Dirk Brounen

Piet Eichholtz

Marcel Theebe

# Inflation Protection from Home-ownership: Long-Run Evidence: 1814 - 2004

**Discussion Paper 08/2005 - 015**

April 2007 (revised version from August 2005)

# INFLATION PROTECTION FROM HOMEOWNERSHIP:
## LONG-RUN EVIDENCE: 1814-2004

Dirk Brounen
Piet Eichholtz
Marcel Theebe

This version: April 2007

*Keywords:* Inflation hedging, House Prices, Investment Horizons
*JEL:* E31, E44, G12

Brounen is Associate Professor of Finance and Real Estate at the RSM Erasmus University in Rotterdam, Eichholtz is Professor of Finance and Real Estate at Maastricht University, and Theebe Assistant Professor of Real Estate at the University of Amsterdam, all in the Netherlands. The authors thank Shaun Bond, Rachel Campbell, Sylvester Eijffinger, John Glascock, Frank de Jong, Jianping Mei, John Quigley, Peter Schotman, Marion Steele, Coen Teulings, Marno Verbeek, Christian Wolff, and participants of seminars at Netspar, the University of Tilburg, the University of Maastricht, the RSM Erasmus University, The University of Cambridge, and participants to the 2000 Allied Social Science Associations conference in Boston for their valuable feedback. Jan Luiten van Zanden is thanked for providing his historic inflation series, and Victor Burger for his help with the rent data.

Contact author: Piet Eichholtz, Maastricht University, *Department of Finance, P.O. Box 616, 6200 MD, Maastricht, The Netherlands, T: +31 433883838, F: +31 433884875, p.eichholtz@finance.unimaas.nl*.

# INFLATION PROTECTION FROM HOMEOWNERSHIP:

## LONG-RUN EVIDENCE: 1814-2004

**Abstract**

This paper examines the inflation hedging capacity of the private home. We employ a unique set of long-term data for house prices, rents, and inflation for Amsterdam dating back to 1814. We analyze inflation protection using various methodologies, time periods, and investment horizons. Our results show that homeownership offers protection against expected inflation for investment horizons of ten years and longer; this is especially the case in periods when inflation is persistent. The hedging capacity of housing to unexpected inflation is weak. Hedge ratios increase with extending investment horizons.

Inflation is one of the main sources of investment risk, especially in the long run. Starting with the seminal theoretical work of Fisher (1930), inflation protection has been under continuous attention from researchers. Contrary to the Fisher model's prediction the empirical evidence collected by Bodie (1976), Nelson (1976), Fama (1975, 1981, and 1990), Fama and Schwert (1977), Feldstein (1980), Geske and Roll (1983), Jaffe and Mandelker (1976), and Lee (1992), suggests that stocks offer poor protection against inflation. Although all of these studies are based on U.S. data, these conclusions do not seem to be country-specific. Solnik (1983) rejected the Fisher assumption for each major stock market of the world, and Gultekin (1983) found a consistent lack of positive relation in most of the twenty-six countries he analyzed.

Most of the existing studies have investigated assets like stocks and bonds, while housing has hardly been studied from an inflation-risk perspective, even though housing generally has a dominant position in the household wealth portfolio. For example, in all Western economies besides Germany and Switzerland, well over half of all households are homeowners[1]. In Europe housing accounts for 40%-60% of total household wealth, as opposed to 19 percent for the average household in the United States[2]. It is also more widespread than the ownership of financial assets, like stocks and mutual funds. For example, more U.S. households own a home than hold stocks (68 percent versus 52 percent in 2001), and homeownership is more evenly spread across income deciles (Belsky and Prakken, 2004). Moreover, housing returns appear to be less severely eroded by inflation than returns of other financial assets. The reason for a potentially positive relation between housing returns and inflation can be attributed to some inherent characteristics. For example, the – implicit – rents on housing are often linked to a general consumer price index. However, convincing empirical evidence for the relation between housing returns and inflation is lacking.

A typical home-owning household is exposed to the housing market for many decades. Homeowners typically inhabit the same house for an average period of twelve years. Besides that, mortgage contracts last for up to thirty years, and home equity serves as an implicit pension insurance. These issues suggest that the investment horizon for homeowners is long. That limits the relevance of the existing studies of housing's role as a protection against inflation, which typically use horizons of a year at most. For example, studies like Fama and Schwert (1977), Gyourko and Linneman (1988), Bond and Seiler (1998), and Sing and Liow (2000) concluded that house prices provide a hedge against both expected and unexpected inflation, but only study housing returns measured at an annual, quarterly, or even monthly frequency, for relatively short time periods. Rubens et al (1989) found residential properties only protect against unexpected inflation, while Stevenson (2000) found little evidence of an effective hedge against either expected or unexpected inflation. Anari and Kolari (2002) examine the impact of inflation on homeowner equity by investigating the relation between house prices and the prices of non-housing goods and services and conclude that U.S. house prices have provided a stable inflation hedge for the period 1968-2000.

Regarding the inflation hedging capacity of stocks some evidence exists for investment horizons exceeding one year. For example, Boudoukh and Richardson (1993) analyze the

---

[1] See for a more detailed discussion on international homeownership: Chiuri and Jappelli (2003).
[2] Please see the OECD Factbook 2007 for a full discussion of international statistics on housing finance.

financial markets for the U.S. and U.K. for the period from 1802 to 1990 and find that stocks provide a hedge against inflation risk for a five-year horizon, while this is not the case for shorter horizons. More recently, Schotman and Schweitzer (2000) demonstrate the explicit dependence of the inflation hedge capacity on the investment horizon. By determining the inflation hedge ratio for different investment horizons they show that equity investors can have positive hedge ratios even if stock returns are negatively correlated with unexpected inflation shocks, and only moderately positively related to expected inflation. Furthermore, they show that hedge ratios go up with increasing investment horizons. As the results of these two studies suggest, the degree of inflation protection for long horizons may well be different from the short-term protection. This horizon issue has not been investigated for long-run homeownership, despite the fact that housing is an asset which is held for a long time horizon.

Besides the lack of long-horizon studies for housing, the literature regarding housing as an inflation hedge is deficient in another crucial way. Existing studies only take house prices into account, while service or rent flows are ignored. If changes in the flow of housing services are perfectly correlated with house price changes, or if this service flow is constant, this is not a problem since the direct return component will not affect the variance of the total return in these cases. However, this has not been investigated and is very unlikely to be the case for housing. In fact, housing service flows are likely to be linked to inflation, and total homeownership returns therefore are likely to share characteristics with returns on inflation-linked bonds. Recent evidence by Campbell and Viceira (2001) concerning long-term inflation-linked bonds shows that these are most suited for hedging the risk that real interest rates decline. This paper studies total housing returns by combining a long-term house price index and a long-term index for market rents.

