Assets as hedges against the inflation rate

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Abstract

This paper investigates, using Swedish data from 1996 to 2016, the possibilities to use different investment assets to hedge against the expected and unexpected inflation rates. With the use of time series regressions, we find that treasury bills have the potential to be good hedges against the expected inflation rate, and that real estate could be a good hedge against the unexpected inflation rate. However, Swedish government bonds and different stock segments, based on industry type or market capitalization do not show signs to have good hedging possibilities.

Keywords: Inflation, asset returns, hedging, Fisher hypothesis

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1. Introduction

Historically, inflation hedging has been a popular topic in the finance research field, especially during the period of the Great Inflation from 1965 to the mid 1980s when the inflation rate peaked just below 14 percent in the United States. In order to prevent value losses of the invested assets, researchers have analyzed the relationship between inflation and asset returns, and tried to find out ways to hedge the investments against the inflation rate.

Why is the topic of inflation hedging still relevant in Sweden when the current inflation rate in April 2016 is 0.8 percent? We argue that the topic of inflation hedging is important in any time period and the threat of the inflation risk should not be underestimated. There are a number of factors, which will be discussed in this paper, that indicate that the inflation could increase rapidly and become a possible threat.

The central bank of Sweden, the Riksbank, implemented several quantitative easing programs in 2015 by buying government bonds in order to increase the current inflation rate to the target of two percent. In February 2015, the Riskbank made the historical decision to set a negative repo rate. These actions have given results and we are now observing an increasing inflation rate in Sweden. There are however economists arguing that these kinds of monetary interventions might get out of control.

As an export depending country, Sweden is largely influenced by global events, and in particular, happenings occurring in the European Union. The European Monetary Union is continuously facing new difficulties, which might lead to a collapse of the euro zone and a following currency war. This is a threat that should be taken seriously. The fact that the inflation has been low in Sweden over the last decades does not guarantee that the inflation will remain at a low level in the future.

Due to a rapidly growing demand for housing, the Swedish government is prepared to largely subsidize the building sector for the coming years. This increase of money supply in the market could have severe macroeconomic effects and would most certainly further increase the Swedish price levels.

One of the most famous articles on the topic of inflation hedging is "Asset returns and Inflation" written by Eugene Fama and William Schwert in 1977. In this article, the authors studied how the return of different assets developed in relation to both the expected and unexpected rate of inflation. This article has been the main inspiration for this thesis.

In this paper, we investigate different assets as potential hedges against the inflation rate by using Swedish data. The assets we focus on are treasury bills, government bonds, real estate and several segments of stocks based on industry and market capitalization. The actual inflation rate can be decomposed into expected and unexpected inflation rates. We define the unexpected part of the inflation as the difference between the actual inflation rate and the expected inflation rate.

Firstly, we analyze the descriptive statistics and autocorrelations of the nominal and the real returns of the assets and inflation rates. At this level we identify some patterns, for example that the treasury bills could be potential expected inflation hedges since the nominal returns of the treasury bills have similar movements as the expected inflation rate when plotted in a graph.

Secondly, we run the main regression tests based on the original model in Fama and Schwert (1977). Nominal returns of each asset are regressed against the expected and the unexpected component of the inflation rate. The expected inflation rate can be obtained using different methods and sources. In this paper, we have chosen to use two of the methods. First we used Swedish household´s expectations of the inflation rate collected by the National Institute of Economic Research. Since this first test is a survey based proxy for expected inflation rate, we name it Test SP. The second proxy of the expected inflation rate used in this thesis is the nominal return of a treasury bill, which is the method used by Fama and Schwert (1977). This second test is referred as Test TP. In order to receive more precisely defined results in the regression analysis, we likewise regress the quarterly and semiannual returns against the two inflation components.

Thirdly, we examine the robustness of the results in the regression analysis. Instead of using CPI, which is the most common measurement of the actual inflation rate, we change the data to CPIX and CPIF respectively. Both indexes measure the underlying inflation rate and are used by the Riskbank. The CPIX excludes the rent costs for households and changes in taxes (not salary related), while the CPIF index takes into account a constant interest rate when calculating the rent costs of households. By changing the data of the actual inflation from CPI to CPIX and CPIF, we can conclude that the results are very similar, which indicates that the regression results are robust.

The remainder of this paper is structured as follows. Section 2 includes the background information about inflation and describes why it is relevant to examine the topic of inflation hedging in Sweden today. Section 3 describes the previous literature regarding the topic of inflation hedging and the relationship between asset returns and inflation. In section 4, the data, methodology and theory used in this paper are presented. The results of the empirical tests are described in section 5 and implications and conclusions discussed in section 6 appendices are provided in the end.

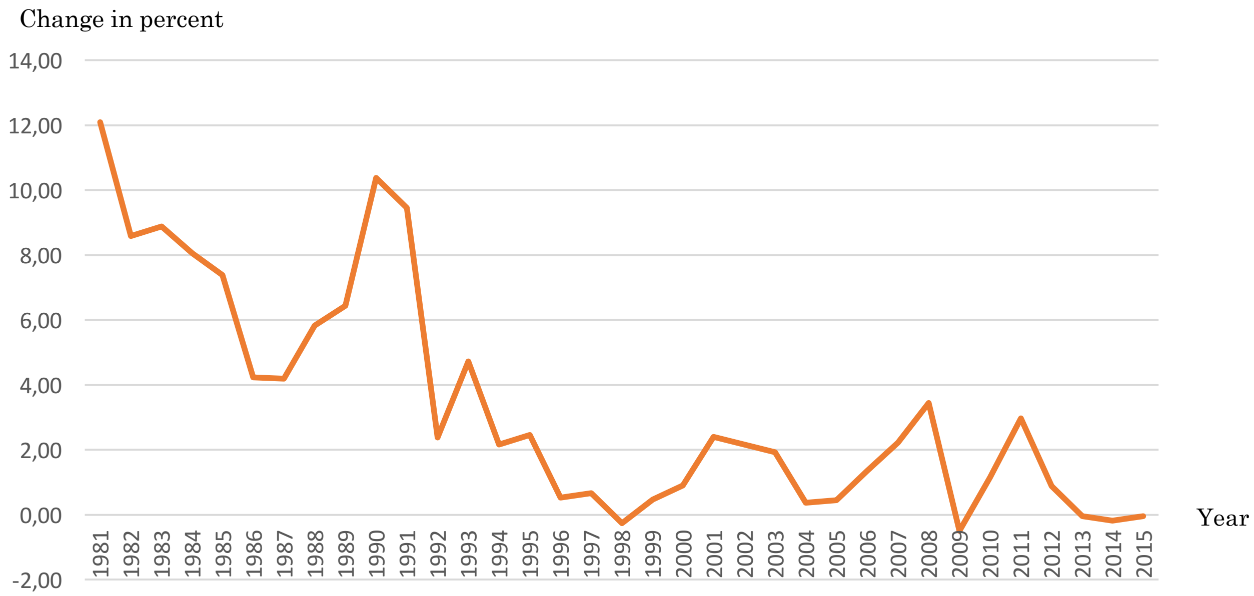
2. Case Background

2.1 Swedish inflation over time

Graph 1 shows the development of the Swedish inflation rate between 1981 and 2015. Even though we can observe what looks like a trend of a decreasing inflation rate, it is evidential that the inflation is volatile and may increase fairly rapidly.

Graph 1

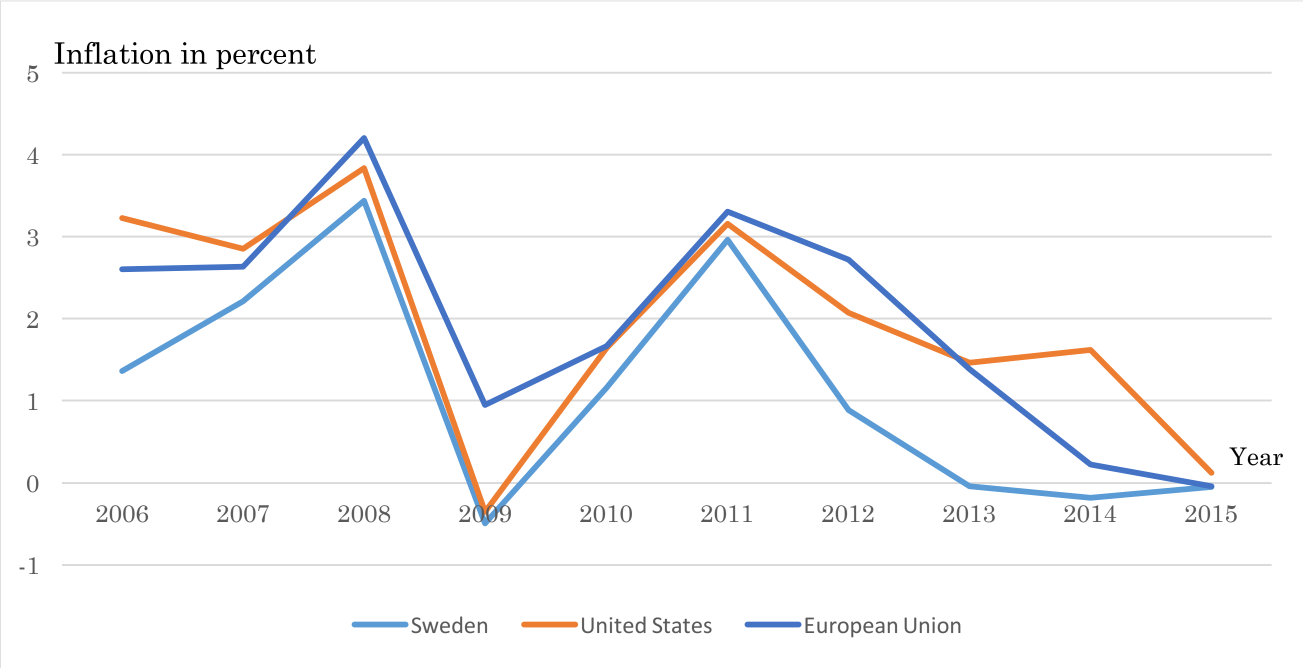
Annual change in Swedish CPI



Graph 1 shows the annual change in the Swedish CPI, i.e. the inflation rate, between 1981 and 2015.
Source: Statistics Sweden.

Graph 2 portrays how the Swedish inflation rate has fluctuated over the last decade in comparison to the one of the European Union and the United States. The Swedish rate of inflation seems to move synchronized with the American and the European Union's inflation rates, even though the Swedish one is lower than the other two rates. This indicates that the inflation rate in a small country like Sweden can be affected by dominant countries' inflation rates.

Graph 2
Swedish inflations rate in comparison with inflation rates of other countries



In graph 2 the annual inflation rates, measured as change of the CPI, of Sweden, the United States and the European Union are plotted. The graph shows how the different inflation rates moves in relation to each other.
Source: The World Bank Group

2.2 Why worry about the inflation today?

As observed in the graphs above, the inflation rates of the Western world have been low during the last decade. One might therefore ask whether inflation hedging has lost its importance? We argue that this is not the case. The inflation rate can be volatile and both macroeconomic events as well as financial- and monetary policies can quickly have large impacts on the rate of inflation. Therefore, an inflation shock will become a threat for anyone who is underestimating the inflation risk.

2.2.1 Quantitative easing

Central Banks can stimulate the economy using different policies. Quantitative Easing, QE, is a monetary policy used by central banks in order to stimulate the overall economy. In a time period of low growth, the central banks can choose to apply a QE program by buying financial assets such as government bonds. The purpose of this method is to boost the economic situation and increase the inflation rate. Since the inflation rate in Sweden has been low, the Riksbank in Sweden has been reducing the repo rate and implementing several QE programs in 2015. By buying government bonds, the supply of these bonds decreases, and the prices increase which in turn lowers the interest rates. These low interest rates encourage people to borrow and spend more money which increase the activities in the economy (Alsterlind et al., 2015).

Since the QE programs performed by the Riksbank in 2015, we observe a trend of increasing inflation in Sweden. Some economists, for example John Williams are skeptical to monetary policies such as QE, where he believes that such policies will lead to hyperinflation (The Economist, 2011) A scenario of hyperinflation does not seem to be in sight for a stable country such as Sweden, but is there truly no risk for a great shock in inflation that could have devastating effects for investors?

2.2.2 The euro crisis

In 2010 the euro zone started to experience a sovereign debt crisis. (Jones, 2014). According to the International Monetary Fund, a new financial crisis may occur due to problematic banking conditions in the euro area (Elliot, 2016). During such unstable circumstances, people start to wonder what will happen if a country decides to leave the euro cooperation and become independent. Swedbanks' analysts state that if an economy decides to leave the Economic and Monetary Union, EMU, it will not only have impacts on the country itself, but also lead to implications for the rest of the countries within the union. If a strong economy like Germany leaves the union, the whole system will most probably collapse since the weak countries are dependent on the strong nations in the union (Swedbank, 2012). Even though Sweden is not a part of the EMU, a system collapse will have significant impact on the economies in Europe and Sweden. The countries that leave EMU will become monetary independent and regain the ability to adjust the relative prices for export and import. To strengthen their international competitiveness, they are likely to devaluate their currencies to stimulate growth (Jones, 2014). The Swedish currency will then become too expensive in the currency war, which will force the Riskbank to devaluate the Swedish krona to maintain Sweden's attractiveness in international trade. The QE programs in Sweden in combination with a devaluation of the krona may lead to a rapidly increase in the inflation rate.

2.2.3 The Swedish housing market

According to Statistics Sweden, the Swedish population has grown significantly over the past few years (Statistics Sweden, 2016). This great increase in population has created a high demand for housing. However, the number of homes has not increased in the same pace as the population, which has led to a great deficit in the Swedish real estate market (Veckans Affärer, 2016). Because of this shortage the prices of houses and apartments have increased drastically over the last decade (Statistics Sweden, 2016). Politicians are starting to prioritize this issue and concrete action plans regarding how to increase number of new homes are continuously proposed. The Swedish government has claimed that they will spend SEK 3.2 billion annually on building apartment houses (Kasurinen, 2016). Government spending on the building sector is a well-known Keynesian way to stimulate GDP growth in recessions and as a consequence, due to the increase in money supply, the inflation rate increases (Jahan et al., 2014). An action like the one planned by the Swedish government today should have similar effects on the inflation rate even though Sweden is not currently experiencing a recession.

2.2.4 Costs of inflation

There are a number of costs associated with a high inflation rate. The most obvious one is that the cost-of-living may grow faster than the incomes, meaning that the purchasing power will decrease. In the long run the classical dichotomy suggests that money is neutral and that the real side of money will be unaffected by the inflation. This is however not true in the short run, where inflation can play a major role in determining the value of the real side of money (Jones, 2014).

