

House Prices and Fundamentals: 355 Years of Evidence

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Abstract

This paper examines the long run relation between prices and rents for houses in Amsterdam from 1650 through 2005. We first demonstrate that these series are cointegrated, a necessary condition for studying movements of the rent-price ratio. We then estimate the deviation of house prices from fundamentals and find that these deviations can be persistent and long-lasting. Lastly, we look at the feedback mechanisms between housing market fundamentals and prices, and find that market correction of the mispricing occurs mainly through prices not rents. This correction back to equilibrium, however, can take decades.

Recently, an extensive debate raged over the question of whether a “housing bubble” existed in the United States and many other countries in the world. Numerous academic articles and popular press accounts pointed to mounting evidence of a U.S. housing bubble as house prices increased on average more than 5 percent per year from 2000 to 2006. On the local level, some markets experienced yearly price increases of more than 20 percent. As a result, even the former chairman of the Board of Governors of the Federal Reserve System, Alan Greenspan, noted that some local markets showed signs of speculative activity.¹ The same holds for other countries. South Africa, for example, saw average house prices increase 244 percent between 1997 and 2005, while that number was 192 percent for Ireland.

The worry of economists and policy makers is that asset price bubbles may quickly turn into busts, resulting in economic contraction. For example, Helbling and Terrones (2003) document 20 severe housing market declines in fourteen countries over the period 1970 to 2002. They also note that these housing market declines generally overlapped or coincided with recessions, and that recessions coinciding with housing market declines resulted in output losses roughly twice as big as those associated with severe equity market declines. For example, they document that the average annual GDP growth rate before a ‘Housing Price Bust’ was 3.4 percent, but declined to 0.8 percent after the ‘Housing Price Bust’. For ‘Equity Price Busts’ the comparable numbers were 4.0 percent and 2.6 percent, respectively. Clearly large housing market movements have a significant impact on the economy.

Recognizing an asset price bubble prior to a price crash is notoriously difficult. Recently, a number of academic studies conducted in the early 2000s questioned whether the U.S. housing market was experiencing the characteristics of a housing price bubble. For example, Case and Shiller (2003) compared U.S. house price growth with income growth since 1985 and concluded that income growth could explain nearly all of the house price increase for over 40 states. Thus income growth, combined with low interest rates, made houses in most states more affordable than they were in 1995. In addition, McCarthy and Peach (2004) presented a critical analysis of the data and methods commonly used to support the claim of a housing bubble. After adjusting common housing market metrics (such as the ratio of the median price of existing homes to the median household income) to account for the effects of interest rate changes, McCarthy and Peach (2004) found little evidence supporting a bubble in the US housing market.

Unfortunately, the problem with identifying the presence (or lack thereof) of bubbles in asset markets is the lack of sufficiently long term data that would allow researchers to identify cases where asset prices significantly deviate from fundamental values.

Furthermore, market-price deviations from fundamental values over a short time period do not guarantee that market prices will decline – the often-predicted bubble crash.

Rather, it is possible that sustained bubble condition periods are possible followed by gradual restoration of the equilibrium relationship.

The purpose of this paper is to utilize a 355-year time series of real house prices and rents to demonstrate that substantial deviations of market prices away from market fundamental values can be persistent. In addition, we show that these “bubble condition”

periods do not necessarily end with the bubble bursting but could as well be resolved by slow convergence of prices and fundamentals.

The following section presents a brief review of recent studies that have examined possible asset bubbles. Section 2 then presents the housing market data as well as the data concerning consumer prices and interest rates, while Section 3 presents the methods and results of our investigation of the relationship between house prices and fundamentals. This analysis of the Amsterdam housing market reveals that significant and long-lasting price deviations are possible, followed by corrections that can either be gradual or sharp. Section 4 examines the way these corrections transpire by analyzing the mechanisms of price and rent adjustment. Finally, Section 5 provides conclusions.

I. Literature Review

Much of the popular press takes for granted that the recent house price increases seen around the world is evidence of a “bubble” in housing markets. For example, in a recent survey, McCarthy and Peach (2004) found that the high ratio of home prices relative to household income and low ratio of home prices relative to market rents for the equivalent property were “the most widely cited evidence of a bubble.”