This paper therefore fills a number of gaps in the empirical literature. We analyze the inflation hedge capacity of homeownership over different investment horizons. For this we collected 191 years of rent, price, and inflation data for Amsterdam, covering a wide variety of market circumstances and inflation regimes. Combining these rent and price data enables us to examine the issue from a unique perspective of analysis of the total return.

The remainder of this paper proceeds as follows. Section I discusses the methodological approach that is applied in our subsequent analysis. After discussing the data in Section II, Section III presents our findings concerning the inflation hedge capacity of homeownership for the 191-year sample period. Finally Section IV summarizes and presents our main conclusions.

## I. Empirical Approach

An intuitive test to find out whether returns derived from homeownership are positively related to inflation, is to regress total housing returns on actual inflation. For many of the existing studies this straightforward equation forms the starting point of any investigation:

$$(1) \qquad R_t = c + \gamma \pi_t + v_t$$

where $R_t$ denotes annual total housing returns, $\pi_t$ reflects annual inflation rates, $c$ is a constant, and $v_t$ is an error term. However, as homeowners usually live for several years in their property before selling it, we question the relevance of analyzing a one-year investment horizon. Therefore, we extend equation (1) by varying the horizons from 1 to $H$ years, resulting in the following equation:

$$(2) \qquad \sum_{h=0}^{H} R_{t+h} = c_H + \gamma_H \cdot \sum_{h=0}^{H} \pi_{t+h} + \sum_{h=0}^{H} v_{t+h}$$

This allows us to test whether the degree of inflation protection varies with the investment horizon. However, when using moving time windows as in (2), standard errors might be distorted by serially correlated residuals. We therefore employed the

Newey-West (1987) method to produce heteroskedasticity and autocorrelation consistent estimates, and use this method for all regressions throughout the paper[3].

Unexpected inflation partly causes actual real returns to deviate from expected real returns. As the actual risk of inflation is the unexpected inflation component, it is informative to distinguish between expected and unexpected inflation when testing for inflation protection. We therefore test:

$$R_t = c + \beta E[\pi_t] + \varphi(\pi_t - E[\pi_t]) + \xi_t \tag{3}$$

in which actual inflation $\pi_t$ is decomposed into an expected part $E[\pi_t]$ and an unexpected part $(\pi_t - E[\pi_t])$. Again, we allow for increasing investment horizons in Equation (4):

$$\sum_{h=1}^{H} R_{t+h} = c_H + \beta_H \cdot E_t[\sum_{h=1}^{H} \pi_{t+h}] + \varphi_H \cdot \left( \sum_{h=1}^{H} \pi_{t+h} - E_t[\sum_{h=1}^{H} \pi_{t+h}] \right) + \sum_{h=1}^{H} \xi_{t+h} \tag{4}$$

As it is impossible to obtain actual inflation expectations over two centuries, we assume expected inflation to be an autoregressive process[4], where:

$$E_t[\pi_{t,H}] = \pi_{t-H} + \varepsilon_t \tag{5}$$

Here expected inflation is equal to the ex post realization of the previous period, with an expanding window that increases simultaneously forwards and backwards.

As a final test of the importance of the investment horizon for inflation protection, we calculate hedge ratios as discussed by Schotman and Schweitzer (2000). With investments in financial assets, a hedge ratio expresses the number of hedging vehicles required to offset the risk of an unprotected position. Similarly, if a residential property is used as a vehicle to hedge inflation risk, one could determine the amount of housing

---

[3] Zhu (1998) and Valkanov (2003) express caution regarding the interpretation of regression results based on extended – and overlapping – horizons, which is mainly due to serially correlated residuals.

[4] As a robustness check we have also worked with alternative specification for expected inflation, which does not affect our results materially.

required to protect against inflation by means of a hedge ratio. Important inputs for this ratio are the degree of inflation persistence and the hedge capacity against expected and unexpected inflation. To start with the former, in the Schotman and Schweitzer (2000) approach, inflation is assumed to be generated by an AR(1) time series model:

$$(6) \qquad \pi_{t+1} = \mu + \alpha\pi_t + \eta_{t+1}$$

In (6), the persistence parameter, $\alpha$, reflects how fast actual inflation, $\pi_t$, returns to its long-run average, $\mu$, in case of a deviation, with $\eta_t$ as an independent shock to inflation.

The short-run relation between housing returns and inflation, the second input for the hedge ratio, is modeled with the specification Fama and Schwert (1977) used to test the Fisher equation including unexpected inflation. With expected inflation assumed to be generated by the AR(1) process shown in (6) and unexpected inflation simply defined as the residual, we estimate the relation between total housing returns and both expected and unexpected inflation, reflected by respectively parameters $\beta$ and $\varphi$:

$$(7) \qquad R_{t+1} = c + \beta E_t[\pi_{t+1}] + \varphi\eta_{t+1} + e_t$$

The hedge ratio will be the share of housing in a mixed portfolio of housing and a risk-free asset, in order to have the optimal protection against inflation with a horizon of $H$ years. The cumulative real total return for such a portfolio with a share of $w$ in housing for investment horizon $H$ is reflected by

$$(8) \qquad r_{r,t+H} = w(R_{t,t+H} - \pi_{t,t+H}) + (1-w)(RF_{t,t+H} - \pi_{t,t+H})$$

Schotman and Schweitzer (2000) show by means of a mean-variance framework that the optimal housing allocation $w$, the hedge ratio, will be:

$$\Delta^{(H)} = \frac{\frac{\alpha\beta}{(1-\alpha)^2}\left[H-1-\frac{\alpha-\alpha^H}{1-\alpha}(1+\alpha)+\alpha\frac{\alpha^2-\alpha^{2H}}{1-\alpha^2}\right]\sigma_\eta^2+\left[\frac{H}{1-\alpha}-\frac{\alpha-\alpha^{H+1}}{(1-\alpha)^2}\right]\varphi\sigma_\eta^2}{\frac{\alpha^2\beta^2}{(1-\alpha)^2}\left[H-1-2\frac{\alpha-\alpha^H}{1-\alpha}+\frac{\alpha^2-\alpha^{2H}}{1-\alpha^2}\right]\sigma_\eta^2+H\sigma_e^2+2\frac{\alpha\beta}{1-\alpha}\left[H-1-\frac{\alpha-\alpha^H}{1-\alpha}\right]\varphi\sigma_\eta^2+\varphi^2H\sigma_\eta^2} \tag{9}$$

In (9), the hedge ratio for horizon $H$ is a function of the estimated inflation persistence parameter $\alpha$ from (6), expected inflation hedge parameter $\beta$ and unexpected inflation parameter $\varphi$ from (7), and the variances of the error terms of both equations. Calculating this ratio for increasing horizons allows us to analyze whether inflation protection from home-ownership depends on the investment horizon.