Another important cost of inflation is the redistribution of wealth. With a high inflation, borrowers will be able to repay loans with banknotes that are worth less than their initial value, making borrowers better off and lenders worse off (Jones, 2014).

The cost of extra taxation in high inflation periods is another notable inflation cost. In many countries it is the nominal income that is the base for taxation. When the inflation is high, the nominal income will increase, which leads to an increase in taxes. At the same time, the real income will remain the same as the consumer prices increase. This means that people will receive the same real income, but have to pay a higher tax (Jones, 2014).

2.2.5 The underestimated inflation risk

In recent years, inflation has not been seen as a great threat in developed markets such as Sweden. However, there are warning signs suggesting that this feeling of safety might be false. As we have reasoned, inflation dangers can be waiting around the corner. The fact that the Riksbank is implementing QE programs in combination with the extraordinary situation of the Swedish real estate market makes the inflationary situation in Sweden a topic heavily discussed by leading economists. On top of this, the risk of a collapse of the EMU is constantly luring.

3. Previous Literature

The Fisher hypothesis is the underlying theory explaining the relationship between inflation and asset returns. Boudoukh, Richardson and Whitelaw found, in their article: “Industry Returns and the Fisher Effect” (1994), that the relation between inflation and stock returns differs among industries. The relationship with the inflation can be partly explained by the cyclical trends in the particular industry. For example, in the noncyclical tobacco industry, an increase in expected inflation is associated with an increase in the expected stock return. On the other hand, for the cyclical transportation equipment industry there would conversely be a decrease in the expected returns.

The article “The relation between Stock Prices and Inflationary Expectations: The international Evidence” (1983) by Bruno Solnik, examines the relationship between returns and inflationary expectations by using interest rates as proxy for expected inflation. Using data of nine stock markets around the world, he showed that the Fisher hypothesis, predicting that real returns are independent of inflationary expectations, is rejected.

The topic of whether stocks and other assets can work as hedges against inflation has been discussed by many researchers over the last 50 years. This subject has been particularly popular in the finance research field during the time period of the Great inflation from 1965 to the mid 1980s where the inflation rate peaked just below 14 percent in the United States (Meltzer, 2005). The findings have been varying and opinions are not consistent.

One of the most famous articles regarding inflation and asset returns is “Asset Returns and Inflation” by Eugene Fama and William Schwert in 1977. Using US data, they investigated the relationship between inflation and the return of different assets and found that the American government bonds and treasury bills are complete hedges against the expected component of the inflation rate. Furthermore, they showed that private residential real estate is a complete hedge against both the unexpected and the expected components of the inflation rate. This study was the starting point for several other research papers and has inspired us to analyze this topic using Swedish data.

Charles R. Nelson showed in the article “Inflation and rates of return on common stocks” (1976) a negative relationship between returns and both the anticipated and the unanticipated inflation by conducting an empirical analysis on data over the post-war period. This outcome is consistent with Fama and Schwert (1977), indicating that this result was relatively reliable, at least during the mid 1970s. Nelson concludes that these findings reject the Fisher hypothesis when concerning common stocks.

Barnes, Boyd and Smith compared, in their article “Inflation and asset returns” (1999), how inflation affected the nominal asset returns in 25 different countries. Their findings supported the theory that inflation, in low to moderate inflation countries, has a negative effect on equity returns. For returns on so called “safe assets” they do not find that those should be significantly affected by inflation. What makes this article especially interesting is that the authors regress the asset returns for the 25 countries against the U.S. inflation as well. By doing this test they could conclude that a high U.S. inflation has a negative effect on returns in most countries. In Sweden however, asset returns are positively correlated with the U.S. inflation using data from the period February 1957 to March 1996.

In the article ”Stock Market Returns and Inflation: Evidence from Other Countries” (1983) by N. Bulent Gultekin, the relationship between stock market returns and inflation in 26 countries was examined. The data analysis, using the monthly inflation rates for the postwar period from January 1947 to December 1979, showed that there is no reliable positive relation between nominal stock returns and inflation rates, but there are differences among countries.

“Inflation Risk and the Inflation Risk Premium” (2010) is an article by Bekaert and Wang that investigates how a number of assets work as inflation hedges for different countries. They found that standard securities such as stocks and bonds do not work well at all as hedges against inflation. Other assets like commodities and real estate show some better results than the standard securities but it is only a marginally improvement. Apart from looking into how good hedges different assets are, the authors discussed the concept of inflation hedging thoroughly. One of the important points that they made is that an asset's ability to hedge against inflation varies over time and can be largely affected by monetary policies.

Some authors, on the other hand, found that stocks could work as a hedge against the inflation rate, for example Schotman and Schweitzer in 2000. They studied the Fisher hypothesis and the inflation hedging possibility of stocks by taking the horizon sensitivity into account. From this they could conclude that even if stocks in most cases are not good hedges in the short run, they can be useful for long term investors. Stocks that are held for more than 15 years can work as hedges if the inflation rate is persistent.

Another article that argues for stocks being potential hedges against inflation is "Common stocks as a hedge against inflation". This is an article written by Zvi Bodie (1976) which, as the title suggests, investigates how well common stocks perform as hedges against inflation. In this article, Bodie showed that equity could function as an inflation hedge, but unlike common belief he discussed that the stocks must be shorted for it to work. The reason for this is that he found stocks to be negatively correlated to both the expected and unexpected rate of inflation using U.S. data from 1953 to 1972.

4. Data and Methodology

4.1 Data description

4.1.1 Inflation rates

The definition of inflation is the persistent rise in the general price level. This price level is usually measured as the change of the CPI which reflects the prices of goods and services used by the average consumer (Kennedy, 2000). For this paper, the change in the CPI Fixed Index Numbers (1980=100), is used as approximation for actual inflation. The data range from December 2001 to March 2016 and is provided by the Statistics Sweden.

The expected inflation can be measured using different methods. In this study, we examine two routines of approximating the expected inflation. The first test is based on a survey method performed by the National Institute of Economic Research. Using the expected inflation data collected from this government agency under the Ministry of Finance, we name it Test Survey Proxy, Test SP. This proxy seems rational to use since the data include the households' expectations of what the inflation would be in the future, which is a direct source of information. The measurements of the monthly data on expected inflation were made between the first and the fifteenth each month and were available from December 2001 to March 2016.

The second proxy for expected inflation in this study is to use the same method as performed in Fama and Schwert (1977) by using the returns of treasury bills. When the treasury bills with one-month time to maturity are used, we name it Test Treasury bill Proxy, Test TP. Since the treasury bills data only were available from March 2006, the expected inflation rate for Test TP starts from March 2006 and continues to March 2016. By having two different datasets of expected inflation rates from separate sources, we can compare the results and receive a more general view of the analysis.

The unexpected inflation rate is defined as the difference between the actual inflation and the expected inflation. We have therefore calculated two unexpected inflation rates for our analysis; one for each of the expected inflation rates used.

To calculate the return of different assets we have looked at the prices or indexes of the specific assets over a certain time period. We have then calculated the nominal returns based on the change in price from one data point to the next in time. One-month difference for monthly returns, three months for quarterly returns and six months for semiannual returns. The data was collected from the Thomson Reuters database Datastream, Statistics Sweden and Nasdaq Nordic OMX.

4.1.2 Treasury bills

Treasury bills are considered to be safe investments with low downside risks and therefore small upside opportunities. They do not pay any coupon but are simple to buy and often sold at a price that is affordable for individual investors which make them popular among small investors (Bodie et al., 2013).

For approximating how the treasury bill market in Sweden has developed over time we use the OMRX T-BILL Indexes which show the total return of all treasury bills traded on the Swedish OMX market. We chose to examine bills with three different time to maturities, namely one month, two months and six months. Using three different bills should give a fair picture of the bill market as a whole. For the treasury bills there was no data older than ten years available, which mean that we have data from March 2006 until March 2016.

4.1.3 Government bonds

Government bonds are similar to treasury bills in the way that they are secured by the government and thereby considered to be safe investments. However, they have longer holding periods than bills and pay a coupon (Bodie et al., 2013).

We used the SD Benchmark DS Government Index for bonds with maturities of three, five and ten years, provided by Thomson Reuters. As with treasury bills, we considered that using three different maturities of bonds would make our findings more reliable. The data is available from March 1996 to March 2016.

4.1.4 Real estate

Seen to the current Swedish housing market and the fact that real estate is the asset that Fama and Schwert (1977) found to be the only hedge against both expected and unexpected inflation, it seems natural for us to include it in our study. The data was collected from Statistics Sweden named Real estate price index for one- and two dwelling buildings for permanent living by region. This data is only reported on a quarterly basis and for this study we use the time period from the third quarter of 2001 to the fourth quarter of 2015.

4.1.5 Stocks

There have been several previous studies done in the US that examine how good common stocks are in purpose of hedging against inflation rate. There have been different results where some researchers have found that stocks do not work well as hedges against inflation, but other studies that have found that stocks might work in the long term if the inflation is persistent. Hence, we think it would be interesting to examine stocks and see how it has performed in relation to the inflation rate in Sweden over the last 15 years.

Since stocks can be categorized based on different factors, we decided to analyze both a benchmark index over the entire Stockholm stock exchange, as well as specific segments. In this paper, we examine if the market capitalization or the industry sector has an effect on the hedging possibilities. Since Boudoukh, Richardson and Whitelaw (1994) found that the relation between inflation and stock returns differs among industries; we thought it would be interesting to compare cyclical with non-cyclical industry sectors to see if they are affected by the inflation differently. The data on the industry sectors ranged from November 2001 to March 2016. For the market capitalization segments, the data range differed. The Small Cap segment started from June 2009 to April 2016, while the Mid Cap started from January 2003 and the Large Cap started from October 2006. The different segments are described below.

Stocks Benchmark

OMX Stockholm Benchmark Price Index is used as an overall estimate of the Swedish stock movement from March 1996 to March 2016. This index consists of the largest and the most traded stocks on the Swedish market and is an indicator of the performance of NASDAQ OMX Stockholm. The source for the data is Thomson Reuters Datastream.

Market capitalization

We investigate if the market capitalization of companies influences how affected the stock is by inflation and thus how good it would be as a hedge against inflation. In this study indexes divided into small, mid size, and large market capitalization are used. Based on the market value, the companies are divided into the three segments. The Large Cap index includes companies with a value of 1 billion euros or more, while the Small Cap index include companies with market value less than 150 million euros. The Mid Cap includes the companies with market value in between the other two segments. Nasdaq Nordic OMX provides the data on these segments.

Forestry and paper

Commodities is known to be used as hedges against inflation due to their low correlation with other asset classes (Woodworth, 1959). Forest, which is one of Sweden's most important natural resources, is commonly seen as a safe investment that is not affected by fluctuations in the rest of the economy since these products, for example tissue, always are in demand (Lundmark, 2004).

In this study we have chosen to use the OMX Stockholm Forestry & Paper PI. This is an index containing the listed forestry and paper companies in Sweden.

Industrials

Industrial products are, as forestry and paper, a great Swedish export sector. It is considered to be fairly cyclical which means that the stock price is largely affected by the overall state of the economy (Boudoukh et al. 1994). These products move with the aggregate economy; hence they will perform better than non-cyclical products in a booming economy but worse in a recession (Boudoukh et al. 1994). The index OMX Stockholm Industrials PI is used to analyze the industrials sector.

Consumer goods

Unlike industrials, consumer goods are relatively non-cyclical products (Boudoukh et al. 1994). The index used is OMX Stockholm Consumer goods PI and includes for example tobacco, clothing and automobile spare parts which are all products that consumers will buy regardless of the state of the economy. Inflation is often described as the change in the Consumer Price Index, hence intuitively; consumer goods should be the sector that moves most similar to the inflation.

4.1.6 CPIX and CPIF

For the robustness test, we use the CPIX index and the CPIF index respectively, instead of the CPI, as a proxy for the actual inflation rate. The data of the two indexes ranged from 1996 to 2016 and the two indexes measure the underlying inflation rate, where the CPIX excludes the rent costs for households and changes in taxes (not salary related) (National Institute of Economic Research, 2008). The CPIF index takes into account a constant interest rate when calculating the rent costs of households (Widén, 2010). These two indexes are both measurements that the Riksbank uses to measure the inflation (The Riksbank, 2011).

4.2 Theory and methodology

All the data collected for the main tests in this paper is time series data. We chose to perform four different tests; test for autocorrelations, time series regression analysis, robustness test and an additional test to analyze price of risk. The latter test will not be described further in the following sections, since it is not a test for hedging possibilities. For more details, see Appendix B. The statistical program STATA is used to conduct these tests. Before we conducted any of these test we examined the statistical properties of the data to see if any conclusions could be made from the descriptive statistics.

4.2.1 Inflation data gathering

Since expected inflation is difficult to measure there are no general method of how to calculate it. It can be derived from a variety of sources and methods and different authors use the method that they believe is the most appropriate for their specific study.

In Fama and Schwert (1977), they used their earlier findings in Fama (1975) and Fama and Schwert (1977b), which showed that a proxy for expected inflation rate at time t is the nominal return or interest rate on a treasury bill which matures at end of time t. Since then, various studies, as the one performed by Tenigbade in 2011, use treasury bill rates as a proxy for the expected inflation rate. By using this method, an underlying assumption is that the real returns on bills are constant through time. This assumption has been criticized since it has been shown to not hold for subsequent analysis done by Fama and Gibbons (1982) and Hartzell et al. (1987).

Alternative methods used by different authors include using the integrated moving average ARIMA model to calculate the expected inflation rate or by using the difference in yields on index-linked bonds and conventional bonds as a measure of expected inflation (Tarbert, 1996).

In Sweden, TNS Sifo Prospera and the National Institute of Economic Research are two institutions that measure the expectation of the Swedish inflation. The method used by TNS Sifo Prospera in order to estimate the expected inflation rate is to undertake a series of surveys answered by labor market organizations, purchase managers and money market players (TNS Sifo Prospera, 2016). The National Institute of Economic Research interviews around 1500 households each month about how they perceive the Swedish inflation. Around 6000 companies are also interviewed each quarter about the Swedish inflation expectations (National Institute of Economic Research, 2016).

In this study, we have chosen to use two different proxies of the expected inflation rate and therefore two separate tests were conducted. In the first test named Test SP, we use the expected inflation data conducted by the National Institute of Economic Research. This data showed the expected inflation for the next-coming twelve months, which means that it is recalculated into monthly, quarterly and semiannual expectations. The reason for using this data by the National Institute of Economic Research is that the other source, TNS Sifo Prospera, does not provide time series data and both institutions have similar results (Lagerwall, 2008).

For the second test, named Test TP, we use the returns of the one-month treasury bill as proxy for the expected inflation rate. This method is in line with the article by Fama and Schwert (1977), as they used the nominal return on a treasury bill which matures at end of time t a proxy for expected inflation rate at time t.

