge against inflation.

Both the descriptive statistics in terms of correlation analysis and regression analysis indicate similar results. However, most of the inflation betas are not statistically significant and have a very low explanatory power. The low statistical significance is well-known in this field of research and a common problem in researches within the real estate sector, mostly due to the lack of quality in the data.

There might be several reasons why real estate is not the hedge against inflation it is traditionally perceived to be. This chapter makes an attempt to find reasons and explanations of the findings; first based on the underlying market, then based on issues with the data, thirdly based on a discussion about disparity between markets and instability of correlations and inflation betas. A discussion about inflation-linked bonds as an alternative inflation hedge is presented in the end of the chapter.

6.1 Nature of Real Estate

The first reason why real estate is not a hedge against inflation might be related to the length of leases. Since leases are normally tied to inflation during the lease period, real estate investors will only be protected against inflation during the lease length. Since the typical commercial lease in Sweden is quite short (around three to five years) rents will adjust back to market rent when these leases are renegotiated. This might be one of the reasons why returns of real estate have a low correlation with inflation and negative inflation betas and why the returns of real estate might be closer related to the business cycle, availability of capital and expectations of interest rates rather than inflation.

Based on the view that the inflation protection is related the lease length and the income component of real estate, sectors and markets with long-term leases linked to inflation should be a better hedge than sectors and markets with short-term leases. Residential leases in Sweden are not adjusted to market levels and are more or less only adjusted to the increase of costs of operation and maintenance. This implies that residential real estate should be a partial hedge against inflation at least. Other sectors within real estate that could offer a hedge against inflation are the ones with long-term leases tied to inflation such as properties with
government tenants like hospitals, police stations or universities. Even “sell and lease back”\textsuperscript{7} investment-vehicles with long-term leases should offer protection against inflation.

The findings, however, do not completely support the belief that residential real estate should be a better hedge than other sectors, since unsecuritized residential real estate total and unsecuritized all real estate total have similar betas, see diagram 9. Although, these views seem to get some support from the inflation betas of the income component from the all sector index since the income betas seem to be less negative than total returns, also see diagram 9.

\begin{center}
\begin{tikzpicture}
\begin{axis}[
    width=\textwidth,
    height=0.3\textwidth,
    ybar,
    enlarge x limits=0.25,
    bar width=10mm,
    xtick=data,
    ytick={-8,-7,-6,-5,-4,-3,-2,-1,0,1,2},
    yticklabels={\textbf{-8},\textbf{-7},\textbf{-6},\textbf{-5},\textbf{-4},\textbf{-3},\textbf{-2},\textbf{-1},\textbf{0},\textbf{1},\textbf{2}},
    xticklabel style={text width=0.2\textwidth,align=right},
    y label style={at={(axis description cs:0.5,1.05)},anchor=south west},
    x label style={at={(axis description cs:0.5,-0.2)},anchor=north west},
    width=\textwidth,
    height=0.3\textwidth,
]
\addplot [fill=blue!30] coordinates {
(Residential R.E. (SCB), -0.12)
(Unsec Res R.E. Total, -0.12)
(Unsec Res R.E. Income, -0.12)
(Unsec All R.E. Total, -0.12)
(Unsec All R.E. Income, -0.12)
(Unsec All R.E. Growth, -0.12)
};
\addplot [fill=red!30] coordinates {
(Residential R.E. (SCB), 0.04)
(Unsec Res R.E. Total, 0.04)
(Unsec Res R.E. Income, 0.04)
(Unsec All R.E. Total, 0.04)
(Unsec All R.E. Income, 0.04)
(Unsec All R.E. Growth, 0.04)
};
\addplot [fill=green!30] coordinates {
(Residential R.E. (SCB), 0.00)
(Unsec Res R.E. Total, 0.00)
(Unsec Res R.E. Income, 0.00)
(Unsec All R.E. Total, 0.00)
(Unsec All R.E. Income, 0.00)
(Unsec All R.E. Growth, 0.00)
};
\end{axis}
\end{tikzpicture}
\end{center}

\textbf{Diagram 9 - Annual inflation betas including breakdown of unsecuritized real estate}

The income return component has positive actual inflation betas for all real estate (0.04) but a negative one for residential real estate (-0.12). The income component therefore seems to be closer related to inflation than the growth and the total returns. However, the betas still have a low explanatory power and a low statistical significant.