As our data set comprises nearly two centuries, the presence of structural breaks in the data is not unlikely. As this will hamper the interpretation of regression outcomes, we test for structural breaks by applying a regime shift model, which cuts our total sample into two distinct eras. These differ with respect to their moving average and volatility of inflation. As the periods 1814-1914 and 1915-2004 appear to be very different in data terms, we will perform all our subsequent analyses for both sub-periods. We will discuss the breakdown of the periods later in the next section.

## II. The Data

To investigate the ability of housing investments to protect against inflation risk, we start with an index of consumer prices, based on a number of different sources. To get a complete picture of the total return derived from home ownership we analyze a total return series, including capital appreciation and (imputed) rental income. Again, these series are based on separate sources. For each of the indices used in this paper, we discuss the sources, the construction and the time series behavior below.

### *A. Consumer prices*

The first long-run data series we use concerns consumer prices. No single index exists that covers all 191 years we study. We therefore use different sources to construct one. Van Zanden (2005) is the source for the development of the general consumer price level until 1850. This index is based on a basket of consumer goods, including rye bread, beer, butter, meat, potatoes, peas, different types of fish, and various textiles. The basket changes with the general use of the products. For the period between 1850 and 1900 we employ Van Riel (2006), who uses a similar basket of goods. From 1900 onwards, we use the CPI calculated by the Dutch Central Bureau of Statistics (CBS), which is based on much broader basket of commonly used consumer goods.

Statistics for the resulting general price index are presented in the first column of Table 1. We provide the development of the annual inflation rate graphically in Figure 1. The annual inflation rate for the complete period is 1.93%, with a 8.47% standard deviation. However, the average inflation rate differs strongly over the various time periods. We have divided our 191 year sample period into five sub-periods, based on inflation policy and economic circumstances. The first period runs from 1814 through 1850. The year 1850 is generally regarded as an important turning point for the Dutch economy, which was very slow to recover from the collapse of the Dutch Republic and the Napoleonic era, and which started industrializing only around that time[5]. The stagnant shape of the Dutch economy is reflected in the development of the general price level, which showed an annual decrease of -0.10%, but the high standard deviation and the graph show that the price level was not at all stable during the period.

----- Table 1: Characteristics of nominal changes -----

----- Figure 1: Inflation, 1814-2004 -----

The next period runs from 1851 through 1914, when the gold standard was – temporarily – abolished for the first time. This period had a considerably higher average annual price growth, but at 0.92% it is still quite low by today’s standards. The period from 1915 until 1939 had a relatively low average inflation rate of 0.70%, but this was a result of very high inflation during the First World War, and severe deflation in the years directly after that. This severe price reversal was the result of the abolishment and subsequent reintroduction of the gold standard, while deflation in the 1930s coincides with the Great Depression. These developments are reflected in an unprecedented standard deviation of 16.30%. The graph confirms the very high volatility of consumer price in that period. As the graph shows the persistence and level of inflation during the period from 1940 to

---

[5] See, for example, De Jonge (1968) and Wintle (2000).

1980 is a historic exception, given the annual average level of 5.95%. The standard deviation is in line with the long-term average. The last sub-period we distinguish runs from 1981 – when monetary policy became structurally and institutionally focused on inflation control – to 2004. For this period, the annual average inflation rate is 2.53%, with a record low standard deviation of 1.69%.

### *B. House prices*

Regarding house prices for the period 1814 – 1965, we use an index based on the same housing transactions data as Eichholtz' (1997) biennial Herengracht index. This series is based on transactions of the houses on the Herengracht, the main canal in Amsterdam, and is constructed using repeated-measures regression. We construct an index for the full time period for which transaction price are available: 1650 through 1973. Sparse data in the first and last years of the Herengracht transaction price sample period forced Eichholtz to estimate a biennial index. We only use the index estimates for 1814-1965, allowing us to construct an annual index. For the remaining period from 1973 through to 2004, the house price series are based on a local index constructed by the Dutch Association of Real Estate Agents (NVM) and the Central Bureau of Statistics (CBS). This index is a mean index of Amsterdam house transaction prices. The second panel of Table 1 provides statistical information regarding the house price series. The table shows that nominal house price increases were far lower during our nineteenth-century sub sample than in the more recent sub period; an annual average increase of 2.14% against 7.15% for the twentieth century. It also shows that nominal house price growth was especially strong in the period between 1940 and 1980.

The house price index is provided graphically in Figure 2, both in nominal terms and in real terms, on a logarithmic scale. The graph shows that nominal house prices in Amsterdam only grew substantially in the twentieth century. Real rents show far less growth. The gap between the nominal and real price series is very small between 1814 and approximately 1900. In the years preceding the First World War, nominal and real house price began to diverge, and this divergence became especially strong from 1914 onwards, only to be reversed in the decade after the war. From the end of the Second World War, the divergence between nominal and real house prices became structural. In nominal terms, the house price index used in this paper increased from 100 in 1814 to 11,669 in 2004. In real terms, the index value is 510 in 2004. So a very large part of the great observed house price changes in the twentieth century was caused by inflation.

----- Figure 2: Nominal and real house prices, 1814-2004 -----

*C. Rents*

The second component of the total return to housing is the rental income. We do not have rental income for the houses on the Herengracht, since these were mostly owner-occupied. The rental income series therefore has to be based on market rents, which are subsequently related to house prices to get an estimate of income. The market rent series comes from two sources. For the period 1814 – 1850 we use a repeated rent index developed by Eichholtz and Theebe (2006). That index is constructed from a sample of 1,055 dwellings owned by the precursors of today's institutional investors: orphanages, hospitals, and poor-relief boards. Only cash flows of new rental contracts were used to create the market rent index, which was again based on repeated-measures regression. The resulting index is truly market-based as government interference in the rental housing market was non-existent before 1914.

For the period after 1850, the same rental data are not available, and we therefore have to turn to other sources to extend the market rent index to 2004. As far as we know, no rental data are available for Amsterdam for the complete 1850 – 2005 period, so we are forced to use national data instead. Van Riel (2006) has estimated market rent developments for the period 1850 – 1913. He did this by estimating the gross rental value of houses on the basis of the wealth tax that was levied on the estimated (imputed) rental income of Dutch houses, which was in its turn based on the actual rents of comparable houses in the vicinity. Tax collectors kept up with the annual development of rents (Horlings, 1995). Van Riel's rent index only involves residential properties, and includes maintenance and repair costs.