4.2.2 Autocorrelation

Two tests for autocorrelations were conducted. Autocorrelation explains how much of a value, in this study asset returns, in time period t is correlated with the value in time period t-1. By doing this test we can see which assets that seem to have a repeated pattern in their returns, meaning that the returns to a large extent depend on their previous performance, and which assets that have a random return pattern. G. William Schwert explains that assets with high autocorrelation of nominal returns do not follow a so called "random walk" as assets with lower autocorrelation do (Schwert, 1996). High autocorrelation assets' returns are therefore more predictable from one time period to another. In their article, Fama and Schwert (1977) show that inflation has a relatively high autocorrelation which should indicate that the inflation rate is quite predictable for a certain future period as well. Hence, if we can predict what the nominal return of an asset will be, and at the same time could predict the future inflation rate, it should be possible to calculate how to use this asset as a hedge against inflation.

We chose to make autocorrelation tests for twelve lags which means looking at the returns for the previous twelve months. In the first test we used the nominal returns of the assets, while in the second test we used the real returns.

We first tested for autocorrelation in the nominal returns of the assets. Thereafter we conducted the same test on the real returns. By doing these two tests we could compare the results and see if the autocorrelation for an asset was different depending on if inflation was taken into account or not.

4.2.3 Time series regression analysis

According to Irving Fisher's findings, known as the Fisher Hypothesis, the expected real interest rate is equal to the nominal interest rate minus the expected inflation rate. The Fisher Equation is usually expressed as $r = i - \pi$, where r is the real interest rate, i is the nominal interest rate and π is the inflation rate (Goolsbee et al., 2013).

Fama and Schwert (1977) noted that an extension of Irving Fisher's equation could be made since the original equation regarding interest rates can be applied to asset returns. They concluded that the nominal returns contain market assessments of the expected inflation rates. By decomposing the inflation rate into two parts, an expected inflation and an unexpected inflation rate, the new equation can be written as:

$$E(\tilde{N}_{jt} | \Phi_{t-1}, A_t) = \mathrm{E}(\mathrm{i}_{jt} | \Phi_{t-1}) + E(\tilde{A}_t | \Phi_{t-1}) + \gamma_j [\mathrm{A}_t - E(\tilde{A}_t | \Phi_{t-1})] \text{ , (*)}$$

where $E(\tilde{N}_{jt} | \Phi_{t-1}, A_t)$ represents the expected nominal return on asset j from time t-1 to t, given the information Φ_{t-1} at the previous period and the inflation rate A_t. The right hand side of the equation contains:

(i) The $\mathrm{E}\ (\mathrm{i}_{jt} | \Phi_{t-1})$ is the expected real return i of asset j from time t-1 to t, given the information that is available the previous period Φ_{t-1}.

(ii) The $E(\tilde{A}_t | \Phi_{t-1})$ is the expected inflation rate $\tilde{A}_t$, given the available information Φ_{t-1} at time t-1.

(iii) The $\mathrm{A}_t - E\ (\tilde{A}_t | \Phi_{t-1})$ is the difference between the actual inflation rate A_t and the expected component of the inflation rate, which represents the unexpected component of inflation rate from t-1 and t.

Building on the equation (*) developed by Fama and Schwert (1977), the regression model that can be used to identify assets as potential hedges against inflation rate is:

$$\tilde{N}_{jt} = \alpha_j + \beta_j E(\tilde{A}_t | \Phi_{t-1}) + \gamma_j [A_t - E(\tilde{A}_t|\Phi_{t-1})] + \tilde{o}_{jt} \ , (**)$$

where the $\tilde{N}_{jt}$ represents the nominal return of asset j from time t-1 to time t. The right hand side of the regression model contains: the intercept α_j for asset j, the expected and unexpected components of inflation rate described above, and the error term $\tilde{o}_{jt}$ of asset j.

Using the regression model (**), we conclude that an asset j is a complete hedge against the expected inflation rate if the coefficient β_j is shown to be not distinguishable from one. Since in that case, it implies that the expected nominal return on asset j varies in the proportion of 1:1 with the expected inflation rate. It also implies that the expected real return on asset j is uncorrelated with the expected inflation rate.

If the coefficient γ_j is equal to one, we conclude that the asset j is a complete hedge against the unexpected inflation rate. This is the case since it means that the nominal return of asset j varies in the proportion of 1:1 with the unexpected inflation rate.

We argue that an asset j is a complete hedge against both expected and unexpected inflation if both the coefficients β_j and γ_j are equal to one. Since then we know that the nominal return of asset j varies 1:1 with both the components of the inflation rate. This model developed by Fama and Schwert in 1977 is used in this paper in order to identify if assets based on Swedish market data can be used to hedge against Swedish inflation rate. In the regression analysis, heteroscedasticity was taken into account by using the robust option in STATA, which adjusts the standard errors for heteroscedasticity.

The regression described above is first run on monthly data, which is the main test of this study. It is believed that the results will be more accurate the shorter time period there is between t and t-1. This assumption is based on the fact that shorter time periods should result in smaller standard errors since there will be less significant changes in the returns between each data point. However, if the Fisher Hypothesis is correct, an asset that is a good hedge against inflation on monthly basis should be a good inflation hedge in any given time period. Thus, we have chosen to examine quarterly and semiannually data as well to test our results accuracy over different time periods.

4.2.4 *Robustness test*

In this study there are some factors that could affect the robustness of the results. To account for this, we conducted some different robustness checks that should indicate if any of our findings would be unreasonable. The regressions against expected and unexpected inflation are the main test in this study. Thus, the measurements of these components are crucial for our results and therefore important to test for robustness.

Both actual inflation and expected inflation can be measured in a number of different ways. For our robustness checks CPIX and CPIF are used instead of CPI as proxies for the actual inflation rate. By using these two indexes we will get inflation rates that could be seen as more correct in some respects since they account for temporal events and changes in lending rates and taxes. If the regression results when using CPIX and CPIF turn out to be similar to the ones received in the main tests, we can assume that the regression model used is in fact robust.

To test the robustness of the expected inflation rate, we decided to incorporate the robustness test of the expected inflation rate in the main test. Since the data of expected inflation is not directly measurable, we perform two separate tests Test SP and Test TP, based on different assumptions and methods.

Another part of the robustness check that we chose to include in the regressions is to take the factor time frame into account. By using monthly, quarterly and semiannual data in the regressions, we expect to draw more precise conclusions.

5. Results

5.1 Descriptive results

Table 1 to Table 4 in Appendix A show summary statistics for the different assets and components of inflation. Comparing these statistics provides an overview of how the Swedish bill-, bond-, stock- and real estate markets have performed over the sample period. Evident is that the stock market in general has performed well, generating positive real returns. As we can see, the inflation has been low during our sample period and actually lower than the Riksbank's inflation target of two percent. These statistics indicates that inflation would not have been a major concern for Swedish investors over this specific period, even though it could have been for a certain shorter period during our sample. On the other hand, some investors might also have been worrying about a possible deflation.

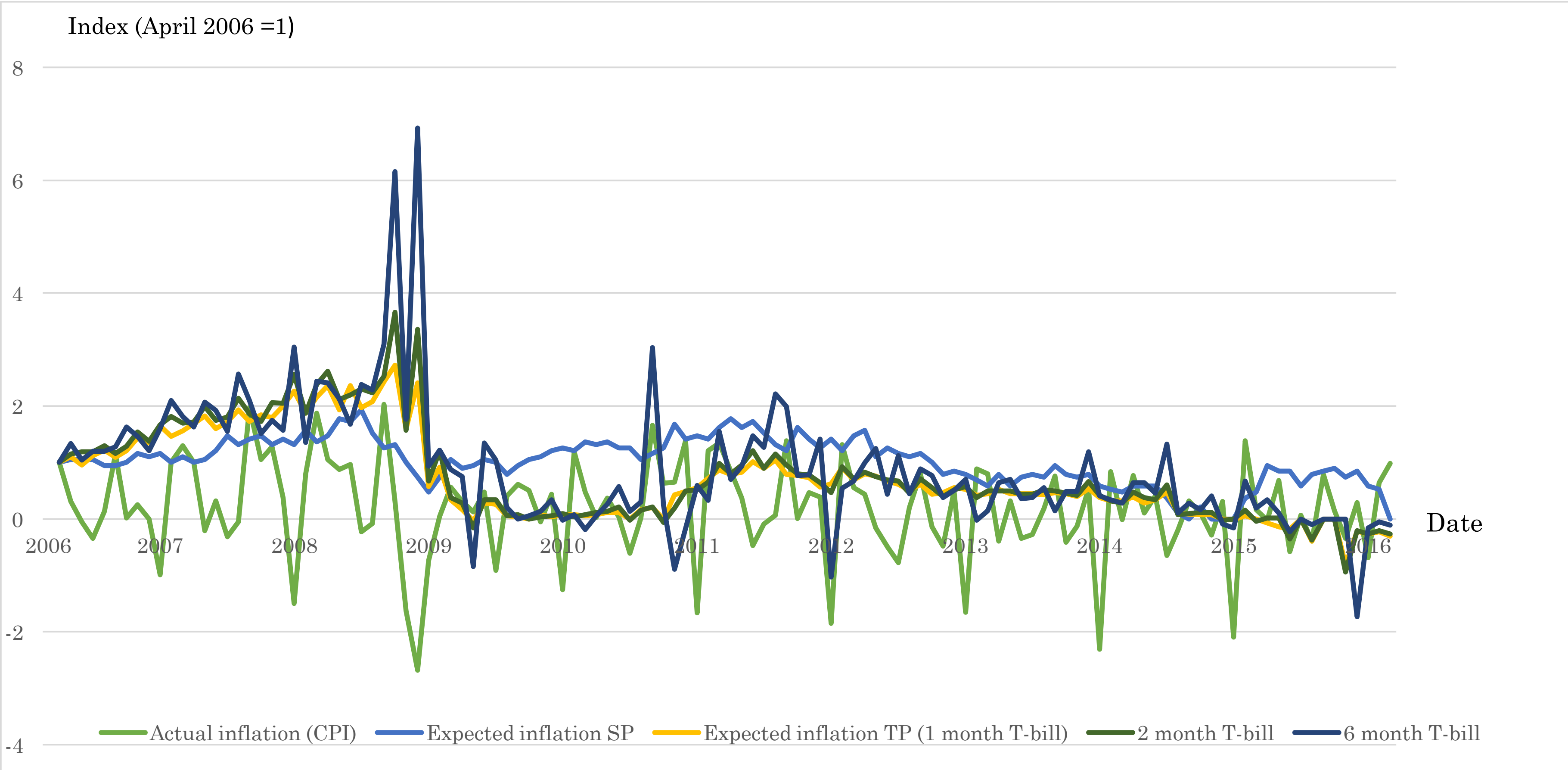
Graph 3 shows the performance of treasury bills in comparison to the inflation rates. We can see that that the three different types of bills seem to move relatively synchronized. Even though the bills follow the expected inflation SP quite well, they are not in line with the actual inflation. All in all, this could indicate that treasury bills can be good hedges against expected inflation but not for unexpected inflation.

In Graph 4 we see how government bonds perform in comparison to the inflation rates. Like the treasury bills, all three bonds move very synchronized with each other, even though they get more volatile with longer time to maturity. Since no clear patterns are shown in relation to the inflation rates, none of the three different types of bond seems to perform well as a hedge against inflation. These bonds move in the opposite direction of inflation, but not in a one-to-one ratio, which would make them a complete hedge.

Graph 5 portrays how stocks in general perform against inflation. It is evident that stocks move in a much more volatile pattern than both the expected inflation rates, it but seem to be more similar to the movements of the actual inflation. At some points the stocks benchmark and the actual inflation are very well matched while in other points there are the complete opposites of each other. These movements could denote that the inflation sometimes affects the performance of stocks but that there are other factors that cancel out the effect of inflation in other points in time.

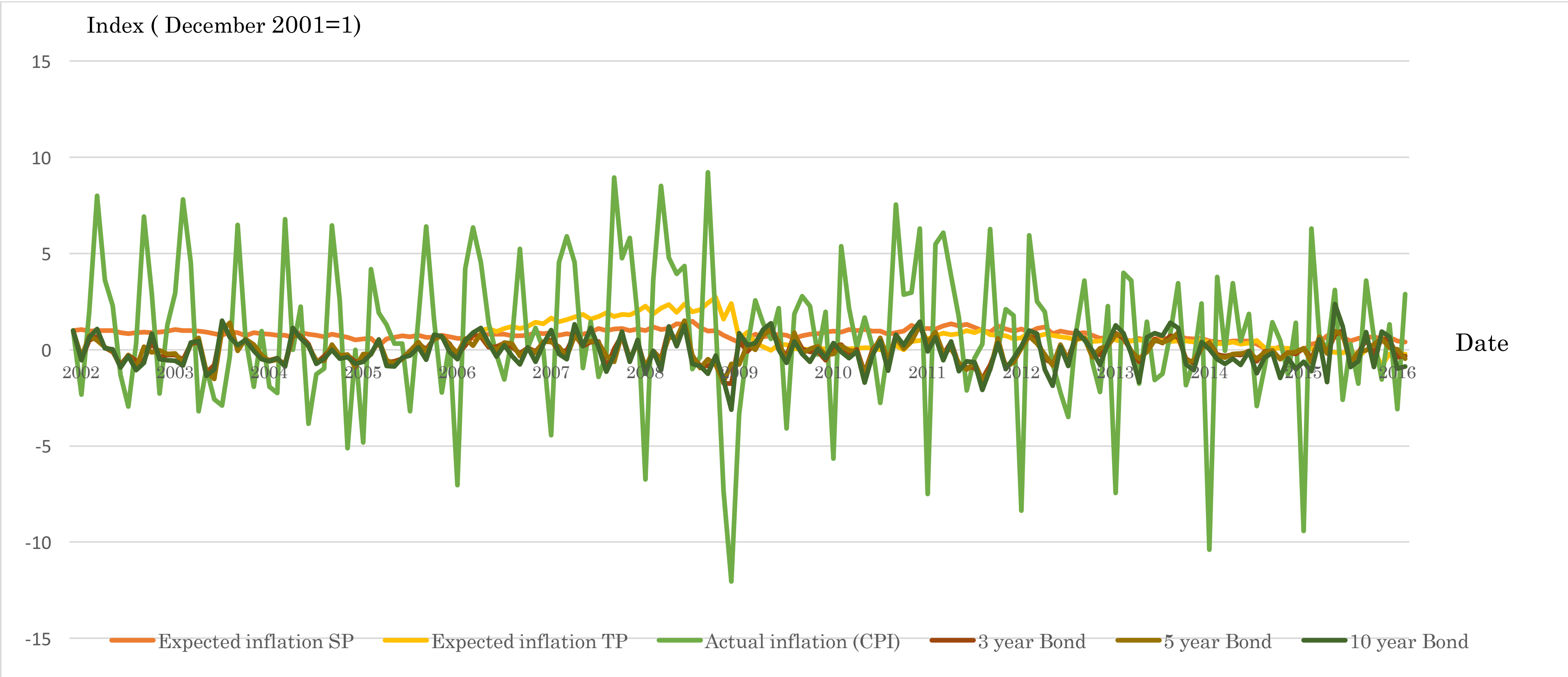
In Graph 6 the performance of real estate investments is shown in comparison to the inflation rates. It seems like real estate moves in the opposite direction with the actual inflation but follows the expected inflation SP a little bit better. However, it does seem like the performance of real estate is connected to the inflation rates to any large extent and this suggests that real estate would not perform well as an inflation hedge.