However, the existence of house price “bubbles” remains a controversial topic in economics. For example, Case and Shiller (2004), using housing market fundamentals as proxied by state-level Per Capita Personal Income and house price indices from Fiserv CSW for the period 1985 to 2002, concluded that house prices in most U.S. cities reflect fundamental values. Nevertheless, additional survey data from four cities suggest

evidence of speculative activity.² However, McCarthy and Peach (2004) using data from 1977 to 2003 suggest that the evidence based on common fundamental value ratios is not conclusive because these ratios ignore the dramatic decline in mortgage interest rates during the 1990s and the growth in housing demand resulting from demographic shifts in the population. After controlling for recent advances in the mortgage markets, McCarthy and Peach (2004) conclude that the benefits of the decline in mortgage interest rates during the 1990s offset the increases in home prices. Himmelberg, Mayer, and Sinai (2005) also examine the traditional metrics of housing market fundamentals, including the house price growth rates, price-to-income ratio, and rent-to-price ratio, and note that the absence of interest rates in such analysis can lead to false conclusions. Their main conclusion, based on the OFHEO repeated sales housing indices from 1980 to 2004, is that the cost of home ownership rose moderately relative to the cost of renting, even though larger deviations from fundamentals occur in some markets. As a result, the analyses of Himmelberg, Mayer, and Sinai (2005) and McCarthy and Peach (2004) support the conclusion of Case and Shiller (2004) that prices in most US housing markets appeared to be in line with market fundamentals.

A number of recent studies have explored the connection between prices and fundamentals. For example, Brunnermeier and Julliard (2008) study the link between inflation and house prices, mainly based on quarterly data for the United Kingdom from 1966 to 2004. They examine the relations between the rent-price ratio, interest rates, and inflation. The central idea of their paper is that potential home buyers may be suffering from money illusion and take insufficient account of the fact that inflation lowers future real mortgage costs. They find that the nominal interest rate, as opposed to the real rate, affects the house price-rent ratio. After decomposing this ratio into a rational and a

mispricing component, they conclude that the latter component is strongly driven by movements in inflation. In addition, Gallin (2004), using U.S. data from 1970 to 2003, shows that long-horizon regressions support the use of the rent-price ratio as an indicator of housing market value.³ Furthermore, Black, Fraser, and Hoesli (2006) analyze house prices relative to fundamentals based on a UK data series starting in 1973 and ending in 2004. They point out that the characteristics of housing markets make arbitrage between the rental market and ownership difficult, potentially leading to extended periods in which observed prices deviate from fundamentals. In Asia, Chung and Kim (2004) present evidence that a real estate bubble existed in the Korean economy. They verify the presence of a bubble through analysis of the long-run equilibrium asset price, a fundamental market value approach, and a price-to-income approach.

Other papers that study the rent-price ratio as the yardstick for fundamental valuation are Ayuso and Restoy (2003), Zhou and Sornette (2003), Lai and van Order (2006), and Hott and Monnin (2006). In general these papers find some evidence supporting the notion that (local) housing markets can deviate from fundamentals. This conclusion is in line with the main findings of Clayton (1996), who studies the Vancouver housing market for the period from 1979 to 1991.

On the theoretical front, Abreu and Brunnermeier (2003) derive a theoretical model of asset prices that indicates that asset bubbles can persist over substantial periods of time, even in the presence of rational arbitrageurs. In their model, the inability of arbitrageurs to coordinate selling combined with individual incentives to time the market lead to bubble persistence. A more recent theoretical model developed by Scheinkman and Xiong (2003) shows that when short-sales are constrained, as is the case in the housing

market, significant asset price bubbles can occur even when traders have small differences in beliefs regarding asset fundamental values.

To conclude, the current literature concerning house prices and fundamentals suggests that prices may deviate from fundamentals over longer periods of time. However, nobody has been able to investigate this issue for a time period long enough to provide direct empirical evidence of these long-run relationships: the typical time series used in the studies cover at most 30 years. In contrast, we use a data series spanning more than three centuries to analyze the long-run relation between house prices and fundamentals.

II. Data

A. Description and Summary Statistics

We use housing market data from multiple sources covering the period from 1650 through 2005. First, we use an index for Amsterdam house prices based on the same data source as Eichholtz (1997) and Van Eeghen, Rosegaarde Bisschop, and Wijnman (1976), and covering the period from 1650 through 1965. However, Eichholtz (1997) estimated a biennial index based on housing and commercial property transaction data for the period 1634 through 1973, thus including the tails of the sample period, in which transaction data were relatively thin. We focus on the housing data alone and disregard the beginning and end of Eichholtz' (1997) sample period, allowing us to compute an annual repeat sales index. We augment this index with national median house price data from the NVM, the national organization of Dutch realtors, covering the period from 1965 through 2005. We provide details regarding the overall index construction procedure and additional information regarding these data in Appendix A1.

We also use multiple sources to construct our rental index. For the first 200 years, from 1650 through 1850, we use data on residential rents for Amsterdam from Eichholtz and Theebe (2007). This series is a repeated market rent index, based on a broad set of rental houses owned by the institutional investors of that time. From 1851, we use two national house rent indices. The first series covers the period from 1851 through 1913 and is from van Riel (2006), while the second dataset spans the remaining period from 1914 through 2004, and is based on a range of publications from the Dutch Central Bureau of Statistics (CBS, 1939, 1948, 1999, 2008).