\textsuperscript{7}A “sell and lease back” construction is typical constructed when a firm who owning its property is a need of capital, typical an investor buys the property and than leases it back to the old owner who can continue with his/her core business in the property.
6.2 Issues with Data

Another reason for unsecuritized real estate’ poor ability to hedge inflation might be due the fact that most unsecuritized real estate return data suffer from appraisal smoothing and does therefore not adjust to changes in inflation as fast as it does in reality.

There are a few problems when looking at time series data that is necessary to keep in mind, especially with unsecuritized real estate data.

Unsecuritized real estate is a unique asset class to start with, and each property has its own unique components and values. This makes it more difficult to observe a true transaction price compared to other securitized assets such as stocks, bonds or commodities.

The unsecuritized real estate market is also less liquid than other markets and less information efficient which means that each transaction takes more time and these transaction prices are usually lagging in time and not always easily available for others.

There are two basic methods used when computing real estate returns. Appraisal method is mostly based on observed transaction prices of comparable properties and statistical method such as regression models which is used to predict transaction prices. There are two major problems with these methods.

- **Random transaction price noise** which is the traditional error term comparable to the securitized assets error term and can be reduced by adding more data to the model. Random noise will increase the volatility but reduce correlations with other assets as well as autocorrelation. This problem is dominating in the statistical methods.

- **Time lag bias (also referred to as appraisal smoothing)** which occurs because the observed transaction prices of comparable properties are spread over time causing them to be outdated when used and can be reduced by only using the most recent transaction prices. Time lag bias will increase autocorrelation while decreasing volatility and correlation with other assets. This problem is dominating in the appraisal methods.

There will always be a trade-off between those two problems since you always increase one when reducing the other. One thing these problems have in common, they reduce the correlation with other assets which might be a problem in our research.
There are a number of methods that claim to treat these problems but most of them are quite complex and not un-debatable in its functions among academics. It was therefore decided not to treat these problems in our research but rather take them into consideration in the outcome.

Another thing to keep in mind is that securitized real estate seems to have a higher correlation with the stock market in the short-run than with the underlying asset’s behavior. There are probably many reasons for this and one might be due to the high leverage of these companies that make them more exposed to interest rate changes and other financial market movements rather than the underlying asset’s behavior.

Yet another problem is related to how the inflation data is measured. The inflation data is collected from Statistics Sweden’s Consumer Price Index in this research, but a comparison with OECD’s Consumer Price Index reveals a large difference between Statistics Sweden’s and OECD’s figures.

Table 11 - Comparison of inflation by SCB and OECD

<table>
<thead>
<tr>
<th>Year</th>
<th>SCB</th>
<th>OECD</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>4.0%</td>
<td>4.7%</td>
<td>-0.7%</td>
</tr>
<tr>
<td>1994</td>
<td>2.5%</td>
<td>2.2%</td>
<td>0.3%</td>
</tr>
<tr>
<td>1995</td>
<td>2.2%</td>
<td>2.5%</td>
<td>-0.3%</td>
</tr>
<tr>
<td>1996</td>
<td>-0.4%</td>
<td>0.5%</td>
<td>-0.9%</td>
</tr>
<tr>
<td>1997</td>
<td>1.7%</td>
<td>0.7%</td>
<td>1.0%</td>
</tr>
<tr>
<td>1998</td>
<td>-1.1%</td>
<td>-0.3%</td>
<td>-0.8%</td>
</tr>
<tr>
<td>1999</td>
<td>1.3%</td>
<td>0.5%</td>
<td>0.8%</td>
</tr>
<tr>
<td>2000</td>
<td>1.1%</td>
<td>0.9%</td>
<td>0.2%</td>
</tr>
<tr>
<td>2001</td>
<td>2.7%</td>
<td>2.4%</td>
<td>0.3%</td>
</tr>
<tr>
<td>2002</td>
<td>2.1%</td>
<td>2.2%</td>
<td>-0.1%</td>
</tr>
<tr>
<td>2003</td>
<td>1.3%</td>
<td>1.9%</td>
<td>-0.6%</td>
</tr>
<tr>
<td>2004</td>
<td>0.3%</td>
<td>0.4%</td>
<td>-0.1%</td>
</tr>
<tr>
<td>2005</td>
<td>0.9%</td>
<td>0.5%</td>
<td>0.4%</td>
</tr>
<tr>
<td>2006</td>
<td>1.6%</td>
<td>1.4%</td>
<td>0.2%</td>
</tr>
<tr>
<td>2007</td>
<td>3.5%</td>
<td>2.2%</td>
<td>1.3%</td>
</tr>
<tr>
<td>2008</td>
<td>0.9%</td>
<td>3.4%</td>
<td>-2.5%</td>
</tr>
<tr>
<td>2009</td>
<td>0.9%</td>
<td>-0.5%</td>
<td>1.4%</td>
</tr>
<tr>
<td>2010</td>
<td>2.3%</td>
<td>1.2%</td>
<td>1.1%</td>
</tr>
<tr>
<td>2011</td>
<td>2.0%</td>
<td>3.0%</td>
<td>-1.0%</td>
</tr>
</tbody>
</table>