The Dutch Cental Bureau of Statistics' (CBS) collection of national rent data started in 1914. We use five different CBS sources to construct a rent index for the period 1914 – 2004. Especially in the early decades of the twentieth century a large number of different sources had to be used to collect the appropriate data. For the later decades (after the Van Riel index), rent data are from CBS (1939, 1948), which have been calculated in the same manner as Van Riel. From 1937 onwards the CBS has published an index for national rents. To show the exact movement of the rent the CBS re-bases the index every five years. Because this re-estimation procedure can create a smoothed index in the first years, we go back to the earliest source possible (CBS, 1959) to provide the rent data of this period. It was fortunate that the CBS provided us with a long time series on the rent development in the Netherlands. For the first decades after 1937, the CBS continued to use the same method for calculating the index (CBS, 1949), but in 1973 they replaced that by a panel survey (CBS, 2002). The panel survey method takes into account quality changes so that the rent index purely mirrors development in rent. This change in the index methodology may affect the index's behaviour, but the CBS (1999) has compared the two index methods and concluded that the indices differ by a stable factor. So the two different concepts can be used in one continuous rent index.

To conclude, we have a rent index covering nearly two centuries, but it has two drawbacks. The first is that it is based on three different construction methods: repeated observed rent regression (1814-1850), measurement of imputed rent by looking at comparable market rents (1851-1973), and survey techniques (1974-2004). The second drawback is that the index is partly based on data for Amsterdam (1814-1850), and partly on data for the Netherlands as a whole (1851-2004). Concerning the first issue, we already quoted the CBS (1999) study indicating that the second and third index construction methods yield equivalent results. By comparing the statistical properties of the rent index until 1850 with that from 1851 onward we can judge the correspondence between the first method and the other two. The second issue, the fact that we look at Amsterdam rents between 1814 and 1850 and national rents afterwards, is only a problem if Amsterdam's rents have behaved very differently than national rents. We are fortunate to have two periods for which rent developments in Amsterdam are available. One CBS study (1938) provides rent data for 1921 – 1936, and the correlation between this index and the national rent index is 0.98. Furthermore an overview of the rent development of period 1995-2004 was provided by the Department of Housing of the city of Amsterdam (2006). Similar to the CBS (1938) study they conducted a panel survey to measure the rent development of all rents in Amsterdam. The correlation between this rent index and the national rent index of the CBS was 0.99. With great caution due to the short time periods, we conclude that the Amsterdam rent development and the national rent development display similar patterns.

The third panel of Table 1 includes statistical information regarding the market rent index. Between 1814 and 2004, market rents have grown by 2.27% per year, on average. As we saw for house prices, the rent increase was considerably higher during the second sub period covering most of the twentieth century (4.32% per annum) than it had been in the preceding century (0.44% per annum). The standard deviation of the rent changes is rather constant across time. For the full sample period we observe a standard deviation of 4.44%, which is very similar to the values we find for the two regime periods of before and after 1914 (4.30% versus 3.64%). Regarding the five historic sub periods our results show that in line with inflation, rents increased most fiercely after World War II. Figure 3 provides graphic representations of the real and nominal rent indices.

----- Figure 3: Nominal and real rent indices, 1814-2004 -----

### *D. The total return index*

The last step in creating a total return index for housing involves the link between the price and the rent index. The capital component of the annual total return is of course the annual percentage change in the price index. Next we derive the income component of total returns by reconstructing the dynamics of Amsterdam rent levels, which were capitalized on the basis of house values. This is performed using various capitalization rates, which were retrieved from market reports of the last twenty years. By rescaling these rental returns into the total return index we obtained a series which is comparable to the total return series that are available since 1978 for the Dutch housing market. This procedure resulted in a series which has a 0.92 correlation with the unsmoothed total return index for housing since 1978[6].

---

[6] Besides the analysis in total returns we have done the full analysis for capital returns only, and the results do not differ very much.

## III. Results

We commence our empirical analysis by regressing the total housing return on the contemporaneous realization of inflation since 1814 as in Equation (1). The results in Table 2 show that in both cases homeownership returns are associated with a weak positive relation with actual inflation. When we repeat this simple analysis for the two distinct eras in our sample we find that the positive association between homeownership returns and inflation is only present since 1915. In the first sub period we document a mildly negative relation. This suggests that homeownership hedges for inflation only when inflation levels are persistent[7].

----- Table 2: Estimates for protection against actual inflation -----

When continuing the analysis with regressions on expanding investment horizons, as in Equation (2), we find that the relation with actual inflation increases as horizons grow. Table 3 shows that while the coefficient for inflation for the annual windows is only 0.181, we report coefficients very close to one (0.998) for horizons that cover thirty years. For long investment horizons homeownership returns and inflation tend to move together over the sample, thus supporting the view that homeownership provides compensation for movements in inflation. This result corroborates strongly with earlier findings of Boudoukh and Richardson (1993) who find very similar results when regressing U.S. stock returns on actual inflation since 1802. They too report very modest (0.070) coefficients for the year-by-year analysis, while on a five year horizon inflation coefficient grew to a significant 0.524. When repeating their analysis for U.K. stocks since 1820 they find very similar coefficients. Furthermore, we find that the analysis appears to perform even better for our housing returns since our explanatory power is around twice of Boudoukh and Richardson's.

----- Table 3: Estimates for protection against actual inflation for different horizons-----

---

[7] All regressions have also been performed on the full sample excluding the First- and Second World War years (because housing markets were put on hold). The results of this robustness check show no significant deviations from the outcomes including the war years.

When distinguishing expected from unexpected inflation we find that most of the positive relation we initially detect between home ownership benefits and inflation is due to expected inflation. Table 4 provides regression results for year-by-year returns, as in Equation (3). For the full sample period of 1814 through to 2004 the coefficient for expected inflation equals a significant 0.344, while unexpected inflation is associated with an insignificant value of only 0.004. For both sub periods we find that expected inflation relates more strongly to our home ownership returns, although insignificantly.

The obvious next step is to extend the investment horizon and examine both types of inflation again, as in Equation (4). The results of this exercise are presented in Table 5, and convey some interesting findings. For expected inflation we find increasing coefficients as the time horizon lengthens. This occurs until ten years, after which the relationship appears to weaken again. For unexpected inflation the same holds, but for all investment horizons we find a weaker coefficient than for expected inflation. This analysis has also been performed for two regime eras, but no significant differences were noted. Our results indicate that homeownership hedges inflation for the typical homeownership horizon, which is twelve years in the Netherlands. For this horizon homeownership returns compensate for inflation.

----- Table 4: Estimates for protection against expected and unexpected inflation -----

----- Table 5: Estimates for protection against expected and unexpected inflation for different horizons-----

As a final test for the importance of the investment horizon when it comes to inflation protection, we calculate hedge ratios as discussed by Schotman and Schweitzer (2000). If a residential property is used as a vehicle to hedge inflation risk, one could determine the amount of housing required to protect against inflation by means of a hedge ratio. Important inputs for this ratio are the degree of inflation persistence and the short-run hedge capacity against expected and unexpected inflation. Using the estimate for inflation persistence, $\alpha$, from Equation (6), the estimates for a 1-year hedge against expected and unexpected inflation, $\beta$ and $\varphi$, from Equation (7), and the variances of the residuals from both regressions, the hedge ratio can be calculated for investment horizon $H$, using Equation (9). We calculate ratios for different horizons for all separate time periods. Table 6 displays the results for some values of $H$ in numbers.