Graph 3
Normalized nominal returns of Treasury Bills and Inflation rates



In graph 3 the normalized nominal returns of Swedish 2 month- and 6 month treasury bills are shown. Normalized nominal returns make, per definition, the first observation in the time series equal to one (April 2006 = 1). These returns are plotted against the actual inflation, measured as the annual change in CPI, and expected inflation. The expected inflation named SP is based on a monthly survey conducted the National Institute of Economic Research. The expected inflation named TP is based on the return of one-month treasury bills as a proxy for the expected inflation.

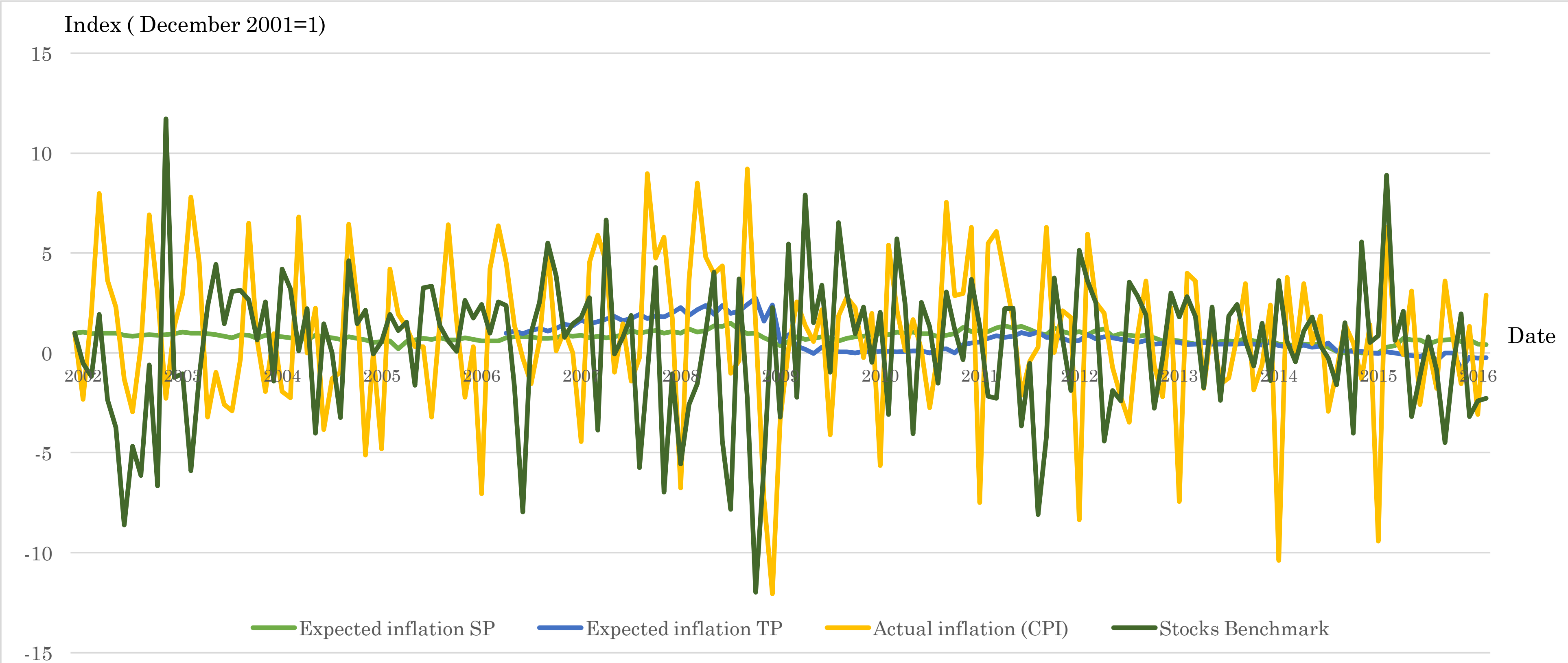
Graph 4
Normalized nominal returns of Government Bonds and Inflation rates



In graph 4 the normalized nominal returns of Swedish 3,- 5- and 10 year government bonds are shown. Normalized nominal returns make, per definition, the first observation in the time series equal to one (April 2006 = 1). These returns are plotted against the actual inflation, measured as the annual change in CPI, and expected inflation. The expected inflation named SP is based on a monthly survey conducted the National Institute of Economic Research. The expected inflation named TP is based on the return of one-month treasury bills as a proxy for the expected inflation

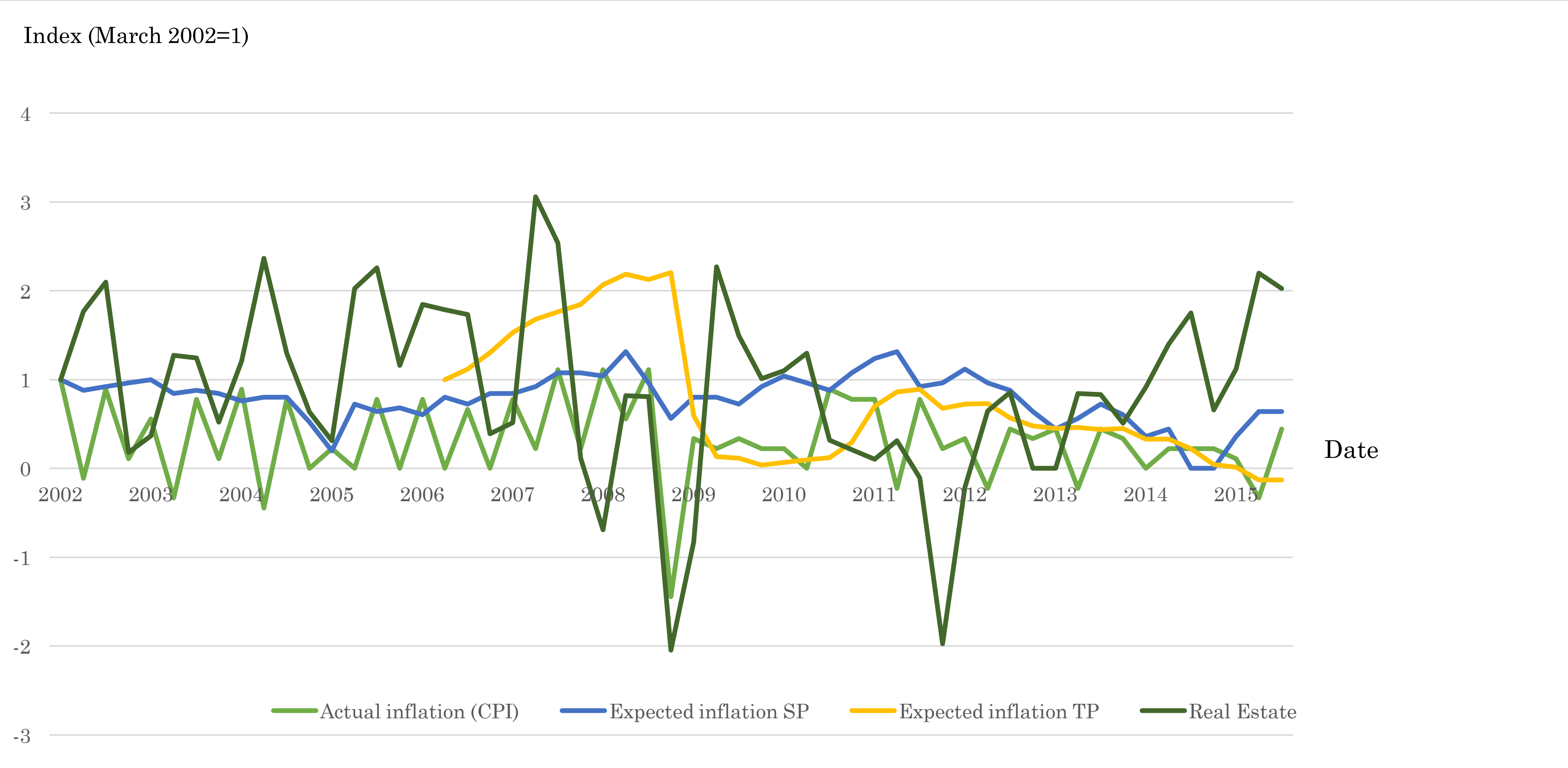
Graph 5

Normalized nominal returns of Stocks Benchmark and Inflation rates



In graph 5 the normalized nominal returns of the Swedish stocks benchmark are shown. Normalized nominal returns make, per definition, the first observation in the time series equal to one (April 2006 = 1). These returns are plotted against the actual inflation, measured as the annual change in CPI, and expected inflation. The expected inflation named SP is based on a monthly survey conducted the National Institute of Economic Research. The expected inflation named TP is based on the return of one-month treasury bills as a proxy for the expected inflation.

Graph 6
Normalized nominal returns of Real Estate and Inflation rates

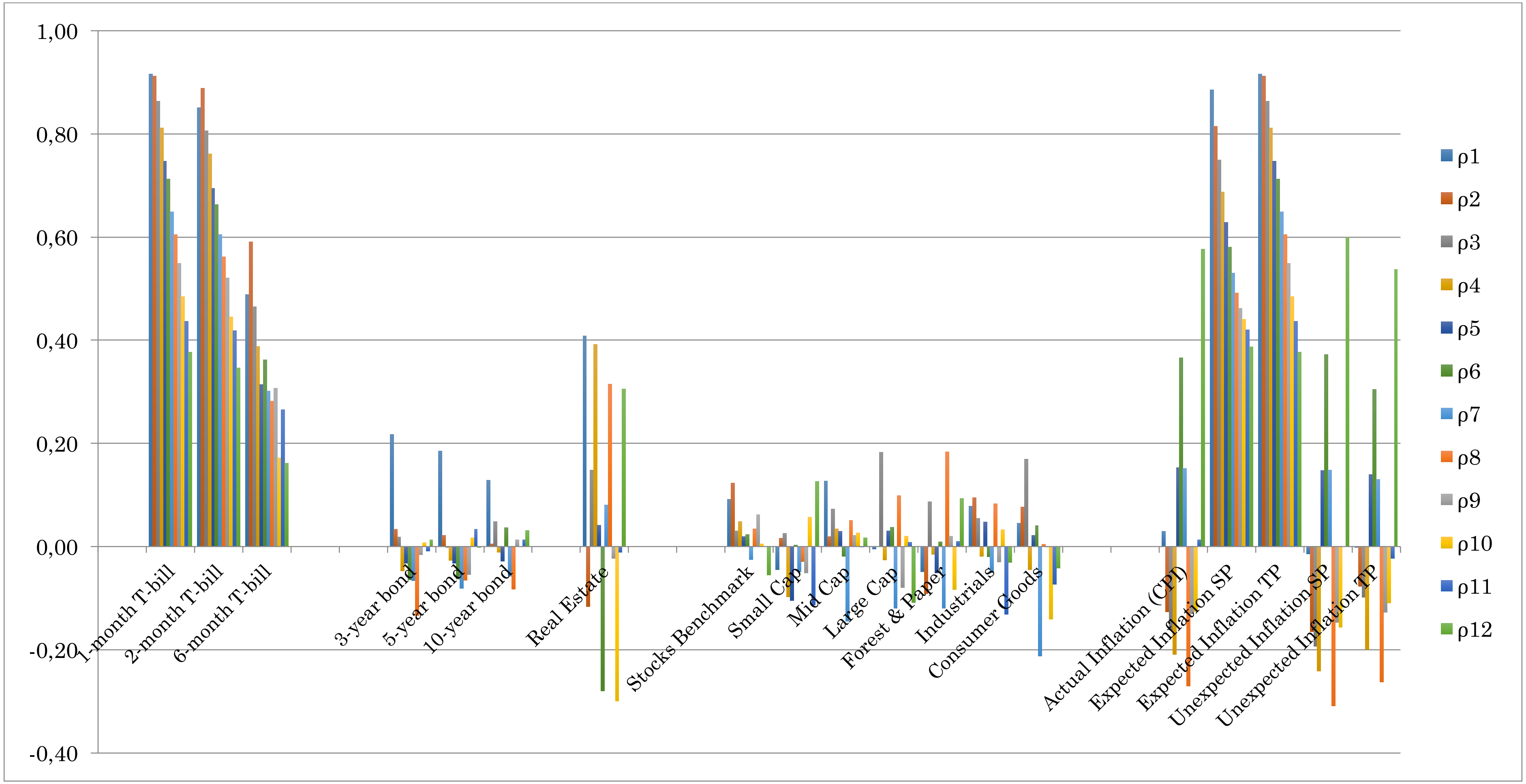


In graph 6 the normalized nominal returns of Swedish real estate are shown. Normalized nominal returns make, per definition, the first observation in the time series equal to one (April 2006 = 1). These returns are plotted against the actual inflation, measured as the annual change in CPI, and expected inflation. The expected inflation named SP is based on a monthly survey conducted the National Institute of Economic Research. The expected inflation named TP is based on the return of one-month treasury bills as a proxy for the expected inflation.