Why do those large differences arise?
To be able to answer that question you have to dig deep into the construction of each index, which is out of the scope of this research, but the important point is to understand what inflation really are. The findings of assets ability to hedge against inflation will be highly depend on the method of measuring inflation. Even if there is a standardized method of measuring changes in consumer prices, the consumer preference will vary between markets and countries. Goods such as rents and residential prices might have a higher weight in the construction of the consumer goods basket in US and New Zealand compare to Sweden for example. If this is true, then it would seem natural that the inflation in those countries would have a higher correlation with the return of real estate.

The essential point here is that the construction of the consumer price index will always affect the results.

### 6.3 Disparity between Markets and Instability of Inflation Betas

According to our literature review it also seems that the assets’ ability to hedge inflation seems to be stronger in emerging markets than in developed markets. Furthermore, real estate as an asset class seems to be a better hedge in US and New Zealand than in Europe (Hoesli, et al., 2008; Bekaert & Wang, 2010; Zhou, et al., 2005).

Interestingly, the findings in the rolling window analysis proves that the relation between inflation and assets returns are not stable over time, the correlation between inflation and returns varies over time. These finding are supported by other resent researches that similarly find that inflation betas are not stable over time (Bekaert & Wang, 2010; Attié & Roache, 2009; Hoesli, et al., 2008).

Reasons for the instability of betas might be due to changes in expectations of inflation and interest rates as well as other variables such as economic activity, changes in monetary policies or changes in global markets.

The shifts discovered in the rolling window analysis reveal three main changes in the dynamics of the markets and relationships between assets.

- The first change according to the analysis happened in 1998-1999 which marked the end of a deregulation of the Swedish markets in different sectors because of increasing internationalisation and rapid technological developments. This deregulational era can be said to have started in the early 1990s after the Swedish banking crisis. Furthermore, the EU promoted the creation of internal market in this period with increased freedom
for companies to enter new markets and the introduction of the Euro as its currency in 1999 (The Swedish Competition Authority, 1998).

- The second change came in 2000-2001 which is the period commonly known for the crash of the IT bubble which forced investors to re-evaluate how they measured risks and returns in part due to a high level of unsupported goodwill in companies and too optimistic future growth predictions among other things.

- The third and final change discovered came after the financial crises in 2008 which again forced investors to re-evaluate their risk perceptions and in fact forced governments and regulators all over the world to reform the whole economical set-up. This reformation is still an on-going process.

6.4 Are Inflation-linked Bonds an Alternative?

If traditional assets are poor hedges against inflation, how should an investor allocate its wealth to be protected against inflation?

Inflation-linked bonds would probably be a first guess, but that opinion was undermined after viewing the yield development of US TIPS (inflation-linked bonds). Diagram 10 presents the real yield of US TIPS.

![Diagram 10 - Real yield US TIPS (April 2003 - April 2012). Source: US Department of Treasury](image-url)
Diagram 10 reveals investor’s desire to protect against inflation. Currently (as of May 2012) the U.S. Treasury department sells five year TIPS with a negative real rate.

The Swedish inflation-linked government bond yield has unfortunately not been obtainable, however the ex-post real return of nominal Swedish treasury bills are also negative today.

Inflation linked bonds do not seem to be an alternative for investors that simultaneously want to be protected against inflation and to make a real return. In one words, an investor has to be exposed to the inflation risk to have a chance of making an ex-post real return in today’s economy.
7. Conclusion

The results of this research indicate that real estate is not a hedge against inflation, as it traditionally is perceived to be. This statement is based on both descriptive statistical and econometric analysis.

The main results from the descriptive statistical analysis indicate that all types of real estate exposures (i.e. residential, unsecuritized and securitized) as well as the stock index analyzed are not a hedge against inflation since those exposures have a negative correlation with actual, expected, unexpected inflation based on both annual and quarterly data. With the exception of unsecuritized real estate that has a positive correlation with unexpected inflation.