----- Table 6: Hedge ratios for different investment horizons -----

These results clearly show that hedge ratios rise with the horizon for both sub-periods. The hedge ratio appears to rise asymptotically to about 0.15. Especially between one and ten years, the hedge ratio increases very quickly. For horizons in excess of ten years, the ratio only increases slightly. This effect is larger during the second regime period after 1914, during which inflation is more persistent[8]. To visualize these results we also plotted these hedge ratios in Figure 4 for investment horizons ranging from one to thirty years.

----- Figures 4: Hedge ratios full sample and for sub periods -----

## IV. Conclusions

Analyzing 191 years of Amsterdam housing returns has provided a number of interesting insights into housing's ability to protect against inflation risks. We add to the literature in three ways. First, we examine the housing market in the (very) long run, enabling us to investigate greatly varying market circumstances and inflation regimes. Second, the long time series we employ enables us to analyze the impact of longer investment horizons, thereby increasing the relevance of the empirical results. Lastly, the fact that we combine house prices and rents permits us to construct a total return index to housing, painting a complete picture of the return a homeowner can expect.

Our results show that owning a house offers inflation protection in the longer run, especially against expected inflation, and especially if inflation is persistent. Our regression results of total housing returns on expected and unexpected inflation are markedly different. We find positive and statistically significant coefficients for all investment horizons regarding expected inflation. Regarding unexpected inflation we only find such a positive relation for horizons between four and ten years, and do not find an economically significant relationship even if we extend the horizon to twenty or thirty

---

[8] Hedge ratios rise with the investment horizon both when we analyze the total payoffs of homeownership and when we focus solely on the capital gains that arise from house price changes. However, for each period we find somewhat stronger results for the cases when the imputed rental increases are also considered. In line with our previous results we find higher hedge ratios for the most recent era in which inflation levels were highest and most persistent.

years. This result is largely in line with Fischer's (1930) prediction. Judged by the results obtained from a second methodology - the hedge ratio - the effect of the time horizon is especially relevant up to horizons of approximately ten years, after which the hedge ratio flattens. During periods when inflation is not persistent, as was the case in the nineteenth century, housing returns are not positively related to the inflation rate.

## References

**Anari, A. and J. Kolari,** “House Prices and Inflation.” *Real Estate Economics*, 2002, 30(1), pp. 67-84.

**Belsky, E. and J. Prakken,** “Housing Wealth Effects: Housing’s Impact on Wealth Accumulation, Wealth Distribution and Consumer Spending.” Joint Center for Housing Studies Report W04-13, Harvard University, December 2004.

**Bodie, Z.** “Common Stocks as a Hedge Against Inflation.” *Journal of Finance*, 1976, 31(2), pp. 9-470.

**Bond, M.T. and M.J. Seiler,** “Real Estate Returns and Inflation: An Added Variable Approach.” *Journal of Real Estate Research*, 1998, 15(3), pp. 327-338.

**Boudoukh, J. and M. Richardson,** “Stock Returns and Inflation: A Long Horizon Perspective.” *American Economic Review*, 1993, 83(5), pp. 1346-1355.

**Campbell, J.H. and L.M. Viceira,** “Who Should Buy Long-Term Bonds?” *American Economic Review*, 2001, 91(1), pp. 99-127.

**Central Bureau of Statistics,** De woningbouw in Amsterdam [Housing construction in Amsterdam]. *Nederlandse conjuctuur, 9*. Afzonderlijke bedrijfstakken. Voorburg, The Netherlands: CBS, 1938.

**Central Bureau of Statistics,** De Nederlandse volkshuishouding, 1914 – 1918 [The Dutch national economy, 1914 – 1918]. *Nederlandse conjuctuur speciale onderzoekingen, 3*. Een economisch-statistische schets. Voorburg, The Netherlands: CBS, 1939.

**Central Bureau of Statistics,** Het nationale inkomen van Nederland, 1921 – 1939 [The Dutch national income, 1921 – 1939]. *Monografieën van de Nederlandse conjunctuur, 7*. Voorburg, The Netherlands: CBS, 1948.

**Central Bureau of Statistics,** Een indexcijfer van de consumptieve uitgaven van verbruikers [An indexation of the consumptive expenditure]. *Statistische en econometrische onderzoekingen, 4 (3)*. Voorburg, The Netherlands: CBS, 1949.

**Central Bureau of Statistics,** *Zestig jaar statistiek in tijdreeksen* [Sixty years statistics in time series]. Voorburg, The Netherlands: CBS, 1959.

**Central Bureau of Statistics,** *De raming van diensten uit eigenwoningbezit* [An estimation of the services from homeownership]. Sector Nationale Rekeningen. Voorburg, The Netherlands: CBS, 1999.

**Central Bureau of Statistics,** *Maandstatistiek van de prijzen* 27 (1) [Monthly price statistics]. Voorburg, The Netherlands: CBS, 2002.

**Department of Housing of the city of Amsterdam,** *Wonen in Amsterdam* 6 [Housing in Amsterdam]. Amsterdam, The Netherlands: City of Amsterdam, 2006.

**Chiuri, M.C. and T. Jappelli, “**Financial Market Imperfections and Home Ownership: A Comparative Study”, *European Economic Review*, 2003, 47, pp. 857-875

**Eichholtz, P.M.A.,** “A Long Run House Price Index: The Herengracht Index, 1628-1973.” *Real Estate Economics,* 1997, 25(2), pp. 175-192.

**Eichholtz, P.M.A. and M.A.J. Theebe**, Housing Market Rents in the Long Run; Amsterdam, 1550-1850, *Working Paper*, Maastricht University, 2006.

**Fama, E.F.,** “Short-term Interest Rates as Predictors of Inflation.” *American Economic Review*, 1975, 6, pp. 269-282.

**Fama, E.F.,** “Stock Returns, Real Activity, Inflation, and Money.” *American Economic Review*, 1981, 71, pp. 545-565.

**Fama, E.F.,** “Stock Returns, Expected Returns, and Real Activity.” *Journal of Finance*, 1990, 45(4), pp. 1089-1108.

**Fama, E.F. and G.W. Schwert,** “Asset Returns and Inflation.” *Journal of Financial Economics*, 1977, 5, pp. 115-146.

**Feldstein, M.** “Inflation and the Stock Market.” *American Economic Review*, 1980, 70(5), pp. 839-847.

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

**Flavin, M. and Y. Takashi,** “Owner-Occupied Housing and the Composition of the Household Portfolio.” *American Economic Review,* 2002, 92(1), 345-62.