Overall, these price and rent series provide a yearly picture of the developments and growth in the Amsterdam housing market over a 355-year period from 1650 to 2005. In order to make adjustments for the cost of living, we use a long-run consumer price index, again based on different sources. Nusteling (1985) 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 broad use of the products. For the period between 1850 and 1913 we employ van Riel (2006), who uses a similar basket of goods, and adds housing rental expenses. From 1914 onwards, we use the CPI calculated by the Dutch Central Bureau of Statistics.

----- Figures 1: CPI 1650-2005-----

Over the first 250 years of the sample period, the Dutch Guilder was based on gold, leading to stable consumer prices throughout the 18th and 19th century. At the beginning

of World War I, however, the gold standard could not be sustained. The Dutch central bank tried to stabilize the exchange rate of the Guilder by maintaining stable interest rates. Nevertheless, money supply massively increased due to (still unregulated) private banks providing excessive loans to the war-torn economy. Consequently, consumer prices tripled until 1918. In the years after the war, many of these loans turned sour, and the Dutch banking sector suffered a severe crisis. When The Netherlands returned to the gold standard in 1925, a decade of deflation began. During this period prices gradually reverted to their historical means. However, after its main trading partners Germany and Great Britain left the gold standard, The Netherlands again had to move away from gold in 1936 – and prices directly trended upwards (Hart; Jonker, and van Zanden, 1997). This was the beginning of a long period in which inflation, though not constant, became the norm.

Figures 2 and 3 provide graphs of the house price and rent indices, in nominal and in real terms. The graphs show that most of the increase in nominal house prices and rents occurred in the twentieth century.

----- Figures 2 and 3, House Prices and Rents in Nominal and Real Terms -----

The indices follow each other closely over time, especially in their long-run movements, but often also in their year-by-year behavior. The series appear both stationary and volatile in the seventeenth and eighteenth century, showing a downward trend in the late eighteenth and early nineteenth century, and are rather stable throughout the remainder of that century.

The twentieth century is most volatile for both series, with large swings in real rents and prices, especially during the two world wars and in the inter-war period. Ironically, a measure by the government aimed at keeping rents at stable levels is the cause for the high volatility in real rents. In 1917, the Dutch government fixed rents in the lower and middle housing market segments to 1916 levels. Due to high inflation at the end of WW I, these fixed nominal rents resulted in a severe drop in real rents, before a period of deflation, caused by a return to the gold standard, drove real rents up to unprecedented levels (Nijssen, 2000). In 1934, real rents peaked at 8 times their 1918 level. It is interesting to observe that, although rent regulation was officially suspended in the period from 1927 through 1940, rents did not adjust downwards despite the Dutch government's policies to deflate wages and prices. During the German occupation, rents were again fixed. After WW II rents stayed highly regulated with maximum annual increases being determined by law – a system still in place today. This has coincided with the longest consistent rise in the level of real rents in Amsterdam's history.

In sum, the year 1916 can be seen as the beginning of a new regime. Before, rents were determined by the market and remained relatively constant in real terms. With substantial governmental intervention thereafter, rents developed very smoothly in nominal terms but displayed high volatility in real terms.

Real prices appear more volatile than rents, with periods of large fluctuations when rents are stable. For example, in the early 1670s, a very volatile decade for the Dutch republic, rents decline, but prices fall much further. Another example is the large peak in house prices around 1780, which corresponds to the fourth Anglo-Dutch war (Eichholtz, 1997). Also a notable price movement occurs in the late 1970s and early 1980s. At the time the

Dutch housing market experienced a house price bubble followed by a bust, but rents remained stable, as Figure 3 shows.

The second striking observation from Figure 3 is that neither the real price nor the real rent index increases dramatically in 355 years. The real price and rent indices, starting both at 100 in 1650, reach respective levels of 278.79 and 251.13 in 2005. However, for most of the sample period the indices vary around 100. The upward climb of real rents and house prices only started in the 1950s; they have now both reached their highest levels ever.

Besides house rents, we also use the market interest rate as a fundamental. Unfortunately, we do not have a single source covering the complete 355-year sample of housing market data, thus we combine several sources that allow us to go back to 1783. For the period 1783 through 1795, we calculate bond yields on the basis of information regarding prices and coupons for bonds issued by the Province of Holland as stated in van Zanden (2000). From 1796 through 1813, we rely on price-quotes of interest bearing government bonds issued by the Treasury of the City of Amsterdam, as provided by the official price list of the Amsterdam Stock Exchange.