5.2 Autocorrelations

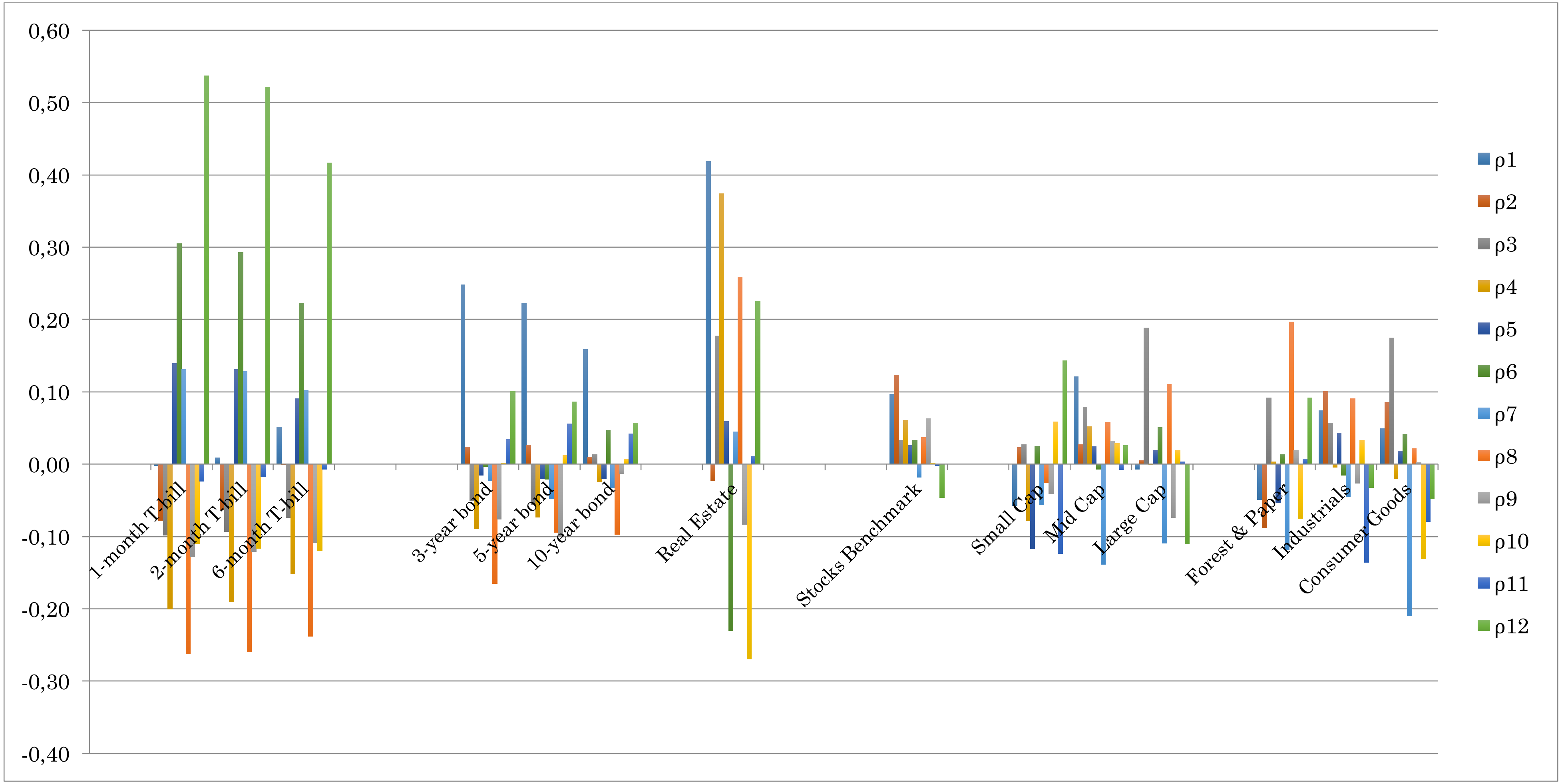
Graph 7 and Table 5 shows the autocorrelations for the inflation rates and the nominal returns on the different assets, while Graph 8 and table 6 displays the autocorrelations for the real returns. Focusing on Graph 7, we can see that the autocorrelations for the nominal returns are high for the all three treasury bills, regardless the lags. For all the other assets and inflation components, except for the expected inflation, the autocorrelations are close to zero. The results of autocorrelations of the real returns in Graph 8 are different in the way that all the assets have autocorrelations close to zero. Comparing the two tables, we can conclude that the results seem to differ depending on the type of asset for the nominal returns, while the results are similar for all the assets regarding the autocorrelations on the real returns. The actual inflation, which represents the difference between the two tables, had a significant impact on the autocorrelation results of treasury bills, which also had the lowest standard deviations of the nominal returns. Since the treasury bills and the expected inflation had relatively similar patterns in autocorrelation of the nominal returns, and this similarity continues to show up for the autocorrelations of the real returns, this indicates that bills might be good hedges against inflation rates.

Graph 7
Autocorrelations for nominal returns, 12 lags



Graph 7 displays monthly autocorrelations for the assets nominal returns. The graph shows the autocorrelations for every asset tested in this study except from real estate (no monthly data was available for real estate). Monthly autocorrelations for the actual inflation and the two different sorts of expected and unexpected inflation are also shown. The expected inflation named SP is based on a monthly survey conducted the National Institute of Economic Research. The expected inflation named TP is based on the return of one-month treasury bills as a proxy for the expected inflation.

Graph 8
Autocorrelations for real returns, 12 lags



Graph 8 displays monthly autocorrelations for the assets real returns. The graph shows the autocorrelations for every asset tested in this study except from real estate (no monthly data was available for real estate).

Table 5

Autocorrelations of nominal returns

Variable	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	ρ_7	ρ_8	ρ_9	ρ_{10}	ρ_{11}	ρ_{12}	Mean	StDv
Treasury bills														
1 month T-bill	0.92	0.91	0.86	0.81	0,75	0.71	0.65	0.60	0.55	0.48	0.44	0.38	0.0011	0.0012
2 month T-bill	0.85	0.89	0.81	0.76	0,69	0.66	0.60	0.56	0.52	0.45	0.42	0.35	0.0012	0.0013
6 month T-bill	0.49	0.59	0.46	0.39	0,31	0.36	0.30	0.28	0.31	0.17	0.27	0.16	0.0014	0.0017
Government Bonds														
3 year Bond	0.22	0.03	0.02	-0.05	-0,03	-0.06	-0.07	-0.13	-0.02	0.01	-0.01	0.01	0.0006	0.0097
5 year Bond	0.19	0.02	0.00	-0.03	-0,03	-0.06	-0.08	-0.07	-0.05	0.02	0.03	0.00	0.0006	0.0100
10 year Bond	0.13	0.01	0.05	-0.01	-0,03	0.04	-0.06	-0.08	0.01	0.00	0.01	0.03	0.0026	0.0172
Real Estate	0.41	-0.12	0.15	0.39	0,04	-0.28	0.08	0.31	-0.02	-0.30	-0.01	0.31	0.0159	0.0176
Stocks														
Stocks Benchmark	0.09	0.12	0.03	0.05	0,02	0.02	-0.03	0.03	0.06	0.01	0.00	-0.06	0.0077	0.0601
Small Cap	-0.05	0.02	0.03	-0.10	-0,10	0.00	-0.05	-0.03	-0.05	0.06	-0.11	0.13	0.0142	0.0549
Mid Cap	0.13	0.02	0.07	0.03	0,03	-0.02	-0.14	0.05	0.02	0.03	0.00	0.02	0.0132	0.0553
Large Cap	0.00	0.00	0.18	-0.03	0,03	0.04	-0.12	0.10	-0.08	0.02	0.01	-0.11	0.0042	0.0565
Industrials	0.08	0.1	0.06	-0.02	0,05	-0.02	-0.05	0.08	-0.03	0.03	-0.13	-0.03	0.0083	0.0630
Forest & Paper	-0.05	-0.09	0.09	-0.02	-0,05	0.01	-0.12	0.18	0.02	-0.08	0.01	0.09	0.0027	0.0649
Consumer Goods	0.05	0.08	0.17	-0.05	0,02	0.04	-0.21	0.01	0	-0.14	-0.07	-0.04	0.0074	0.0522
Inflation														
Actual Inflation (CPI)	0.03	-0.13	-0.16	-0,21	0.15	0.37	0,15	-0.27	-0.13	-0.13	0.01	0.58	0.0009	0.0042
Expected Inflation SP	0.88	0.81	0.75	0,69	0.63	0.58	0,53	0.49	0.46	0.44	0.42	0.39	0.0016	0.0006
Expected Inflation TP	0.92	0.91	0.86	0,81	0.75	0.71	0,65	0.60	0.55	0.48	0.44	0.38	0.0011	0.0012
Unexpected Inflation SP	-0.01	-0.17	-0.19	-0,24	0.15	0.37	0,15	-0.31	-0.15	-0.16	0.00	0.60	-0.0007	0.0041
Unexpected Inflation TP	0.00	-0.08	-0.10	-0,20	0.14	0.31	0,13	-0.26	-0.13	-0.11	-0.02	0.54	-0.0002	0.0043

Table 5 displays monthly autocorrelations for the assets nominal returns. The table shows the autocorrelations for every asset tested in this study except from real estate (no monthly data was available for real estate). Monthly autocorrelations for the actual inflation and the two different sorts of expected and unexpected inflation are also shown. The expected inflation named SP is based on a monthly survey conducted the National Institute of Economic Research. The expected inflation named TP is based on the return of one-month treasury bills as a proxy for the expected inflation.

Table 6
Autocorrelations of real returns

Variable	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	ρ_7	ρ_8	ρ_9	ρ_{10}	ρ_{11}	ρ_{12}	Mean	StDv
Treasury bills														
1 month T-bill	0.00	-0.08	-0.10	-0.20	0.14	0.31	0.13	-0.26	-0.13	-0.11	-0.02	0.54	0.0002	0.0043
2 month T-bill	0.01	-0.06	-0.09	-0.19	0.13	0.29	0.13	-0.26	-0.12	-0.12	-0.02	0.52	0.0002	0.0044
6 month T-bill	0.05	0.00	-0.07	-0.15	0.09	0.22	0.10	-0.24	-0.11	-0.12	-0.01	0.42	0.0005	0.0046
Government Bonds														
3 year Bond	0.25	0.02	-0.05	-0.09	-0.02	0.00	-0.02	-0.17	-0.08	0.00	0.03	0.10	-0.0003	0.0111
5 year Bond	0.22	0.03	-0.06	-0.07	-0.02	-0.02	-0.05	-0.09	-0.10	0.01	0.06	0.09	-0.0003	0.0113
10 year Bond	0.16	0.01	0.01	-0.02	-0.02	0.05	-0.03	-0.10	-0.01	0.01	0.04	0.06	0.0017	0.0184
Real Estate	0.42	-0.02	0.18	0.37	0.06	-0.23	0.05	0.26	-0.08	-0.27	0.01	0.22	0.0132	0.0175
Stocks														
Stocks Benchmark	0.10	0.12	0.03	0.06	0.03	0.03	-0.02	0.04	0.06	0.00	0.00	-0.05	0.0068	0.0605
Small Cap	-0.06	0.02	0.03	-0.08	-0.12	0.03	-0.06	-0.03	-0.04	0.06	-0.12	0.14	0.0136	0.0553
Mid Cap	0.12	0.03	0.08	0.05	0.02	-0.01	-0.14	0.06	0.03	0.03	-0.01	0.03	0.0123	0.0557
Large Cap	-0.01	0.01	0.19	0.00	0.02	0.05	-0.11	0.11	-0.07	0.02	0.00	-0.11	0.0033	0.0567
Industrials	0.07	0.10	0.06	0.00	0.04	-0.02	-0.05	0.09	-0.03	0.03	-0.14	-0.03	0.0074	0.0633
Forest & Paper	-0.05	-0.09	0.09	0.00	-0.05	0.01	-0.12	0.20	0.02	-0.08	0.01	0.09	0.0017	0.0651
Consumer Goods	0.05	0.09	0.17	-0.02	0.02	0.04	-0.21	0.02	0.00	-0.13	-0.08	-0.05	0.0065	0.0523

Table 6 displays monthly autocorrelations for the assets real returns. The table show the autocorrelations for every asset tested in this study except from real estate (no monthly data was available for real estate).

5.3 Regression results

4.3.1 Monthly data: Test SP

As shown in Table 7, all three types of treasury bills have estimates of betas that are close to one, where the one-month bill is the closest. This is an expected result, knowing that the returns of treasury bills are fairly predictable and closely linked to other market rates which are set to match the rate of inflation in Sweden (The Riksbank, 2015). These results are similar to the ones of Fama and Schwert (1977). Since the estimates of betas of these three assets are close to one, and all of them are statistically significant at one percent level, we can conclude that treasury bills are almost complete hedges against expected inflation. None of the treasury bill estimates of gammas are significant and they are all close to zero. Even though they all have high standard errors in comparison with the value of the gamma, it still indicates that the gammas will in most cases be close to zero. This shows that treasury bills are almost not affected at all by the unexpected inflation and they are therefore not good hedges against the unexpected inflation rate.

Unfortunately, none of the treasury bond estimates of betas turned out to be significant. Because of this, we cannot make any conclusions about the hedging possibilities of bonds regarding expected inflation. On the other hand, the estimated gammas are significant on at least a 90 percent significance level for all bonds and at a 95 percent significance level for three-year bonds. We can with certainty conclude that all bonds have negative gammas. These estimated gammas would most likely be in the range between zero and minus one which means that they can be used as a hedge against unexpected inflation, however not close to a complete hedge.

The regression results for the stocks benchmark, the three different industry sectors and the three market capitalization segments have relatively significant estimates of betas. The values of these estimates are much lower than the the ones of the treasury bills but this is an expected result since we have seen from the descriptive statistics that stocks have performed very well in a time period of low inflation. Other studies, such as the one conducted by Fama and Schwert (1977), have also found that stocks usually have highly negative estimates of betas. We can assume that neither stocks in general or stocks in any of these specific sectors are good hedges against the expected inflation rate. Neither does the market capitalization have outstanding effect on the hedging possibilities of the stock. The stocks estimates of gammas did not turn out to be significant which means that we cannot determine if their hedging possibilities for the unexpected inflation rate.

Table 7

Regression results for Test SP using monthly nominal returns of asset j and CPI

Hedges against expected and unexpected inflation rates,

$$\tilde{N}_{jt} = \boldsymbol{\alpha_j} + \boldsymbol{\beta_j E}\left(\tilde{A}_t \middle| \boldsymbol{\Phi_{t-1}}\right) + \boldsymbol{\gamma_j}\left[\boldsymbol{A_t} - \boldsymbol{E}\left(\tilde{A}_t \middle| \boldsymbol{\Phi_{t-1}}\right)\right] + \tilde{o}_{jt} \,,$$

Asset	Constant $\boldsymbol{\alpha_j}$	Expected $\boldsymbol{\beta_j}$	Unexpected_$\boldsymbol{\gamma_j}$	R-squared	N
1 month T-bill	-0.000371**	0.944***	0.00138	0.266	120
	(0.000161)	(0.116)	(0.0312)		
2 month T-bill	-0.000312*	0.917***	-0.00424	0.228	120
	(0.000170)	(0.122)	(0.0368)		
6 month T-bill	7.30e-05	0.807***	-0.0213	0.095	120
	(0.000251)	(0.172)	(0.0708)		
3 year Bond	-0.000146	0.0189	-0.447**	0.040	171
	(0.00175)	(1.112)	(0.211)		
5 year Bond	0.000490	-0.324	-0.325*	0.020	171
	(0.00183)	(1.171)	(0.187)		
10 year Bond	0.00474	-1.928	-0.743*	0.039	171
	(0.00352)	(2.005)	(0.386)		
Stocks Benchmark	0.0317***	-16.70**	-0.166	0.029	171
	(0.0121)	(7.549)	(1.025)		
Small Cap	0.0297*	-11.28	-0.635	0.021	80
	(0.0174)	(10.22)	(1.766)		
Mid Cap	0.0482***	-22.46**	-0.259	0.056	157
	(0.0142)	(8.695)	(1.193)		
Large Cap	0.0303**	-16.24*	0.304	0.036	112
	(0.0152)	(9.256)	(1.252)		
Industrials	0.0378**	-18.46*	-0.127	0.028	171
	(0.0158)	(9.709)	(1.343)		
Forestry & Paper	0.0363**	-20.70**	0.557	0.033	171
	(0.0167)	(9.918)	(1.324)		
Consumer Goods	0.0390***	-19.41**	0.750	0.046	171
	(0.0132)	(7.740)	(0.942)		

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 7 displays the regression results using monthly data. For this test the survey method has been used to determine the expected inflation.