**Geske, R. and R. Roll**, “The Fiscal and Monetary Linkage between Stock Returns and Inflation.” *Journal of Finance*, 1983, 38(1), pp. 1-33.

**Gultekin, N.B.** “Stock Market Returns and Inflation: Evidence from Other Countries.” *Journal of Finance*, 1983, 38(1), pp. 49-65.

**Gyourko, J. and P. Linneman,** “Owner-Occupied Homes, Income-Producing Properties, and REITs as Inflation Hedges: Empirical Findings.” *Journal of Real Estate Finance and Economics*, 1988, 4(1), pp. 347-372.

**Horlings, E.,** *The economic development of the Dutch service sector, 1800 – 1850*. Utrecht: University of Utrecht, 1995.

**Jaffe, J.J. and G. Mandelker,** “The ‘Fisher Effect’ for Risky Assets: An Empirical Investigation.” *Journal of Finance*, 1976, 31(2), pp. 447-458.

**Jonge, J.A. de,** *De industrialisatie in Nederland tussen 1850 en 1914* [Industrialization in the Netherlands: 1850 – 1914]. Amsterdam, 1968.

**Lee, B.** “Causal Relations Among Stock Returns, Interest Rates, Real Activity, and Inflation.” *Journal of Finance*, 1992, 47(4), pp. 1591-1603.

**Nelson, C.R.** “Inflation and Rates of Return on Common Stocks.” *Journal of Finance*, 1976, 31(2), pp. 471-483.

**Newey, W.K. and K.D. West,** “A Simple, Postive Semi-definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix.” *Econometrica*, 1987, 55(3), pp.703-708.

**Riel, A. van,** *Prices and economic development in the Netherlands, 1800 – 1913; Markets, institutions and policy restrains*, forthcoming, 2006.

**Rubens, J.H., M.T. Bond and J.R. Webb,** “The Inflation-Hedging Effectiveness of Real Estate.” *Journal of Real Estate Research*, 1989, 4(2), pp. 45-55.

**Schotman, P.C. and M. Schweitzer,** “Horizon Sensitivity of the Inflation Hedge of Stocks.” *Journal of Empirical Finance*, 2000, 7, 301-315.

**Sing, T.F. and S.H.Y. Liow**, “The Inflation-Hedging Characteristics of Real Estate and Financial Assets in Singapore.” *Journal of Real Estate Portfolio Management*, 2000, 6(4), pp. 373-386.

**Solnik, B.** “The Relation Between Stock Prices and Inflationary Expectations: The International Evidence.” *Journal of Finance*, 1983, 38(1), pp. 35-48.

**Stevenson, S.** “A Long-Term Analysis of Regional Housing Markets and Inflation.” *Journal of Housing Economics*, 2000, 9(1), pp. 24-39.

**Valkanov, R.** “Long-run Regressions: Theoretical results and applications.” *Journal of Financial Economics,* 2003, 68(2), pp. 201-232.

**Wintle, M.** *An Economic and Social History of the Netherlands, 1800 – 1920.* Cambridge University Press, United Kingdom, 2000.

**Zanden, J.L. van,** “What happened to the standard of living before the Industrial Revolution? New evidence from the western part of the Netherlands”, in R.C. Allen, T. Bengtsson and M. Dribe (eds.), *Living Standards in the Past*, Oxford University Press, Oxford, 2005, pp. 173-95.

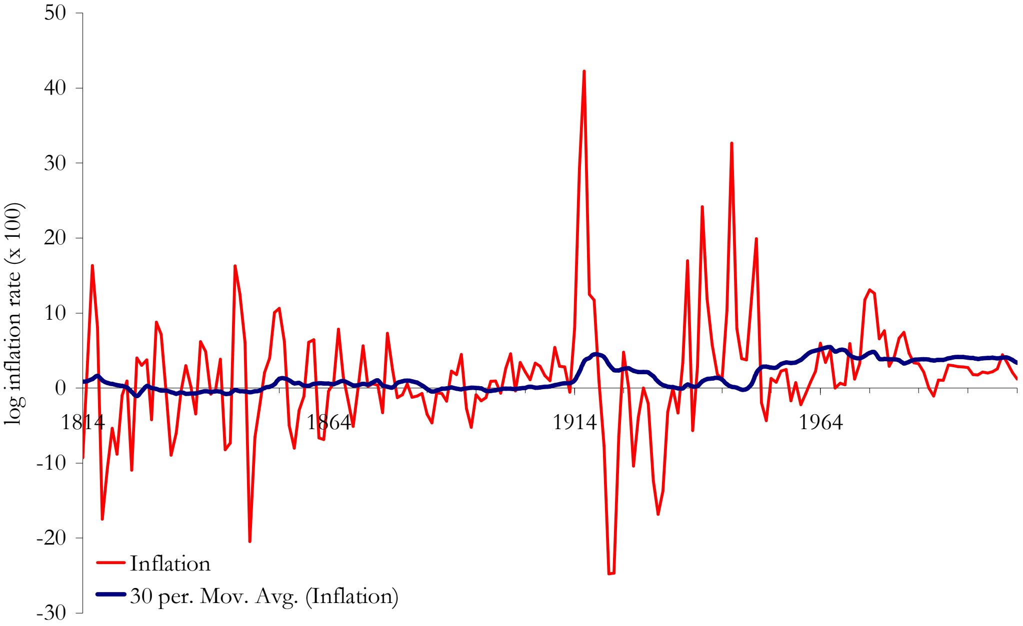
**Zhu, Z.** “*Stock Returns and Inflation at Long Horizon: Revisiting the Empirical Evidence.*” working paper, University of Oklahoma, Department of Economics, 1998

**Table 1**: *Characteristics of nominal changes in house prices, rents and CPI*

| **Time Period** | **Annual inflation rate** | | **Annual changes of nominal house prices** | | **Annual changes of rents** | |
|---|---|---|---|---|---|---|
| | Mean (%) | Std. (%) | Mean (%) | Std. (%) | Mean (%) | Std. (%) |
| Full Sample (1814-2004) | 1.93 | 8.47 | 4.50 | 20.56 | 2.27 | 4.44 |
| 1814 - 1914 | 0.46 | 5.94 | 2.14 | 14.93 | 0.44 | 4.30 |
| 1915 - 2004 | 3.58 | 10.41 | 7.15 | 25.27 | 4.32 | 3.64 |
| 1814 - 1850 | -0.10 | 8.29 | 2.54 | 18.95 | 0.78 | 4.86 |
| 1851 - 1914 | 0.92 | 4.00 | 1.80 | 12.37 | 0.24 | 3.97 |
| 1915 - 1939 | 0.70 | 16.30 | 5.97 | 34.25 | 2.57 | 3.31 |
| 1940 - 1980 | 5.95 | 8.27 | 9.20 | 25.70 | 5.39 | 4.22 |
| 1981 - 2004 | 2.53 | 1.69 | 4.87 | 9.21 | 4.33 | 1.84 |