In 1814, the debt of the Dutch government was restructured, and in that year, a perpetual government bond was issued. Two more perpetual bonds were issued in 1900. We use the government yield index that Eichholtz and Koedijk (1996) created on the basis of these bonds for the period from 1814 through 1955. Since the Dutch government has been buying back these bonds in the last decades, their current market prices no longer reflect

market interest rates, and therefore, we augment this series with a series of long government bond yields from the Central Bureau of Statistics (CBS) from 1956 onward.

Tables 1 and 2 show the mean annual change and volatility of house prices, rents, and interest rates. Numbers are provided in nominal and in real terms, over the period from 1650 through 2005. We also provide this information for various sub-periods identified as having similar demographic and economic conditions in the city of Amsterdam.

Focusing on the real changes and rates, it is clear that the majority of the growth in prices and rents occurred in the decades after World War II. In the period before that, including two world wars and the Great Depression, real house prices and rents fluctuated more than in any of the other sub-periods. Inflation during and directly after World War I first halved real values, followed by a unique period of deflation that led both prices and rents to peak in the 1930s. The sub-period that had the strongest decline in real house prices and rents was from 1781 to 1814, which was the only extended period in Amsterdam's recorded history with a consistently declining population. This period saw real prices decline on average by 1.6 percent per year (or -0.0386 in logarithmic terms). In contrast to bubble periods, we see a 33-year period of sustained price declines, implying a market implosion. Interestingly real rents decline also, but at a slower 1.3 percent per year (or -0.0186 in logarithms) pace. This evidence clearly contradicts the popular perception that housing prices only go up, and that even if they do go down, it will only be for short periods.

----- Table 1 and 2: Changes in Nominal and Real Prices, Rents and Interest Rates -----

Regarding the interest rate, two striking features are evident in Table 2. First is the very high real interest rate from 1815 through 1850. During this period, the real interest rate averaged over 5% per year. This period followed a sustained economic and political crisis, which resulted in a restructuring of government debt. As a result, Dutch government debt was probably not regarded as risk-free. The second striking feature is the negative real interest rate for the post-World War II period. We find an average interest rate of -0.08% between 1946 and 1973.

B. Testing for Stationarity

We use market rents and interest rates as proxies for housing fundamentals. The first step is to determine if the two indices are stationary using the Augmented Dickey-Fuller tests. A series is considered non-stationary if it contains a unit root. We follow Dickey and Fuller (1981) to determine the existence of a unit root and therefore whether the series is stationary. The Dickey-Fuller test requires estimating the following autoregressive (AR(p)) process for the rent (L) and price (P) series:

$$\Delta y_t = \mu + \beta^* y_{t-1} + \beta_1^* \Delta y_{t-1} + \beta_2^* \Delta y_{t-2} + \dots + \beta_{p-1}^* \Delta y_{t-p+1} + u_t \quad (1.)$$

where y_t denotes the rent and price series, respectively, and $\beta^* = (\beta_1 + \beta_2 + \dots + \beta_p) - 1$.

The rent and price series contain a unit root (and are non-stationary) if we fail to reject the null hypothesis that $\beta^* = 1$ by comparing the estimated DF t -statistic to the critical values obtained from the Dickey-Fuller distribution.

Table 3 reports the augmented Dickey-Fuller (ADF) test statistics for the rent and price series. Based on the ADF statistics, we confirm that both series contain unit roots and thus are non-stationary. We repeat the test using first differences of each series (Table 4), and find that we are able to reject the null hypothesis of non-stationarity.

The choice of lag-length when estimating the augmented Dickey-Fuller equation is not exact. Thus, we also test for unit roots using the Phillips-Perron non-parametric procedure (Phillips and Perron, 1998), which corrects for autocorrelation. Tables 3 and 4 also report the Phillips-Perron test statistics, which confirm the presence of unit roots.

----- Table 3 and 4: Unit Root Tests -----

III. House prices and fundamentals

In the first step of our analysis we investigate the price-rent ratio in order to calculate potential price deviations from market fundamentals. Figure 4 shows the Amsterdam rent-price ratio for our complete sample period, as well as its average over that period. Obviously, when house prices are high relative to housing rents, the rent-price ratio is low. Thus, many market observers conclude that a rent-price ratio far below its historical average indicates that asset prices have increased beyond fundamental values (i.e. housing rents) – suggesting a possible bubble in the housing market.

----- Figure 4: The Rent-price Ratio -----

While the rent-price ratio is a measure of house prices relative to fundamentals, it does not give a complete picture of the housing market. For example, during the period 1781 through 1815 we see a dramatic rise in the rent-price ratio from 1.1 to 2.6, suggesting that prices are decreasing relative to rents. We have seen that during this period, rents and prices were both declining at relatively similar rates: -1.3 percent and -1.6 percent,

respectively. Even at this small difference in relative declines, the rent-price ratio changed substantially.