Bonds (i.e. mortgage and governments bonds) have a negative correlation with actual inflation but a positive correlation with expected inflation. Gold is the only asset with a positive correlation with all types of annual inflation (i.e. actual, expected and unexpected inflation) making it the favorite choice for an inflation hedge measured with annual correlations.

Correlations of different assets returns with inflation do not seem to be stable over time according to our rolling windows analysis. This outcome is supported by other recent reports by Bekaert and Wang (2010) and Attié and Roache (2009) where they discover that inflation betas change over time due to reasons like changing market dynamics and changes in the business cycle.

The most recent change in market dynamics came after the financial crises in 2008 according to our rolling windows analysis. Correlations between actual inflation and gold are then negatively correlated while correlations between actual inflation and real estate exposures grow less negative while residential exposure even has a significantly positive sign.

The results from regression analysis indicate that none of the real estate exposures have a positive beta against actual, expected nor unexpected inflation based on both annual and quarterly data which makes them a poor inflation hedge. Again the only exception here is unsecuritized real estate which also has a positive beta for unexpected annual inflation.

Gold is again the only asset that offers any hedge against all inflation types based on regression analysis with annual data. Stocks and bonds have negative betas for all inflation types, both on annual and quarterly data. With the exception of bonds that have a positive beta
against expected inflation based on both quarterly and annual data and stocks that have a positive beta against unexpected inflation based on annual data.

However, all regressions have a low R square which means that the explanatory power of the regressions is low and none of the assets with a positive beta are statistical significant. Hence any solid conclusion is difficult to make.

There might be several explanations behind why real estate does seem such a poor hedge against inflation. One explanation could be that leases in Sweden are in general too short to hedge owners of properties against inflation in the long-term since rents adjust back to market levels when they expire and are renegotiated. This contributes to the fact that the total returns of real estates seem to have closer relations to the availability of finance, the business cycle and interest rates expectations rather than inflation.

Even though, according to the rolling window analysis, residential real estate seems to have been the only asset in this research that has offered a partial hedge against actual inflation since 2008, that relationship is far from stable. Hence, the only conclusion that can be made is that investors cannot rely on the traditionally perceived inflations hedges like real estate and inflation-linked bonds, mostly because of constantly changing economics and market environments.
Bibliography


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[Accessed 25 January 2012].


Appendix

Statistical Tests

**Autocorrelation Test**

Autocorrelation, or serial correlation, is when one of the classical assumptions for ordinary least squares (OLS) regression models is violated.

The classical assumptions, according to Studenmund (2011), are as follows:

I. The regression model is linear, is correctly specified, and has an additive error term.
II. The error term has a zero population mean.
III. All explanatory variables are uncorrelated with the error term.
IV. Observations of the error term are uncorrelated with each other (no autocorrelation).
V. The error term has a constant variance (no heteroskedasticity).
VI. No explanatory variable is a perfect linear function of any other explanatory variable(s) (no perfect multicollinearity).
VII. The error term is normally distributed (this assumption is optional but usually is invoked).

The Classical Assumption IV refers to autocorrelation and states that “observations of the error term are uncorrelated with each other” (Studenmund, 2011).

*The observations of the error term are drawn independently from each other. If a systematic correlation exists between one observation of the error term and another, then it will be more difficult for OLS to get accurate estimates of the standard errors of the coefficients. For example, if the fact that the error from one observation is positive increases the probability that the error from another observation also is positive, then the two observations of the error term are positively correlated. Such a correlation would violate Classical Assumption IV.*

*In economic applications, this assumption is most important in time-series models. In such a context, Assumption IV says that an increase in the error term in one time period (a random shock, for example) does not show up in or affect in any way the error term in another time period.*

*In some cases, though, this assumption is unrealistic, since the effects of a random shock sometimes last for a number of time periods. For example, a natural disaster like Hurricane Katrina will have a negative impact on a region far after the time period in which it was truly a random event. If, over all the observations of the sample, error is correlated with the lagged error, then the error term is said to be serially correlated (or auto-correlated), and Assumption IV is violated.*

(Studenmund, 2011)

It is also a risk that there might be a trouble with a seasonally based serial correlation in the quarterly model since many markets (including real estate markets) have seasonal cycles and the current quarter will thus be correlated with the same quarter the previous year.