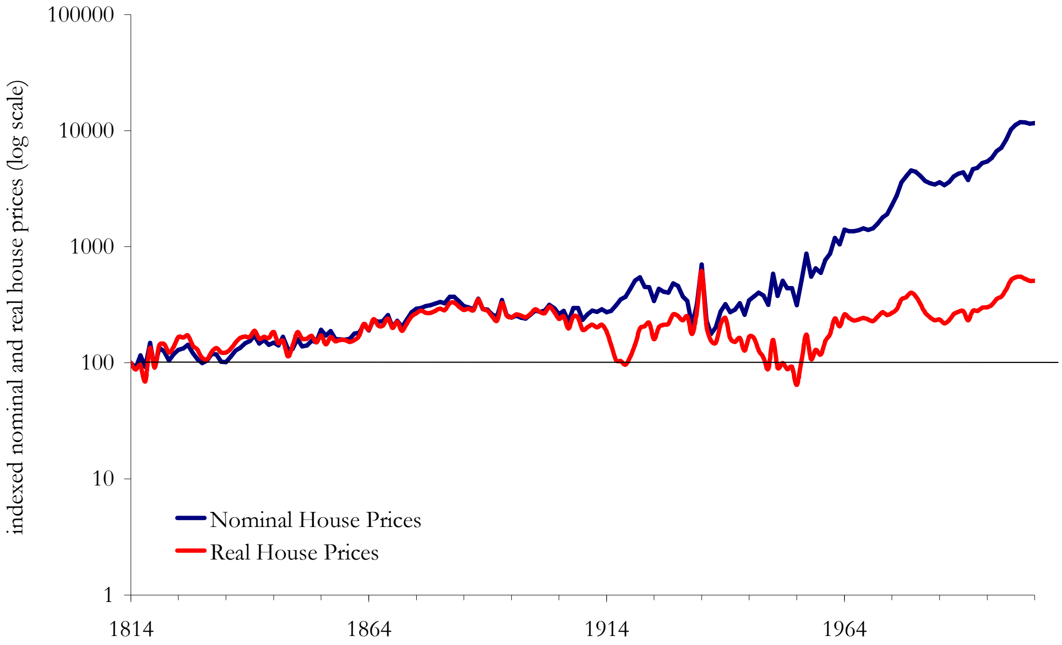
Inflation numbers are derived from Dutch general price indices for different time periods. Until 1850, these data have been compiled by van Zanden (2005), for the period between 1850-1900 we employ van Riel (2006), and from 1900 onwards our inflation data originate form the Dutch Central Bureau of Statistics. The house price data in our sample are based on housing transaction data for the Herengracht, which are compiled into an index using repeated-measures regression. After 1973 house price series are taken from the Dutch Association of Real Estate Agents. Finally, the market rent series comes from three sources. Until 1850 data are taken from Eichholtz and Theebe (2006) and are complemented by data from Van Riel (2006) and the Dutch Central Bureau of Statistics for the later years.

**Figure 1**: *Inflation, 1814-2004*



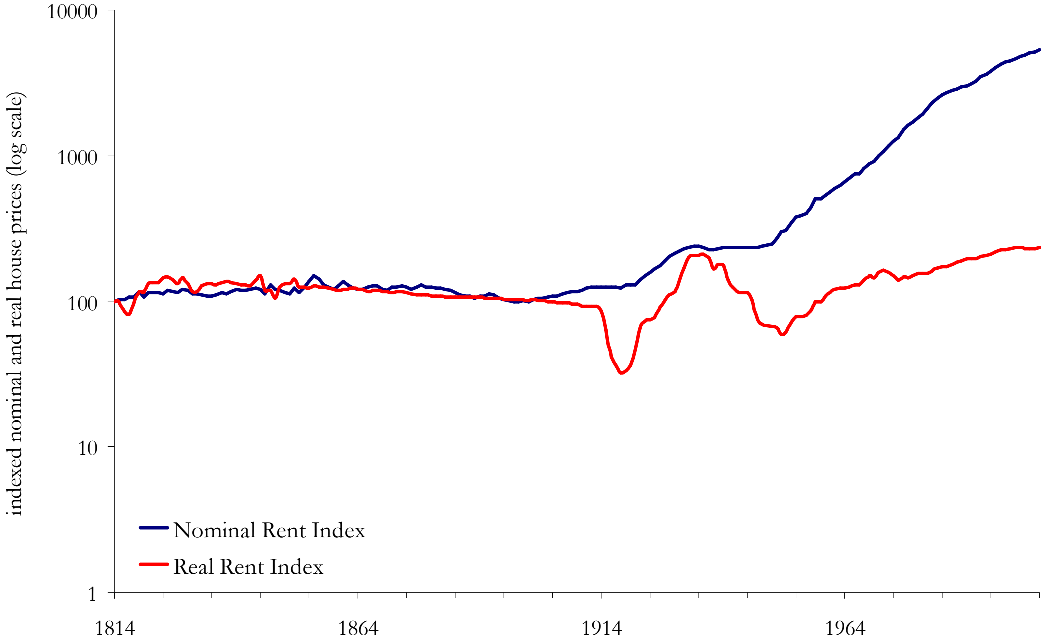
Inflation numbers are derived from Dutch general price indices for different time periods. Until 1850, these data have been compiled by van Zanden (2005), for the period between 1850-1900 we employ van Riel (2006), and from 1900 onwards our inflation data originate form the Dutch Central Bureau of Statistics.

**Figure 2**: *Nominal and real house prices, 1814-2004*



The nominal house price index is based on housing transactions data for the Herengracht, which are compiled into an index using repeated-measures regression. After 1973 house price series are taken from the Dutch Association of Real Estate Agents. The nominal index is converted into a real house price index using inflation numbers derived from Dutch general price indices for different time periods. Until 1850, these data have been compiled by van Zanden (2005), for the period between 1850-1900 we employ van Riel (2006), and from 1900 onwards our inflation data originate form the Dutch Central Bureau of Statistics.

**Figure 3**: *Nominal and real rent indices, 1814-2004*



The nominal market rent series comes from three sources. Until 1850 data are taken from Eichholtz and Theebe (2006). These are complemented by data from Van Riel (2006) and the Dutch Central Bureau of Statistics for the later years. The nominal index is converted into a real rent index using inflation numbers derived from Dutch general price indices for different time periods. Until 1850, these data have been compiled by van Zanden (2005), for the period between 1850-1900 we employ van Riel (2006), and from 1900 onwards our inflation data originate form the Dutch Bureau of Statistics.