In addition, another important observation to be made from Figure 4 is that the rent-price ratio has deviated from its long-run average for long periods of time. For example, the ratio is below its long-run average for most of the eighteenth century, and above it for the first 60 years of the nineteenth century. Clearly, the graph suggests that a deviation of the rent-price ratio from its own average is not a guarantee for a quick reversion to that average. In the last 75 years, the ratio has been rather volatile, especially so during the middle decades of the twentieth century. We note that in the last 20 years, the Amsterdam rent-price ratio has declined, but it still remains within historical range.

Our further analysis is based on the methods employed by Campbell and Shiller (1988 and 2001), Brunnermeier and Julliard (2008), and Campbell et al. (2006). This approach is based on the present value model: the former two papers use dividends and interest rates as the fundamentals underlying stock prices, whereas the latter two papers use rents and interest rates as fundamentals for house prices. Of course, dividends, rents and interest rates are themselves resting on deeper foundations, such as economic development, demographics, technological change, and wars and other disasters. However, the method used by these authors assumes that rents and interest rates capture those fundamentals.

As in Campbell et al (2006), we define the gross return on housing (R_h) over the period from t to $t+1$ as a function of the price of housing (P) and the rental payment (L):

$$R_{h,t+1} = \frac{P_{t+1} + L_{t+1}}{P_t} . \quad (2.)$$

Taking logs and assuming the rent-price ratio is stationary, we can express (2) as

$$l_t - p_t = k + E_t \left[\sum_{j=0}^{\infty} \rho^j r_{h,t+1+j} - \sum_{j=0}^{\infty} \rho^j \Delta l_{t+1+j} \right] \quad (3.)$$

where $r_{h,t}$ is the log return to housing, p_t is the log house price, l_t is the log rent, Δl_{t+1} is

$l_{t+1} - l_t$, ρ is defined as $\frac{1}{1 + e^{(\overline{l-p})}}$ with $(\overline{l-p})$ the long-run average rent-price ratio, and

k is a constant of linearization that equals $(1-\rho)^{-1} [\ln(\rho) + (1-\rho)\ln(1/\rho - 1)]$. Campbell et

al (2006) show that by defining the return to housing as a function of an interest rate and

a risk premium ($r_h = i + \pi_h$), the rent-price ratio can be decomposed into three components

consisting of the discounted expected future real interest rates, the discounted expected

future rent growth, and the discounted housing risk premium. Thus, the rent-price ratio is

expressed as:

$$l_t - p_t = k + \sum_{\tau=1}^{\infty} \rho^{\tau-1} \hat{E}_t [i_{t+\tau}] + \sum_{\tau=1}^{\infty} \rho^{\tau-1} \hat{E}_t [\pi_{h,t+\tau}] - \sum_{\tau=1}^{\infty} \rho^{\tau-1} \hat{E}_t [\Delta l_{t+\tau}] \quad (4.)$$

where \hat{E}_t is the conditional expectation computed from a τ -period VAR forecast.

For each year between 1785 and 2005, we compute $l_t - p_t$ using the Amsterdam house price

and rent indices scaled to the 2002 ratio of 4.5 percent⁴. At each period t , we calculate

the average rent-price ratio over the prior 40-years ($t-1$ to $t-40$) as an approximation of

$(\overline{l-p})$. We then calculate ρ and k for each year based on our $(\overline{l-p})$ approximation. We

approximate the discounted expected future rent growth, discounted expected future

housing risk premium, and discounted expected real interest rate in (4) for each year t

based on 40-year forecasts for each variable obtained from the maximum likelihood

estimation of a VAR(2) model over the period $t-1$ to $t-40$.⁵

Based on our estimates of the fundamental values driving the rent-price ratio, we calculate the pricing error as

$$\varepsilon_t = (l_t - p_t) - \left(\tilde{k}_t + \tilde{i}_t + \tilde{\pi}_t - \tilde{\Delta}l_t \right) \quad (5.)$$

where \tilde{k} , \tilde{i} , $\tilde{\pi}$, $\tilde{\Delta}l$ denote our calculated approximations of the constant of linearization, the future real rate, future housing risk premium, and future rental growth, respectively. This pricing error represents the price deviations from fundamentals and is the focus of our subsequent analysis.

----- Figure 5: Rent-price Ratio and Theoretical Counterpart -----

----- Figure 6: The Pricing Error -----

Figure 5 shows that the theoretical rent-price ratio based on fundamentals closely follows the actual rent-price ratio through time. The fundamentals-based ratio is less volatile, however, both in year to year changes and in long-term swings. Figure 6 depicts the difference between the rent-price ratio and its theoretical counterpart. This graph shows that prices (or rents) can deviate from fundamentals for extended periods of time. For example, throughout the 19th century, the pricing error was continuously positive, indicating that actual rents were higher or the actual prices lower than predicted by our model. Starting with World War I, a period of financial turbulences left its mark both on the actual rent-price ratio and on its fundamental counterpart. During WWI, The Netherlands first experienced a period of strong inflation, followed by deflation in the early 1920s and during the early 1930s, again followed by inflation in the late 1930s and WW II. For both series, volatility shoots up caused by huge swings in house prices and inflation⁶. In these uncertain times, house prices seem to be more depressed than

fundamentals suggest, indicating that investors attached a substantial discount to long term investments like housing.