The biggest problems with autocorrelation, according to Studenmund (2011), is that it causes the OLS model to no longer be the minimum variance estimator it is intended to be and the hypothesis testing of the model will be unreliable since this tends to underestimate the standard errors of the coefficients and therefore overestimate the t-score.
Autocorrelation is equal to zero in a perfect market and the outcome of one measurement will therefore not influence the next measurement.

The following equation will be used to test for a sample autocorrelation:

\[ \rho_k = \frac{\gamma_k}{\gamma_0} = \frac{\text{cov}(R_{it}, R_{i,t-k})}{\text{var}(R_{it})} \]

Equation 4 will be used to test for a sample cross correlation:

\[ \rho_{ij,k} = \frac{\gamma_{ij,k}}{\sqrt{\gamma_{i,0}\gamma_{j,0}}} = \frac{\text{cov}(R_{it}, R_{j,t-k})}{\sqrt{\text{var}(R_{it})\text{var}(R_{jt})}} \]

The following diagram shows the first 16 autocorrelations for quarterly data and the first 8 for yearly data.

Diagram 11 - Autocorrelation for quarterly and yearly data

Autocorrelation approaches zero after a few lags but further tests are necessary since the graphs in diagram 11 do not reveal a conclusive result.

While the residual plot can be used to visually detect autocorrelation the Durbin-Watson d test was chosen since it can also be conducted to test for this.

The following equation was used to for the Durbin-Watson d test:
\[
DW = \frac{\sum_{n}^{2}(e_{1} - e_{n-1})^{2}}{\sum_{1}^{n} e_{n}^{2}}
\]

Table 12 - Outcome of the Durbin-Watson d test

<table>
<thead>
<tr>
<th></th>
<th>Actual inflation</th>
<th>Expected inflation</th>
<th>Unexpected inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quarterly data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential R.E.</td>
<td>1.2</td>
<td>1.4</td>
<td>1.2</td>
</tr>
<tr>
<td>EPRA</td>
<td>2.0</td>
<td>2.1</td>
<td>2.0</td>
</tr>
<tr>
<td>Securitized R.E.</td>
<td>1.9</td>
<td>2.0</td>
<td>1.8</td>
</tr>
<tr>
<td>Gold</td>
<td>2.0</td>
<td>2.1</td>
<td>2.0</td>
</tr>
<tr>
<td>Stocks</td>
<td>1.7</td>
<td>1.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Mortgage Bonds</td>
<td>1.6</td>
<td>1.6</td>
<td>1.7</td>
</tr>
<tr>
<td>Government Bonds</td>
<td>1.5</td>
<td>1.5</td>
<td>1.6</td>
</tr>
<tr>
<td><strong>Annual data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential R.E.</td>
<td>1.6</td>
<td>1.7</td>
<td>1.3</td>
</tr>
<tr>
<td>EPRA</td>
<td>1.7</td>
<td>1.6</td>
<td>1.7</td>
</tr>
<tr>
<td>Unsecuritized R.E. All Properties Total</td>
<td>1.3</td>
<td>1.5</td>
<td>1.1</td>
</tr>
<tr>
<td>Unsecuritized R.E. All Properties Income</td>
<td>0.2</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Unsecuritized R.E. Residential Total</td>
<td>1.9</td>
<td>2.1</td>
<td>1.6</td>
</tr>
<tr>
<td>Unsecuritized R.E. Residential Income</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Unsecuritized R.E. All Properties Growth</td>
<td>1.2</td>
<td>1.4</td>
<td>1.1</td>
</tr>
<tr>
<td>Securitized R.E.</td>
<td>1.8</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Gold</td>
<td>1.8</td>
<td>1.7</td>
<td>1.8</td>
</tr>
<tr>
<td>Stocks</td>
<td>2.0</td>
<td>1.7</td>
<td>1.8</td>
</tr>
<tr>
<td>Mortgage Bonds</td>
<td>1.0</td>
<td>1.4</td>
<td>0.7</td>
</tr>
<tr>
<td>Government Bonds</td>
<td>1.2</td>
<td>1.4</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Table 12 shows that there is only an extreme positive autocorrelation problem with both the unsecuritized real estate income data from IPD since, according to Studenmund (2011), there is an extreme positive autocorrelation if the Durbin-Watson d test (DW) = 0, an extreme negative autocorrelation if DW ≈ 4 and no autocorrelation if DW ≈ 2.

Since this problem does not seem to be much spread in the data it was decided not to treat this problem and therefore continue using the OLS regression model.
**Stationarity Test**

Another problem with time-series data is that independent variables can appear to be more significant than they actually are if they have the same underlying trend as the dependent variable (Studenmund, 2011). The underlying common trend might therefore exaggerate the “actual” correlation of the two variables. Such a problem is called a spurious correlation.