5.3.2 Quarterly data: Test SP

Table 8 shows the regression results for Test SP using quarterly data. All the three estimates of the treasury bill betas are statistically significant at one percent or five percent level. We see that the betas are slightly smaller than the corresponding monthly betas but still relatively close to one. These results further strengthen the belief that treasury bills can work as good hedges against expected inflation. When looking at the estimates of gammas we can no longer say with certainty that they will be approximately zero. The values of the gamma are still close to zero but the standard errors are larger than they were in the monthly results. A probable reason for this is that the number of observations are reduced to one fourth of the monthly data.

The treasury bond estimates of betas are, not surprisingly, still not significant and we can therefore not say if the results indicate a good hedging possibility or not. The significance level for the estimated gammas has also decreased, which once again is most likely caused by a reduction in the number of observations. For the three- and five year bonds the gammas are relatively close to minus one but due to the high standard errors we cannot conclude that they would be good hedges against unexpected inflation.

Real estate does not have a very significant estimate of the beta. Considering a negative beta of minus 1.95 with a standard error of 1.13 this means that the beta could be close to minus one, but no significant conclusions can be drawn. What is striking with the regression results for real estate is that the estimated gamma is almost identical to one which should mean that real estate provides a complete hedge against unexpected inflation. Unfortunately, the standard error is so high that no such conclusion can be made.

Similar to the other assets, the significance level for the stock estimates of betas has also been lowered when having quarterly data. We would however still argue that none of the different stocks segments that we have examined could be a good hedge against expected inflation due to the persistent extreme betas that they show. For the unexpected inflation it is more difficult to draw any conclusions. All of the stock gammas have the possibility to be close to one or minus one, which could mean that they may be used to hedge against unexpected inflation.

Overall, reducing the number of observations has notably lowered the significance level of the regression results. This has led to a difficulty to draw any definite conclusions but we can see that the estimates of betas and gammas in general are similar to the ones we received from the monthly data.

Table 8

Regression results for Test SP using quarterly nominal returns of asset j and CPI

Hedges against expected and unexpected inflation rates,

$$\text{Ñ}_{jt} = \boldsymbol{\alpha_j} + \boldsymbol{\beta_j} \boldsymbol{E}(\text{Ã}_t | \boldsymbol{\Phi_{t-1}}) + \boldsymbol{\gamma_j}[\boldsymbol{A_t} - \boldsymbol{E}(\text{Ã}_t | \boldsymbol{\Phi_{t-1}})] + \text{õ}_{jt} \,,$$

Asset	Constant $\boldsymbol{\alpha_j}$	Expected $\boldsymbol{\beta_j}$	Unexpected_$\boldsymbol{\gamma_j}$	R-squared	N
1 month T-bill	-0.00049	0.817***	-0.0156	0.184	39
	(0.000941)	(0.204)	(0.198)		
2 month T-bill	-0.00047	0.803***	-0.0635	0.159	39
	(0.000992)	(0.213)	(0.221)		
6 month T-bill	9.72e-05	0.733**	-0.268	0.133	39
	(0.00142)	(0.288)	(0.328)		
3 year Bond	0.00218	-0.798	-1.257*	0.101	57
	(0.00579)	(1.253)	(0.716)		
5 year Bond	0.00102	-0.582	-1.274**	0.099	57
	(0.00604)	(1.312)	(0.582)		
10 year Bond	0.0206*	-3.558	-1.729	0.106	57
	(0.0118)	(2.307)	(1.107)		
Real Estate	0.0275***	-1.951*	0.997	0.092	56
	(0.00581)	(1.130)	(0.643)		
Stocks					
Benchmark	0.0630**	-9.549	0.188	0.024	57
	(0.0288)	(5.908)	(4.740)		
Small Cap	0.0585	-3.704	-0.217	0.006	27
	(0.0385)	(8.739)	(6.549)		
Mid Cap	0.113***	-13.21	3.153	0.057	52
	(0.0408)	(8.191)	(5.558)		
Large Cap	0.0538	-7.329	3.088	0.036	37
	(0.0367)	(7.253)	(4.743)		
Industrials	0.0755*	-10.32	0.551	0.022	56
	(0.0412)	(8.484)	(5.684)		
Forestry & Paper	0.0823**	-14.92**	2.068	0.054	56
	(0.0393)	(7.270)	(3.322)		
Consumer Goods	0.0782**	-12.34*	0.308	0.047	56
	(0.0321)	(6.409)	(3.979)		

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 8 displays the regression results using quarterly data. For this test the survey method has been used to determine the expected inflation.

5.3.3. Semiannually data: Test SP

For the semiannual regressions in Table 11 found in Appendix A, even fewer observations can be made. Due to the reduction of data points the results found in these analyses are less significant than what they were with monthly and quarterly data. In general, the estimates of betas and gammas for the semiannual data follow the same pattern as they did for monthly and quarterly but the standard errors are overall higher in comparison to the values of the betas and gammas.

5.3.4 Monthly data: Test TP

Table 9 shows the regression results using monthly data for Test TP. Using the one-month bill rate as an approximation for the expected inflation has naturally given us a result showing that the one-month bill should be a complete hedge against the expected inflation. The one-month bill is therefore not included in the results. The two-months and six-months bills also have estimates betas very close to one, which was an expected result knowing that all the three types of bills have moved synchronized over the last 15 years. From this result, we argue that treasury bills are almost complete hedges against inflation, which was the same conclusion drawn from the Test SP. We must however take into consideration that due to how the Test TP is constructed, this test could be slightly biased regarding the results of the bills. When it comes to the unexpected rate of inflation, none of the estimates of gammas are significant. Similar to the Test SP, we can conclude that the gammas will be close to zero and that treasury bills therefore cannot be used to hedge against unexpected inflation.

In general, we observe that the estimates of betas for all types of sectors of stocks are less negative when using the treasury bill approximation in Test TP. These betas do have smaller standard errors than their equivalents in the Test SP. Even though the stocks' results in the two different tests may seem quite different in absolute terms, they do both prove that stocks cannot be used as a hedge against the expected inflation rate.

Table 9

Regression results for Test TP using monthly nominal returns of asset j and CPI

Hedges against expected and unexpected inflation rates,

$$\tilde{N}_{jt} = \boldsymbol{\alpha_j} + \boldsymbol{\beta_j E}\left(\tilde{A}_t \mid \boldsymbol{\Phi_{t-1}}\right) + \boldsymbol{\gamma_j}\left[\boldsymbol{A_t} - \boldsymbol{E}(\tilde{A}_t \mid \boldsymbol{\Phi_{t-1}})\right] + \tilde{o}_{jt} ,$$

Asset	Constant $\boldsymbol{\alpha_j}$	Expected $\boldsymbol{\beta_j}$	Unexpected_$\boldsymbol{\gamma_j}$	R-squared	N
2 month T-bill	-1.65e-05	1.031***	-0.00742	0.977	120
	(2.14e-05)	(0.0261)	(0.00764)		
6 month T-bill	8.89e-05	1.128***	-0.0309	0.641	120
	(0.000126)	(0.120)	(0.0472)		
3 year bond	-0.00119	0.930	-0.528**	0.082	120
	(0.00107)	(0.831)	(0.243)		
5 year bond	-0.00093	0.695	-0.393*	0.045	120
	(0.00109)	(0.792)	(0.220)		
10 year bond	0.00099	0.873	-0.930*	0.057	120
	(0.00229)	(1.496)	(0.472)		
Stocks Benchmark	0.0177***	-11.57**	0.675	0.067	120
	(0.00648)	(5.127)	(1.225)		
Small Cap	0.0240***	-19.73*	-0.576	0.043	81
	(0.00870)	(10.85)	(1.737)		
Mid Cap	0.0272***	-16.46***	0.308	0.113	120
	(0.00723)	(5.070)	(1.240)		
Large Cap	0.0189***	-13.24**	0.224	0.084	113
	(0.00659)	(5.641)	(1.159)		
Industrials	0.0243***	-14.83**	0.959	0.076	120
	(0.00794)	(6.563)	(1.653)		
Forestry & Paper	0.0210**	-15.89**	-0.439	0.071	120
	(0.00955)	(6.823)	(1.554)		
Consumer Goods	0.0232***	-15.07***	0.786	0.112	120
	(0.00682)	(4.858)	(1.070)		

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 9 displays the regression results using monthly data. For this test the one-month treasury bill rate has been used as a proxy for the expected inflation.

5.3.5 Quarterly and semiannually data: Test TP

Focusing on Table 10 and Table 12, we can observe that once again all the bills, both quarterly and semiannually, have estimates of betas close to one which are all significant. Interestingly, all the estimates of gammas for the bills and bonds are significant at the highest one percent level when quarterly data is used. None of the gammas would be a complete hedge against the unexpected inflation rate but both the three- and five-year bond have potential to be used as a hedge against the unexpected inflation rate. However, since this result differs from the monthly findings, the accuracy can be questioned.

Similar to the Test SP, the results for Test TP shows that real estate has an estimate of gamma that is very close to one for the quarterly data. Furthermore, in this test the gamma is significant at the five percent level, which strongly indicates that real estate can be a good hedge against unexpected inflation. For the semiannual data we did not get a significant gamma for real estate and can therefore not comment whether it could work as a hedge or not.

The estimates of betas for stocks are all relatively significant, which was not the case when SP was used. Compared to the monthly stock betas, the quarterly and semiannually betas are relatively similar which indicates that the Fisher hypothesis should be true for our study. On the other hand, the stocks estimates of gammas are not significant at all and hence no conclusions can be made about their hedging possibilities.

Table 10

Regression results for Test TP using quarterly nominal returns of asset j and CPI

Hedges against expected and unexpected inflation rates,

$$\tilde{N}_{jt} = \boldsymbol{\alpha_j} + \boldsymbol{\beta_j} \boldsymbol{E}\left(\tilde{A}_t \mid \boldsymbol{\Phi_{t-1}}\right) + \boldsymbol{\gamma_j}\left[\boldsymbol{A_t} - \boldsymbol{E}(\tilde{A}_t \mid \boldsymbol{\Phi_{t-1}})\right] + \tilde{o}_{jt} ,$$

Asset	Constant $\boldsymbol{\alpha_j}$	Expected $\boldsymbol{\beta_j}$	Unexpected_$\boldsymbol{\gamma_j}$	R-squared	N
2 month T-bill	4.59e-05	0.995***	-0.0467***	0.995	40
	(5.50e-05)	(0.00889)	(0.0150)		
6 month T-bill	0.00073*	0.952***	-0.246***	0.855	40
	(0.000366)	(0.0546)	(0.0905)		
3 year Bond	-0.00147	0.105	-1.747***	0.250	40
	(0.00389)	(1.104)	(0.469)		
5 year Bond	-0.00088	-0.0780	-1.621***	0.217	40
	(0.00383)	(1.075)	(0.393)		
10 year Bond	0.00691	-0.595	-2.885***	0.202	40
	(0.00742)	(1.764)	(0.653)		
Real Estate	0.0164***	-0.685	1.014**	0.158	39
	(0.00325)	(0.856)	(0.435)		
Stocks Benchmark	0.0481**	-9.405**	3.114	0.186	40
	(0.0197)	(4.010)	(2.318)		
Small Cap	0.0673***	-16.36	-0.599	0.077	27
	(0.0228)	(13.21)	(5.201)		
Mid Cap	0.0736***	-13.03***	3.816	0.280	40
	(0.0208)	(3.592)	(2.538)		
Large Cap	0.0491**	-11.01**	2.944	0.254	37
	(0.0202)	(4.077)	(1.957)		
Industrials	0.0655***	-11.90**	3.892	0.204	40
	(0.0241)	(5.062)	(2.807)		
Forestry & Paper	0.0507*	-11.99**	1.707	0.164	40
	(0.0255)	(5.312)	(2.033)		
Consumer Goods	0.0645***	-13.32***	1.451	0.245	40

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 10 displays the regression results using quarterly data. For this test the one-month treasury bill rate has been used as a proxy for the expected inflation.

5.4 Robustness tests

Since we chose to include the factor time periods and expected inflation in our main regression tests presented above, the remaining part of the robustness tests is the test for the data of the actual inflation rate.

CPIX and CPIF: actual inflation

From running the same regressions as we did using CPI, but instead use CPIX and CPIF, we can conclude that the results overall are very similar. This is true for both Test SP and Test TP using monthly data as long as the results are significant, which is not always the case. (See Table 13 to Table 16 in Appendix A). If more data had been available, the standard errors had most certainly been smaller and the significance level would increase. All in all, we argue that the results from using all three indexes for the actual inflation rate prove that the regression model used is robust.

6. Implications and Conclusions

The results from this study have shown that treasury bills work as almost complete hedges against the expected inflation rate and real estate could be complete hedge against the unexpected inflation rate in Sweden, while bonds and stocks did not seem to have good hedging possibilities. In this section we will explain why this is the case and discuss what implications this might have for anyone who wants to hedge against the inflation in the future. We will furthermore problematize the reasoning and introduce some suggestions for future research.

It is important to understand that even if the regression result shows that an asset is a complete hedge against the inflation rate, it does not imply that the inflation explain a large part of the nominal returns of the asset. The purpose of the regression test is not to find factors to explain as much as possible of the nominal returns of the asset, but rather to explore the relationship between the two components of the inflation rate and the assets.

6.1 Implications

6.1.1 Treasury bills

The fact that treasury bills can work as a complete hedge against the expected inflation in Sweden over the last decade was hardly surprising. First of all, other studies including Fama and Schwert (1977), have found that treasury bills are a good hedge against expected inflation so it was predictable that this would be the case in our study. In fact, treasury bills have a built-in protection against expected inflation due to the way in which they are traded. A buyer of a treasury bill knows what return will be received at maturity already before the transaction takes place. (Swedish National Debt Office, 2007). If this return would be lower than the investor's expected inflation rate he or she would most probably choose to not buy the bill in the first place.