Throughout the second half of the twentieth century the magnitude of the mispricing declines as the distortions from the turbulent (inter)war periods fade out. Alternating periods of relative over-/underpricing of homes with regard to fundamentals can be observed. For example, in the 1970s, home prices appreciate much more than suggested, as low after-tax mortgage costs diminished in real terms through high inflation. This bubble lasts for a few years only. Residential real estate investors' exuberance tips over when real interest rates increase sharply in the 1980s as the targeting of inflation becomes a prime concern of the monetary policy. The rent-price ratio not only returns to its fundamental value, but overshoots in the following years, indicating depressed market sentiments. From 1993 onwards, the rent-price ratio remains constantly below its fundamental counterpart, which suggests that the steep increase in house prices in the last decade is not sustainable in the longer run.

IV. Adjustment mechanisms

Since continuously negative or positive pricing errors have occurred over the varying time frames, the question emerges as to whether prices or rents will correct to eliminate the mispricing. Step three of our analysis deals with this question and investigates the rent-price ratio adjustment mechanism.

Following Gallin (2004), we estimate the following vector error correction model:

$$\Delta y_t = A_0 y_{t-1} + A_1 y_{t-1} + A_2 x_{t-1} + \eta_t \quad (6.)$$

where y_t is defined as $(\ln(R) - \ln(P))'$, and x_{t-1} includes exogenous variables influencing Δy_t . Matrix A_1 represents the product of the cointegration vector and the matrix containing the error correction coefficients (Gallin 2004). We formally test for the existence of a cointegration vector for the price and rent series and if this vector is different from $(1 - 1)$. We find no evidence for the cointegration vector to differ from $(1 - 1)$, which is in line with theory and allows for a more efficient estimation of the model. A positive (negative) error correction coefficient for prices implies that prices will decrease (increase) when the current rent-price ratio is low relative to the long run average – and vice versa for rents: a positive coefficient suggests falling (increasing) rents in times of a relatively low (high) rent-price ratio.

Since our bond yield series only begins in 1783, we cannot include it in the model for the entire period. Thus, the first model covers the entire sample from 1650 to 2005, but contains only the rent and price series. The second model covers the period from 1783-2005 and includes the bond yields as an exogenous variable.

Table 5 reports the estimated error correction coefficients for both specifications. The signs of all error correction coefficients are in line with expectations. For prices, the error correction coefficients are statistically significant at the 5% confidence level. For rents, the coefficient in the specification including bond yields is significant as well. The evidence in Table 5 suggests that when prices diverge from fundamentals both rents and prices can be the mechanism for restoring equilibrium. However, the absolute size of the price coefficients is 4 to 6 times higher than the size of the rent coefficients. As a result, we conclude that rents and prices do adjust to imbalances, and, consistent with Gallin (2004), our results show that prices appear to adjust more than rents.

----- Table 5: Error Correction Coefficients -----

V. Conclusions

One of the primary problems associated with identifying the presence of pricing bubbles in asset markets is the lack of sufficiently long time-horizon data. Thus, the purpose of this paper is to utilize a 355-year time series of real house prices and rents to investigate whether substantial deviations of market prices away from market fundamental values can persist.

Our analysis consisted of two parts. First, we estimated a measure of housing market mispricing based on the relationship between market fundamentals (expected rent growth and expected house price appreciation) and the price-rent ratio. Second, we investigated the link between the rent-price ratio and changes in rents and house prices over various time horizons.

Several lessons can be learned from our analysis. First, house prices and rents are cointegrated, indicating that they are likely to be driven by the same underlying fundamentals. Second, our analysis of the rent-price ratio reveals sustained periods of “bubble” and “crisis” conditions, which can continue without a corresponding correction (or crash). Third, our analysis shows that changes in house prices and rents are both mechanisms for “correcting” imbalances between prices and fundamentals. Between these, prices appear to have greater importance in correcting disequilibria.

Based on these findings, our investigation into the long-run developments of house prices and rents has implications for the current debate over the recent price increases in worldwide housing markets. While it appears that many markets currently have bubble characteristics, our study shows that bubble crashes are not inevitable in the short run. While prices do revert back to fundamentals, this reversion may take decades.