The focus was on a spurious correlation with the data caused by non-stationary time series.

A stationary series is one whose basic properties, for example its mean and its variance, do not change over time. In contrast, a non-stationary series has one or more basic properties that do change over time (Studenmund, 2011).

A time-series variable, $Y_t$, is stationary if:

1. The mean of $Y_t$ is constant over time.
2. The variance of $Y_t$ is constant over time.
3. The simple correlation coefficient between $Y_t$ and $Y_{t-k}$ depends on the length of the lag (k) but no other variable (for all k).

If one or more of these criteria are not met, then $Y_t$ is non-stationary. If a series is non-stationary, that problem is often referred to as non-stationarity (Studenmund, 2011).

The major consequence of non-stationarity for regression analysis is spurious correlation that inflates $R^2$ and the t-scores (Studenmund, 2011).

The Dickey-Fuller test was used to test for non-stationarity, which is the standard test for that problem. This test examines the hypothesis of a unit root\(^8\) and if the model would be better expressed using the first-difference.

The following equation was used for the Dickey-Fuller test (where $v_t$ is the classical error term):

\[ Y_t = \alpha Y_{t-1} + \beta x_t + \gamma t + \epsilon_t \]

\(^8\)Using a typical regression model in equation 6.

If $| \alpha | = 1$ then it’s a random walk and the expected value of $Y_t$ does not converge on any value, meaning that it is non-stationary. $\alpha = 1$ is called a unit root and if a variable has a unit root, then the equation holds and the variable follows a random walk and is non-stationary. The relationship between unit roots and non-stationarity is so strong that most econometricians use the words interchangeably, even though they recognize that both trends and unit roots can cause non-stationarity (Studenmund, 2011).
Equation 6

\[ Y_t = \alpha Y_{t-1} + v_t \]

It was decided that **if \(|\alpha| < 1\), then \(Y_t\) is stationary** (since, with large enough sample, the expected value of \(Y_t\) will eventually approach 0). **If \(|\alpha| > 1\), then \(Y_t\) is non-stationary** (since the expected value of \(Y_t\) will continuously increase due to a trend).

However, **if \(|\alpha| = 1\), then \(Y_t\) is non-stationary** due to a unit root (Studenmund, 2011).

### Table 13 - Outcome of the Dickey-Fuller test

<table>
<thead>
<tr>
<th></th>
<th>(a) for annual returns</th>
<th>(a) for quarterly returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential R.E (SCB)</td>
<td>-0.77</td>
<td>-0.66</td>
</tr>
<tr>
<td>Securitized R.E Total (EPRA)</td>
<td>-0.86**</td>
<td>-1.00*</td>
</tr>
<tr>
<td>Securitized R.E Growth (CREX)</td>
<td>-0.92**</td>
<td>-0.95**</td>
</tr>
<tr>
<td>Unsecuritized R.E. Residential Total</td>
<td>-0.90**</td>
<td>-</td>
</tr>
<tr>
<td>Unsecuritized R.E. Residential Income</td>
<td>-0.01</td>
<td>-</td>
</tr>
<tr>
<td>Unsecuritized R.E. All Total</td>
<td>-0.61</td>
<td>-</td>
</tr>
<tr>
<td>Unsecuritized R.E. All Income</td>
<td>-0.12</td>
<td>-</td>
</tr>
<tr>
<td>Unsecuritized R.E. All Growth</td>
<td>-0.61</td>
<td>-</td>
</tr>
<tr>
<td>Gold</td>
<td>-0.89**</td>
<td>-1.03*</td>
</tr>
<tr>
<td>Stocks</td>
<td>-1.03*</td>
<td>-0.82**</td>
</tr>
<tr>
<td>Mortgage Bonds</td>
<td>-0.85**</td>
<td>-0.79</td>
</tr>
<tr>
<td>Government Bonds</td>
<td>-0.93**</td>
<td>-0.76</td>
</tr>
</tbody>
</table>

*Has a problem with non-stationarity; **Might have a problem with non-stationarity

There might be some issue with non-stationarity in three datasets used; the annual data on stocks and the quarterly EPRA data and on gold. A few other datasets are on the edge of being deemed non-stationary due to a unit root.

It was decided not to treat for non-stationarity, or test for cointegration, since the respective \(R^2\) in the regression model were not that high and we did not want to lose any information by treating this.