Even though treasury bills are good approximations for the expected inflation, using the one-month treasury bill rate and regress it against two- and six-months bills in Test TP might give slightly biased results. We have seen that the different bills in general move synchronized and to regress one type of bill against another will ultimately give regression coefficients close to one. This does not mean that the one-month bill is not a good approximation for the expected inflation or that the other bills would not work as a good hedge against the expected inflation, but one should be aware that the estimates of betas might be overestimated in the Test TP.

For the treasury bills, we see that the returns using the quarterly data can be decomposed into three one-month-returns. Using the same logic, the semiannual returns of the treasury bill can be decomposed into two three month -returns, three two-month returns or six one-month returns. By having the knowledge that the longer term to maturity treasury bills can be decomposed into shorter-term bills, opportunities rises to use rollover strategies in order to hedge against the expected inflation rate. From the monthly regression results for example in Table 7, we conclude that the short-term treasury bills are good hedges against the expected inflation rate, but the studied treasury bills only have short time to maturity and will not provide a good hedge concerning the longer time horizons. Instead of holding a six-month treasury bill, a different option is to use a rollover strategy on the one-month treasury bills. The reason behind this alternative strategy is that the one-month bills include more frequently updated information of the expected inflation, which the longer six-month treasury bill does not take into account. In general terms, this rollover strategy of bills that have short time to maturity can be used to hedge the expected inflation within the time period of holding the asset.

6.1.2 Government bonds

Since the government bond estimates of betas were not significant we can unfortunately not draw any conclusions about their hedging possibilities. We are aware of that other authors such as Fama and Schwert (1977) have found that government bonds are good hedges against expected inflation, which suggest that this could have been the case also in our study if the results were significant. This should however not be taken for granted and we have for example seen in this study that the autocorrelation of bonds does not seem to be notably different in nominal than real terms which indicates less hedging possibilities. Graph 4 also showed that bonds do not seem to move in synchronization with the inflation rate, which suggests that and bonds should not be good inflation hedges.

Why would government bonds not work as good hedges against the expected inflation even though the transaction procedure is in the same way as treasury bills? We argue that one reason ought to be the difficulties in predicting the inflation. Not only for the average citizen, but also for the Riksbank as well. Since bonds have a longer time to maturity than bills, their rate is set much earlier in comparison to the one of bills. Predicting the inflation rate, and hence the future reference rate, is easier to do when the time horizon is short and there is therefore a bigger chance of errors when setting the rate for a bond than for a bill. This means that it takes a long time until the return of government bonds are affected by the changes in the inflation rate.

6.1.3 Stocks

Stocks were the assets that had the most extreme estimates of betas in our study, showing that they are no good hedges against expected inflation. We have seen that the Swedish stock market has performed exceptionally well over the last 15 years while the inflation has been very low or even negative. The betas are negative since people have believed that the inflation will decrease while the stock returns have increased.

One fascinating finding is how well the stock market has performed in an otherwise quite cool Swedish economy. Sweden has had an annual GDP growth rate of 2.4 percent since 1996 which is far less than the annual rate of return of stocks. It looks like investors believe in Swedish companies even though the GDP statistics might speak against it. One should remember that we have only been looking at listed companies which should be financially strong and able to perform reasonably well even in economic turmoil. Had this study included all Swedish companies the result might have been different since smaller owner-managed companies usually are more affected by changes in the macro environment and are more exposed to total business risk (Hutchinson, 1995).

Another reason to why stocks in general perform as they do in relation to the inflation rate could be that they actually are profitmaking companies that are affected by many other things than only the macro environment in general and the inflation rate in particular. This is probably the reason to why the explanatory power is low for stocks.

It is shown that the industry sector or market capitalization of the company do not seem to matter. This might be caused by the stock estimates of betas being extremely high. If the betas had been closer to the ones that Fama and Schwert (1977) found it would perhaps have been more obvious differences between the different kinds of stocks.

Table 17 in Appendix B shows that the inflation risk does not seem to be priced in European stock markets, indicating that investors in general have not worried about the inflation during our sample period. This expected result confirms that inflation is not a major concern for investors and could indicate that the investors are underestimating the inflation risk.

6.1.4 Real estate

Unlike Fama & Schwert (1977), our study did not find that real estate is a complete hedge against both expected and unexpected inflation. We did however receive results that suggested that real estate is close to a complete hedge against the unexpected inflation but this result was only significant for the Test TP. Seeing that real estate should be a good hedge against the unexpected but not the expected inflation is an interesting finding since something that is expected should be easier to hedge against. One reason for this, somewhat peculiar case, might be that residential housing is not traded in the same frequency as other assets. Houses and apartments are in most cases bought for living in and not for purely investment purposes, even though that occurs as well. This suggests that the owners will not sell and buy real estate to hedge their invested money when they believe that the inflation is changing. Instead, an apartment or house is mostly held for a longer time period; in the long run the real value of money should remain the same.

A factor that could be important to consider is the fact that the real estate prices have increased unusually fast during our sample period, which could be the reason to why the asset seems to be a perfect hedge against the unexpected inflation. If the housing prices would have increased in a more normal pace the result might have been different.

6.1.5 Future research topics

As described in the background there is a shortage of housing in Sweden, which has increased the real estate prices drastically. This is a price inflation that is not included in the consumer price indexes and therefore might be forgotten. It could be debated that we in fact are experiencing a high inflation in Sweden right now. Such an inflation is referred to as asset price inflation, which means that the prices of assets like for example real estate are increasing more than consumer prices. For future studies it would be interesting to use an inflation measurement that takes the housing prices into account and see what implications this would have for a country with rapidly growing housing prices.

Furthermore, it could be studied how assets, other than the ones that we have looked at in this paper, could work as inflation hedges on the Swedish market. How would for example options, corporate bonds or gold perform in comparison to the assets in our study?

Even though we did not find that stocks could be good inflation hedges in Sweden some previous literature have suggested that these assets could work as hedges in the long run. Using a longer sample period than the one in this thesis might give different results and could be studied.

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Appendices

Appendix A

Table 1
Monthly nominal returns

Variable	Mean	StDv	Max	Min	N	Skew
Treasury Bills						
1 month T-bill	0.11%	0.12%	0.44%	-0.13%	120	0.79
2 month T-bill	0.12%	0.13%	0.55%	-0.14%	120	1.02
6 month T-bill	0.14%	0.17%	1.06%	-0.26%	120	2.10
Government Bonds						
3 year Bond	0.06%	0.97%	2.78%	-3.19%	240	-0.02
5 year Bond	0.06%	1.00%	2.82%	-2.45%	240	0.12
10 year Bond	0.26%	1.72%	6.23%	-4.89%	240	-0.05
Real Estate	1.59%	1.76%	5.38%	-3.60%	56	-0.59
Stocks						
Stocks Benchmark	0.77%	6.01%	18.96%	-19.43%	240	-0.43
Small Cap	1.42%	5.49%	14.95%	-11.68%	82	-0.06
Mid Cap	1.32%	5.53%	14.22%	-18.04%	159	-0.58
Large Cap	0.42%	5.65%	13.07%	-21.75%	114	-0.78
Industrials	0.83%	6.30%	16.17%	-22.69%	172	-0.69
Forestry & Paper	0.27%	6.49%	18.94%	-21.10%	172	0.06
Consumer Goods	0.74%	5.22%	14.94%	-19.81%	172	-0.55
Inflation						
Actual Inflation (CPI)	0.09%	0.42%	1.03%	-1.34%	172	-0.47
Expected Inflation SP	0.16%	0.06%	0.30%	0.00%	171	-0.46
Expected Inflation TP	0.11%	0.12%	0.44%	-0.13%	120	0.79
Unexpected Inflation SP	-0.07%	0.41%	0.83%	-1.46%	171	-0.48
Unexpected Inflation TP	-0.02%	0.43%	0.81%	-1.73%	120	-1.04

Table 1 presents some descriptive statistics for the monthly nominal returns of the assets tested in this study. It also shows descriptive statistics for the actual inflation and the two different kinds of expected and unexpected inflation. The expected inflation named SP is based on a monthly survey conducted the National Institute of Economic Research. The expected inflation named TP is based on the return of one-month treasury bills as a proxy for the expected inflation.

Table 2
Monthly real returns

Variable	Mean	StDv	Max	Min	N	Skew
Treasury Bills						
1 month T-bill	0.02%	0.43%	1.73%	-0.81%	120	1.04
2 month T-bill	0.02%	0.44%	1.85%	-0.81%	120	1.11
6 month T-bill	0.05%	0.46%	2.40%	-0.73%	120	1.53
Government Bonds						
3 year Bond	-0.03%	1.11%	4.12%	-3.59%	240	0.12
5 year Bond	-0.03%	1.13%	3.56%	-2.93%	240	0.18
10 year Bond	0.17%	1.84%	7.58%	-5.28%	240	0.05
Real Estate	1.32%	1.75%	4.82%	-3.92%	56	-0.42
Stocks						
Stocks Benchmark	0.68%	6.05%	19.21%	-19.58%	240	-0.45
Small Cap	1.36%	5.53%	15,10%	-11.71%	82	-0.04
Mid Cap	1.23%	5.57%	14.37%	-18.19%	159	-0.54
Large Cap	0.33%	5.67%	12.65%	-21.90%	114	-0.78
Industrials	0.74%	6.33%	15.47%	-22.85%	172	-0.68
Forestry & Paper	0.17%	6.51%	18.99%	-21.26%	172	0.10
Consumer Goods	0.65%	5.23%	14.87%	-19.97%	172	-0.54

Table 2 presents some descriptive statistics for the monthly real returns of the assets tested in this study.

Table 3
Annual nominal returns

Variable	Mean	StDv
Treasury Bills		
1 month T-bill	1.37%	0.42%
2 month T-bill	1.40%	0.44%
6 month T-bill	1.67%	0.60%
Government Bonds		
3 year Bond	0.74%	3.36%
5 year Bond	0.73%	3.45%
10 year Bond	3.14%	5.98%
Real Estate	6.53%	3.53%
Stocks		
Stocks Benchmark	9.65%	20.81%
Small Cap	18.43%	19.02%
Mid Cap	1704%	19.14%
Large Cap	5.12%	19.57%
Industrials	10.41%	21.81%
Forestry & Paper	3.24%	22.49%
Consumer Goods	9.25%	18.09%
Inflation		
Actual Inflation (CPI)	1.13%	1.45%
Expected Inflation SP	1.96%	0.20%
Expected Inflation TP	1.37%	0.42%
Unexpected Inflation SP	-0.84%	1.42%
Unexpected Inflation TP	-0.26%	1.50%

Table 3 presents some descriptive statistics for the annual nominal returns of the assets tested in this study. It also shows descriptive statistics for the actual inflation and the two different kinds of expected and unexpected inflation. The expected inflation named SP is based on a monthly survey conducted the National Institute of Economic Research. The expected inflation named TP is based on the return of one-month treasury bills as a proxy for the expected inflation.

Table 4
Annual real returns

Variable	Mean	StDv
Treasury Bills		
1 month T-bill	0.26%	1.50%
2 month T-bill	0.28%	1.51%
6 month T-bill	0.55%	1.60%
Government Bonds		
3 year Bond	-0.30%	3.85%
5 year Bond	-0.32%	3.91%
10 year Bond	2.08%	6.37%
Real Estate	5.38%	3.51%
Stocks		
Stocks Benchmark	8.53%	20.97%
Small Cap	17.56%	19.14%
Mid Cap	15.86%	19.29%
Large Cap	4.03%	19.65%
Industrials	9.19%	21.92%
Forestry & Paper	2.09%	22.53%
Consumer Goods	8.04%	18.12%

Table 4 presents some descriptive statistics for the annual real returns of the assets tested in this study.

Table 11
Regression results for Test SP using semiannual nominal returns of asset j and CPI

Hedges against expected and unexpected inflation rates,

$$\tilde{N}_{\boldsymbol{jt}} = \boldsymbol{\alpha_j} + \boldsymbol{\beta_j}\boldsymbol{E}\left(\tilde{A}_{\boldsymbol{t}}|\ \boldsymbol{\Phi_{t-1}}\right) + \ \boldsymbol{\gamma_j}\left[\boldsymbol{A_t} - \boldsymbol{E}(\tilde{A}_{\boldsymbol{t}}|\boldsymbol{\Phi_{t-1}})\right] + \ \tilde{o}_{\boldsymbol{jt}}\ ,$$

Asset	Constant $\boldsymbol{\alpha_j}$	Expected $\boldsymbol{\beta_j}$	Unexpected_$\boldsymbol{\gamma_j}$	R-squared	N
1 month T-bill	0.00087	0.359	0.0686	0.144	19
	(0.00245)	(0.256)	(0.404)		
2 month T-bill	0.00097	0.326	0.0236	0.116	19
	(0.00254)	(0.271)	(0.434)		
6 month T-bill	0.00254	0.217	-0.111	0.053	19
	(0.00311)	(0.324)	(0.569)		
3 year Bond	-0.0399*	2.362*	0.403	0.217	27
	(0.0223)	(1.197)	(1.137)		
5 year Bond	0.00657	-1.164	-1.274	0.083	28
	(0.0122)	(0.805)	(1.221)		
10 year Bond	0.0321	-2.752	-2.490	0.134	28
	(0.0342)	(1.648)	(2.245)		
Real Estate	0.0602***	-0.578	1.183	0.111	27
	(0.0107)	(0.753)	(1.042)		
Stocks Benchmark	0.0891	-4.160	-1.857	0.034	28
	(0.0560)	(4.701)	(7.718)		
Small Cap	0.132	-2.077	0.208	0.021	13
	(0.0980)	(8.003)	(9.839)		
Mid Cap	0.212**	-4.352	2.591	0.053	25
	(0.102)	(6.270)	(9.649)		
Large Cap	0.0914	-1.913	1.853	0.023	18
	(0.0614)	(5.096)	(8.267)		
Industrials	0.126	-1.399	2.706	0.013	27
	(0.0905)	(6.598)	(9.871)		
Forestry & Paper	0.146**	-8.277**	-2.219	0.179	27
	(0.0632)	(3.984)	(5.313)		
Consumer Goods	0.110	-4.658	-1.523	0.050	27
	(0.0659)	(4.551)	(7.107)		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 11 displays the regression results using semiannual data. For this test the survey method has been used to determine the expected inflation.