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Appendix A1

The House Price Index

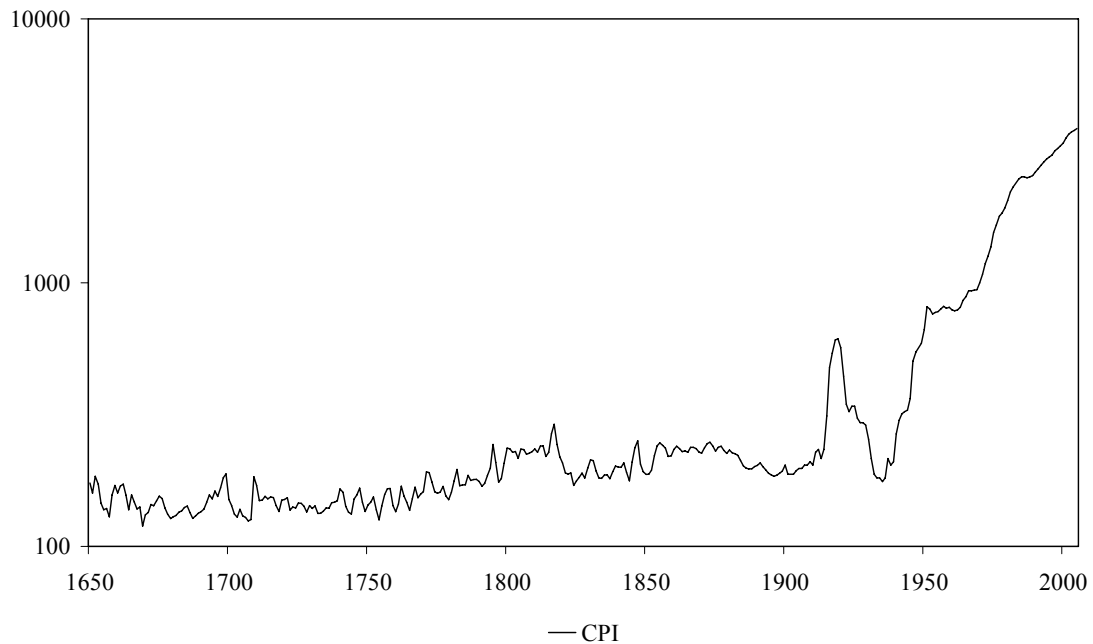
Regarding house prices for the period 1650 – 1965, we use an index based on the same housing transactions data as Eichholtz' (1997) biennial Herengracht index. This series is based on transactions of the houses on the Herengracht, a canal in Amsterdam, and is constructed using repeated-measures regression. 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 2005, the house price series are based on a local index constructed by the Dutch Association of Real Estate Agents and the Central Bureau of Statistics. This index is a mean index of Dutch house transaction prices.

The Rent Index

We also use multiple sources to construct our rental index. From 1650 through 1850, we use data on residential rents for Amsterdam from Eichholtz and Theebe (2007). This series is a repeated market rent index, based on a broad set of rental houses owned by the institutional investors of that time, as collected by Lesger (1986). Unfortunately, the sample could not be extended beyond 1850, since to our knowledge no sufficient number of rent records is available in the archives for Amsterdam after 1850.

From 1851, we use two national house rent indices. The first series covers the period 1851 through 1913 and is from van Riel (2006). In the Netherlands, tax authorities estimated the potential rental income that could be generated from owner occupied residential real estate, since the imputed rents were treated as income and taxed. The rent capacity is not a percentage of the value of house, which would make the rent index a direct function of prices. Instead, the average rent of comparable houses in the vicinity was taxed, providing information on the development of market rents. The second dataset spans the remaining period 1914 through 2005, and is based on a range of publications from the Dutch Central Bureau of Statistics (CBS, 1939, 1948, 1999, 2008).