**Table 2**: *Estimates for protection against actual inflation (γ)*[*]

| **Time Period** | **C**<br>**(SE)** | **γ**<br>**(SE)** | **Adj R²** |
|---|---|---|---|
| *Total Returns* | | | |
| Full Sample (1814-2004) | 0.042***<br>(0.015) | 0.181<br>(0.189) | 0.001 |
| 1814-1914 | 0.021***<br>(0.015) | -0.079<br>(0.256) | 0.001 |
| 1915-2004 | 0.065***<br>(0.028) | 0.219<br>(0.281) | 0.006 |

[*] Based on Equation (1): $R_t = c + \gamma \pi_t + v_t$

The Newey-West HAC standard errors are stated in parentheses, coefficient marked with *, **, *** are statistically significant at 90%, 95%, 99%.

**Table 3**: *Estimates for protection against actual inflation (γ) for different horizons*[*]

| Investment Horizon | c<br>(SE) | γ<br>(SE) | Adj R² |
|---|---|---|---|
| 1 | 0.042***<br>(0.015) | 0.181<br>(0.189) | 0.001 |
| 2 | 0.041***<br>(0.016) | 0.230***<br>(0.110) | 0.026 |
| 3 | 0.061***<br>(0.021) | 0.309***<br>(0.111) | 0.051 |
| 4 | 0.080***<br>(0.027) | 0.350***<br>(0.108) | 0.084 |
| 5 | 0.095***<br>(0.031) | 0.387***<br>(0.107) | 0.112 |
| 10 | 0.168***<br>(0.030) | 0.463***<br>(0.071) | 0.186 |
| 20 | 0.256***<br>(0.034) | 0.620***<br>(0.079) | 0.311 |
| 30 | 0.173**<br>(0.074) | 0.998***<br>(0.146) | 0.518 |

[*] Based on Equation (2): $\sum_{h=0}^{H} R_{t+h} = c_H + \gamma_H \cdot \sum_{h=0}^{H} \pi_{t+h} + \sum_{h=0}^{H} \nu_{t+h}$

The Newey-West HAC standard errors are stated in parentheses, coefficient marked with *, **, *** are statistically significant at 90%, 95%, 99%.

**Table 4:** *Estimates for protection against expected (β) and unexpected (φ) inflation*[*]

| **Time Period** | **C**<br>**(SE)** | **β**<br>**(SE)** | **φ**<br>**(SE)** | **Adj R²** |
|---|---|---|---|---|
| Full Sample (1814-2004) | 0.039***<br>(0.010) | 0.344***<br>(0.134) | 0.004<br>(0.184) | 0.018 |
| 1814-1914 | 0.020**<br>(0.009) | 0.270<br>(0.286) | -0.214<br>(0.287) | 0.015 |
| 1915-2004 | 0.063***<br>(0.021) | 0.285<br>(0.197) | 0.120<br>(0.242) | 0.009 |

[*] Based on Equation (3) $R_t = c + \beta E[\pi_t] + \varphi(\pi_t - E[\pi_t]) + \xi_t$

The Newey-West HAC standard errors are stated in parentheses, coefficient marked with *, **, *** are statistically significant at 90%, 95%, 99%.

**Table 5:** *Estimates for protection against expected (β) and unexpected (φ) inflation for different horizons*[*]

| Investment Horizon | C (SE) | β (SE) | φ (SE) | Adj R² |
|---|---|---|---|---|
| 1 | 0.039*** <br> (0.010) | 0.344*** <br> (0.134) | 0.004 <br> (0.184) | 0.018 |
| 2 | 0.043*** <br> (0.015) | 0.230* <br> (0.117) | 0.130 <br> (0.095) | 0.011 |
| 3 | 0.055*** <br> (0.021) | 0.370*** <br> (0.096) | 0.153* <br> (0.090) | 0.055 |
| 4 | 0.078** <br> (0.028) | 0.377*** <br> (0.114) | 0.237*** <br> (0.082) | 0.096 |
| 5 | 0.095*** <br> (0.034) | 0.367*** <br> (0.122) | 0.306*** <br> (0.085) | 0.102 |
| 10 | 0.142*** <br> (0.049) | 0.545*** <br> (0.138) | 0.363*** <br> (0.101) | 0.194 |
| 20 | 0.332*** <br> (0.082) | 0.382*** <br> (0.139) | 0.094 <br> (0.089) | 0.180 |
| 30 | 0.586*** <br> (0.123) | 0.330*** <br> (0.077) | 0.038** <br> (0.021) | 0.172 |

[*] Based on Equation (4):

$$\sum_{h=1}^{H} R_{t+h} = c_H + \beta_H \cdot E_t[\sum_{h=1}^{H} \pi_{t+h}] + \varphi_H \cdot \left( \sum_{h=1}^{H} \pi_{t+h} - E_t[\sum_{h=1}^{H} \pi_{t+h}] \right) + \sum_{h=1}^{H} \xi_{t+h}$$

The Newey-West HAC standard errors are stated in parentheses, coefficient marked with *, **, *** are statistically significant at 90%, 95%, 99%.

**Table 6**: *Hedge ratios for different investment horizons*

| | **Horizon in years** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Time Period** | **1** | **5** | **10** | **15** | **20** | **25** | **30** |
| Full Sample (1814-2004) | 0.002 | 0.086 | 0.119 | 0.130 | 0.136 | 0.140 | 0.142 |
| 1814-1914 | -0.029 | 0.050 | 0.066 | 0.072 | 0.075 | 0.076 | 0.077 |
| 1915-2004 | 0.011 | 0.074 | 0.103 | 0.114 | 0.120 | 0.123 | 0.125 |

Based on Equation (9):

$$\Delta^{(H)} = \frac{\frac{\alpha\beta}{(1-\alpha)^2}\left[H-1-\frac{\alpha-\alpha^H}{1-\alpha}(1+\alpha)+\alpha\frac{\alpha^2-\alpha^{2H}}{1-\alpha^2}\right]\sigma_\eta^2+\left[\frac{H}{1-\alpha}-\frac{\alpha-\alpha^{H+1}}{(1-\alpha)^2}\right]\varphi\sigma_\eta^2}{\frac{\alpha^2\beta^2}{(1-\alpha)^2}\left[H-1-2\frac{\alpha-\alpha^H}{1-\alpha}+\frac{\alpha^2-\alpha^{2H}}{1-\alpha^2}\right]\sigma_\eta^2+H\sigma_e^2+2\frac{\alpha\beta}{1-\alpha}\left[H-1-\frac{\alpha-\alpha^H}{1-\alpha}\right]\varphi\sigma_\eta^2+\varphi^2 H\sigma_\eta^2}$$

**Figure 4**: *Hedge ratios for sub periods*