Table 12

Regression results for Test TP using semiannual nominal returns of asset j and CPI

Hedges against expected and unexpected inflation rates,

$$\tilde{N}_{jt} = \boldsymbol{\alpha_j} + \boldsymbol{\beta_j} \boldsymbol{E}\left(\tilde{A}_t \middle| \boldsymbol{\Phi_{t-1}}\right) + \boldsymbol{\gamma_j}\left[\boldsymbol{A_t} - \boldsymbol{E}(\tilde{A}_t | \boldsymbol{\Phi_{t-1}})\right] + \tilde{o}_{jt} \,,$$

Asset	Constant $\boldsymbol{\alpha_j}$	Expected $\boldsymbol{\beta_j}$	Unexpected_$\boldsymbol{\gamma_j}$	R-squared	N
2 month T-bill	4.23e-05	0.998***	-0.0488***	0.997	19
	(0.000119)	(0.00900)	(0.0164)		
6 month T-bill	0.00114	0.997***	-0.207	0.903	19
	(0.000692)	(0.0726)	(0.133)		
3 year Bond	-0.00968	1.990	1.858*	0.216	18
	(0.0109)	(2.006)	(0.983)		
5 year Bond	-0.00123	-0.147	-1.740**	0.252	19
	(0.00782)	(0.824)	(0.778)		
10 year Bond	0.0107	-0.457	-3.598**	0.292	19
	(0.0166)	(1.565)	(1.253)		
Real Estate	0.0339***	-1.073	0.448	0.148	19
	(0.00656)	(1.000)	(0.768)		
Stocks Benchmark	0.105**	-9.369*	2.206	0.279	19
	(0.0390)	(4.464)	(3.501)		
Small Cap	0.161***	-22.03*	-0.0494	0.317	13
	(0.0443)	(12.14)	(5.764)		
Mid Cap	0.165***	-14.07***	2.842	0.451	19
	(0.0346)	(3.904)	(3.289)		
Large Cap	0.107***	-11.34**	3.060	0.476	18
	(0.0353)	(4.005)	(2.571)		
Industrials	0.140***	-10.92*	5.446	0.335	19
	(0.0468)	(6.197)	(3.947)		
Forestry & Paper	0.125***	-14.43***	-3.172	0.469	19
	(0.0257)	(3.157)	(2.163)		
Consumer Goods	0.144***	-13.25***	0.585	0.438	19
	(0.0349)	(3.094)	(2.603)		

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 12 displays the regression results using semiannual data. For this test the one-month treasury bill rate has been used as a proxy for the expected inflation.

Table 13

Regression results for Test SP using monthly nominal returns of asset j and CPIF

Hedges against expected and unexpected inflation rates,

$$\tilde{N}_{jt} = \boldsymbol{\alpha_j} + \boldsymbol{\beta_j E}\left(\tilde{A}_t \middle| \boldsymbol{\Phi_{t-1}}\right) + \boldsymbol{\gamma_j}\left[\boldsymbol{A_t} - \boldsymbol{E}\left(\tilde{A}_t \middle| \boldsymbol{\Phi_{t-1}}\right)\right] + \tilde{o}_{jt} ,$$

Asset	Constant α_j	Expected β_j	Unexpected_γ_j	R-squared	N
1 month T-bill	-0.000377**	0.949***	0.00790	0.266	120
	(0.000173)	(0.120)	(0.0253)		
2 month T-bill	-0.000310	0.920***	0.00714	0.228	120
	(0.000187)	(0.126)	(0.0268)		
6 month T-bill	9.25e-05	0.808***	0.0112	0.093	120
	(0.000297)	(0.179)	(0.0391)		
3 year Bond	0.000580	-0.338	-0.366*	0.023	171
	(0.00181)	(1.136)	(0.193)		
5 year Bond	0.00102	-0.589	-0.284	0.014	171
	(0.00184)	(1.177)	(0.192)		
10 year Bond	0.00595*	-2.514	-0.584*	0.023	171
	(0.00359)	(2.037)	(0.324)		
Stocks Benchmark	0.0319***	-16.55**	0.764	0.032	171
	(0.0115)	(7.242)	(1.159)		
Small Cap	0.0302*	-11.14	0.223	0.020	80
	(0.0171)	(10.16)	(1.831)		
Mid Cap	0.0486***	-22.49***	0.228	0.056	157
	(0.0138)	(8.488)	(1.283)		
Large Cap	0.0296**	-15.34*	1.752	0.049	112
	(0.0144)	(8.839)	(1.562)		
Industrials	0.0380**	-18.20*	1.057	0.032	171
	(0.0152)	(9.418)	(1.509)		
Forestry & Paper	0.0354**	-20.18**	0.694	0.033	171
	(0.0163)	(9.664)	(1.419)		
Consumer Goods	0.0378***	-18.52**	1.536	0.055	171
	(0.0127)	(7.440)	(1.073)		

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 13 displays the results of the robustness test using the CPIX measurement for the true inflation and the survey method to determine the expected inflation. CPIF takes into account a constant interest rate when calculating the rent costs of households.

Table 14

Regression results for Test TP using monthly nominal returns of asset j and CPIF

Hedges against expected and unexpected inflation rates,

$$Ñ_{jt} = \boldsymbol{\alpha}_j + \boldsymbol{\beta}_j \boldsymbol{E}\left(Ã_t \middle| \boldsymbol{\Phi}_{t-1}\right) + \boldsymbol{\gamma}_j\left[\boldsymbol{A}_t - \boldsymbol{E}(Ã_t | \boldsymbol{\Phi}_{t-1})\right] + õ_{jt} ,$$

Asset	Constant $\boldsymbol{\alpha}_j$	Expected $\boldsymbol{\beta}_j$	Unexpected_$\boldsymbol{\gamma}_j$	R-squared	N
2 month T-bill	-1.85e-05	1.034***	-0.00179	0.977	120
	(2.13e-05)	(0.0277)	(0.00443)		
6 month T-bill	7.50e-05	1.146***	-0.00127	0.635	120
	(0.000126)	(0.132)	(0.0269)		
3 year Bond	-0.00105	0.910	-0.406*	0.050	119
	(0.00112)	(0.902)	(0.235)		
5 year Bond	-0.00072	0.628	-0.307	0.027	119
	(0.00112)	(0.820)	(0.240)		
10 year Bond	0.00115	0.895	-0.677	0.029	119
	(0.00237)	(1.653)	(0.416)		
Stocks Benchmark	0.0150**	-9.775*	1.906	0.074	119
	(0.00636)	(4.953)	(1.408)		
Small Cap	0.0227**	-18.16	0.138	0.036	80
	(0.00909)	(11.19)	(1.873)		
Mid Cap	0.0259***	-15.46***	1.204	0.114	119
	(0.00747)	(5.017)	(1.548)		
Large Cap	0.0170**	-11.74**	1.780	0.094	112
	(0.00668)	(5.461)	(1.483)		
Industrials	0.0222***	-13.10**	2.822	0.094	119
	(0.00812)	(6.449)	(1.897)		
Forestry & Paper	0.0206**	-15.54**	-0.0996	0.068	119
	(0.00990)	(6.903)	(1.810)		
Consumer Goods	0.0215***	-13.81***	1.950	0.121	119
	(0.00694)	(4.684)	(1.346)		

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 14 displays the results of the robustness test using the CPIX measurement for the true inflation and the one-month treasury bill rate as a proxy for the expected inflation. CPIF takes into account a constant interest rate when calculating the rent costs of households.

Table 15

Regression results for Test SP using monthly nominal returns of asset j and CPIX

Hedges against expected and unexpected inflation rates,

$$Ñ_{jt} = \boldsymbol{\alpha_j} + \boldsymbol{\beta_j E}(Ã_t|\ \boldsymbol{\Phi_{t-1}}) + \ \boldsymbol{\gamma_j}[\boldsymbol{A_t} - \boldsymbol{E}(Ã_t|\boldsymbol{\Phi_{t-1}})] + \ õ_{jt}\ ,$$

Asset	Constant $\boldsymbol{\alpha_j}$	Expected $\boldsymbol{\beta_j}$	Unexpected_$\boldsymbol{\gamma_j}$	R-squared	N
1 month T-bill	-0.00031*	0.914***	0.00296	0.242	117
	(0.000178)	(0.122)	(0.0237)		
2 month T-bill	-0.00024	0.886***	0.00115	0.206	117
	(0.000196)	(0.130)	(0.0250)		
6 month T-bill	0.00018	0.762***	-0.00031	0.079	117
	(0.000319)	(0.190)	(0.0355)		
3 year Bond	0.00011	-0.120	-0.359*	0.026	169
	(0.00185)	(1.153)	(0.182)		
5 year Bond	0.00069	-0.445	-0.304*	0.018	169
	(0.00188)	(1.191)	(0.181)		
10 year Bond	0.00481	-1.980	-0.576*	0.024	169
	(0.00368)	(2.071)	(0.312)		
Stocks Benchmark	0.0355***	-18.28**	0.610	0.037	169
	(0.0118)	(7.378)	(1.022)		
Small Cap	0.0346*	-13.38	-0.394	0.028	78
	(0.0175)	(10.27)	(1.460)		
Mid Cap	0.0524***	-24.38***	0.104	0.065	155
	(0.0141)	(8.634)	(1.099)		
Large Cap	0.0335**	-17.26*	1.260	0.051	110
	(0.0148)	(9.007)	(1.329)		
Industrials	0.0406***	-19.51**	0.690	0.033	169
	(0.0155)	(9.558)	(1.291)		
Forestry & Paper	0.0402**	-22.50**	0.695	0.041	169
	(0.0165)	(9.732)	(1.212)		
Consumer Goods	0.0412***	-20.14***	1.442	0.062	169
	(0.0129)	(7.564)	(0.925)		

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 15 displays the results of the robustness test using the CPIX measurement for the true inflation and the survey method to determine the expected inflation. CPIX excludes the rent costs for households and changes in taxes (not salary related).

Table 16

Regression results for Test TP using monthly nominal returns of asset j and CPIX

Hedges against expected and unexpected inflation rates,

$$\text{Ñ}_{jt} = \boldsymbol{\alpha_j} + \boldsymbol{\beta_j E}\left(\text{Ã}_t \middle| \boldsymbol{\Phi_{t-1}}\right) + \boldsymbol{\gamma_j}\left[\boldsymbol{A_t} - \boldsymbol{E}(\text{Ã}_t | \boldsymbol{\Phi_{t-1}})\right] + \text{õ}_{jt} ,$$

Asset	Constant $\boldsymbol{\alpha_j}$	Expected $\boldsymbol{\beta_j}$	Unexpected_$\boldsymbol{\gamma_j}$	R-squared	N
2 month T-bill	-2.38e-05	1.036***	-0.00305	0.976	117
	(2.32e-05)	(0.0284)	(0.00407)		
6 month T-bill	6.43e-05	1.148***	-0.00902	0.629	117
	(0.000137)	(0.136)	(0.0250)		
3 year Bond	-0.00141	1.071	-0.383*	0.057	117
	(0.00114)	(0.906)	(0.226)		
5 year Bond	-0.00094	0.700	-0.334	0.035	117
	(0.00115)	(0.828)	(0.230)		
10 year Bond	0.00029	1.281	-0.645	0.035	117
	(0.00241)	(1.656)	(0.407)		
Stocks Benchmark	0.0178***	-11.16**	1.593	0.082	117
	(0.00650)	(5.025)	(1.214)		
Small Cap	0.0277***	-24.00**	-0.484	0.059	78
	(0.00888)	(10.91)	(1.499)		
Mid Cap	0.0291***	-17.12***	0.822	0.128	117
	(0.00738)	(4.999)	(1.336)		
Large Cap	0.0199***	-13.28**	1.174	0.101	110
	(0.00659)	(5.485)	(1.248)		
Industrials	0.0251***	-14.65**	2.102	0.095	117
	(0.00809)	(6.469)	(1.602)		
Forestry & Paper	0.0242**	-17.33**	-0.171	0.084	117
	(0.00964)	(6.823)	(1.530)		
Consumer Goods	0.0242***	-15.17***	1.632	0.133	117
	(0.00683)	(4.649)	(1.151)		

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 16 displays the results of the robustness test using the CPIX measurement for the true inflation and the one-month treasury bill rate as a proxy for the expected inflation. CPIX excludes the rent costs for households and changes in taxes (not salary related).

Appendix B

Additional Test: Price of inflation risk
Data and Method:
In order to examine if the price of risk for inflation seem to be priced or not, we chose to use the Fama French three factor model and add an expected inflation risk factor EXINF and an unexpected inflation risk factor UNEXINF. The data used in this section are obtained from the Kenneth R. French´s webpage. We used 25 European portfolios sorted on size and book-to-market for stocks and the monthly data ranged from June 1996 to April 2014. The market excess return, SMB and HML and riskfree rate during the same period was also collected from the same source.

The two-step asset-pricing model in Fama MacBeth (1973) is as follows:

The first pass time series regression:

$$R_{t+1}^{i} - R_{t}^{f} = \alpha_i + \beta_{1,i}\left(R_{t+1}^{m} - R_{t}^{f}\right) + \beta_{2,i}SMB + \beta_{3,i}HML + \beta_{4,i}EXINF + \beta_{5,i}UNEXINF + \varepsilon_{t+1}^{i}$$

Where:
(1) The $R_{t+1}^{i} - R_{t}^{f}$ is the excess return of stock i at time t
(2) The α_i is the intercept
(3) The β_i is the sensitivity of excess return of stock i to each factor
(4) The $\left(R_{t+1}^{m} - R_{t}^{f}\right)$ is the market risk premium at time t
(5) The SMB is the size factor from Fama French
(6) The HML is the book-to-market factor from Fama French
(7) The $EXINF$ is the expected inflation risk factor
(8) The $UNEXINF$ is the unexpected inflation risk factor
(9) The ε_{t+1}^{i} is the residual

The second pass cross-sectional regression:

$$R_{t+1}^{i} - R_{t}^{f} = \lambda_{0,t} + \lambda_{1,t}\hat{\beta}_{m}^{i} + \lambda_{2,t}\hat{\beta}_{smb}^{i} + \lambda_{3,t}\hat{\beta}_{hml}^{i} + \lambda_{4,t}\hat{\beta}_{exinf}^{i} + \lambda_{4,t}\hat{\beta}_{unexinf}^{i} + \alpha_{t}^{i}$$

Where:
(1) The $R_{t+1}^{i} - R_{t}^{f}$ is the excess return of stock i at time t
(2) The λ_t is the price of risk estimate of each factor
(3) $\hat{\beta}^{i}$is the estimates of betas from the first pass regressions
(4) α_{t}^{i} is the residual

The estimate of the price of risk is calculated using this formula:

$$\hat{\lambda} = \frac{1}{T}\sum_{t-1}^{T}\hat{\lambda}_{t}^{i}$$

Results:

The results from the second pass regression below shows the estimates of the price of risk for the different factors:

Table 17: Second Pass Regression

VARIABLES	Price of risk
Excess Market Return	-0.474*
	(0.257)
SMB	-0.0540
	(0.0366)
HML	0.293***
	(0.0470)
EXINF	-0.0124
	(0.0297)
UNEXINF	0.0278
	(0.0558)
Constant	0.959***
	(0.245)
Observations	25
R-squared	0.743

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1