Figure 1:
Consumer Price Index, 1650-2005

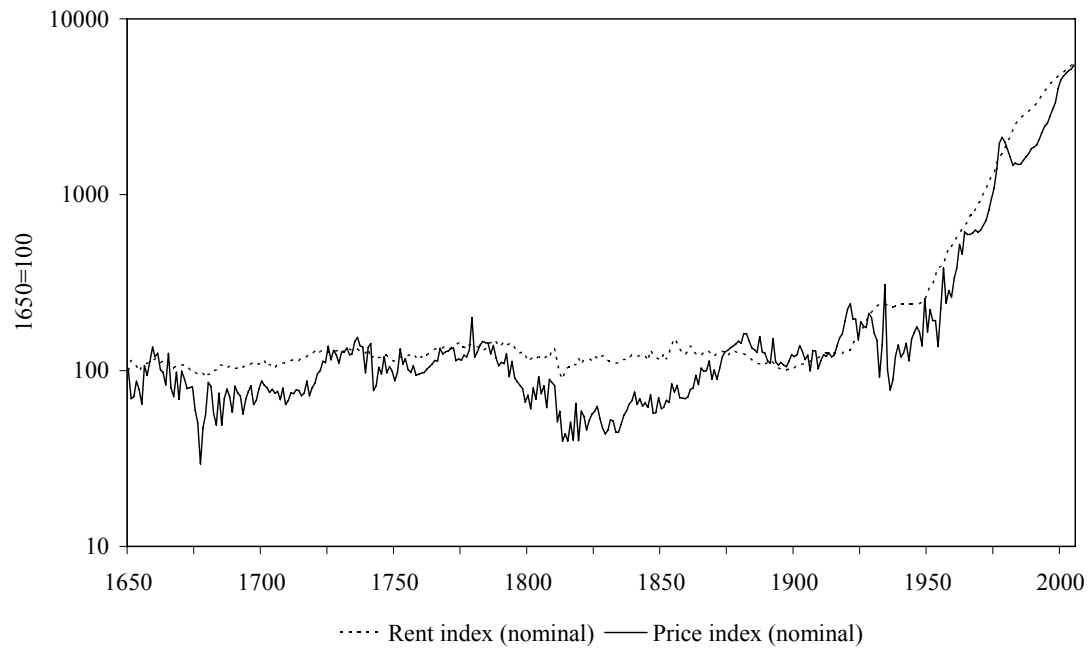


Notes: Over the first 250 years, the Dutch currency was based on gold, leading to stable consumer prices throughout the 18th and 19th century. At the beginning of World War I, however, the gold standard could not be sustained anymore and money supply massively increased. As a consequence, consumer prices tripled until 1918. In the years after the war, the banking sector suffered from the only banking crisis in its long history, caused by non-performing loans originating from the war time. When The Netherlands returned to the gold standard in 1925, prices gradually reverted to their historical means. In 1936, The Netherlands again had to move away from gold – and prices trended upwards since then.

Graph is scaled in logarithms.

Sources: Nusteling (1985), Van Riel (2006), Central Bureau of Statistics

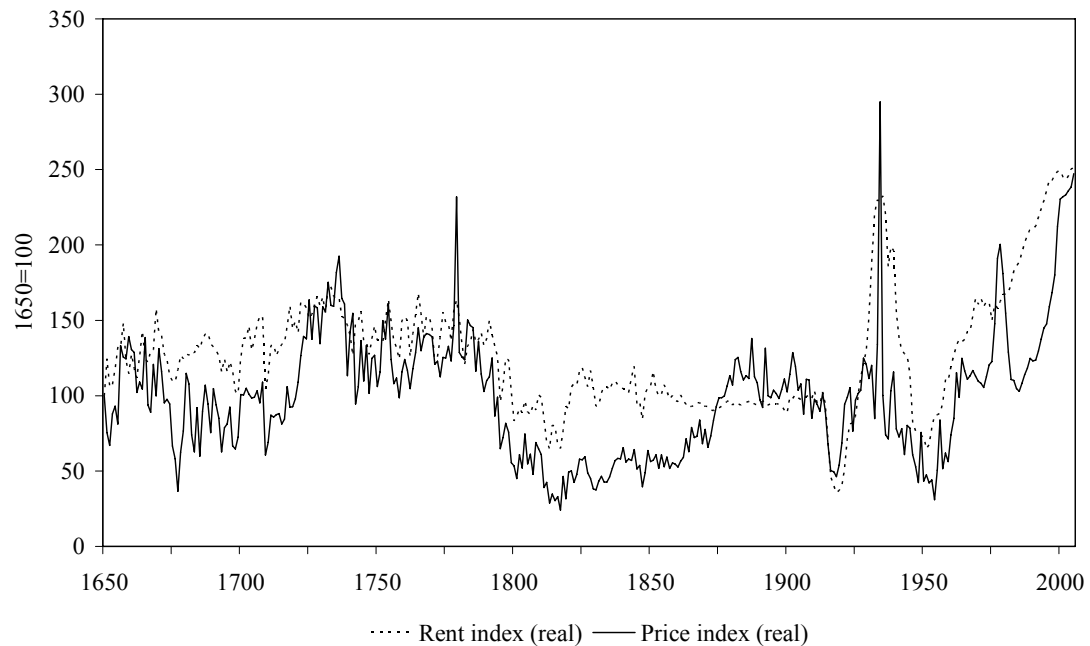
Figure 2:
Nominal Rents and House Prices, 1650-2005



Notes: Graph is scaled in logarithms.

Sources: For the house price index: Van Eeghen, Rosegaarde Bisschop, and Wijnman (1976), NVM.
For the rent index: Eichholtz and Theebe (2007), Van Riel (2006), Central Bureau of Statistics (1939, 1948, 1999, 2008).

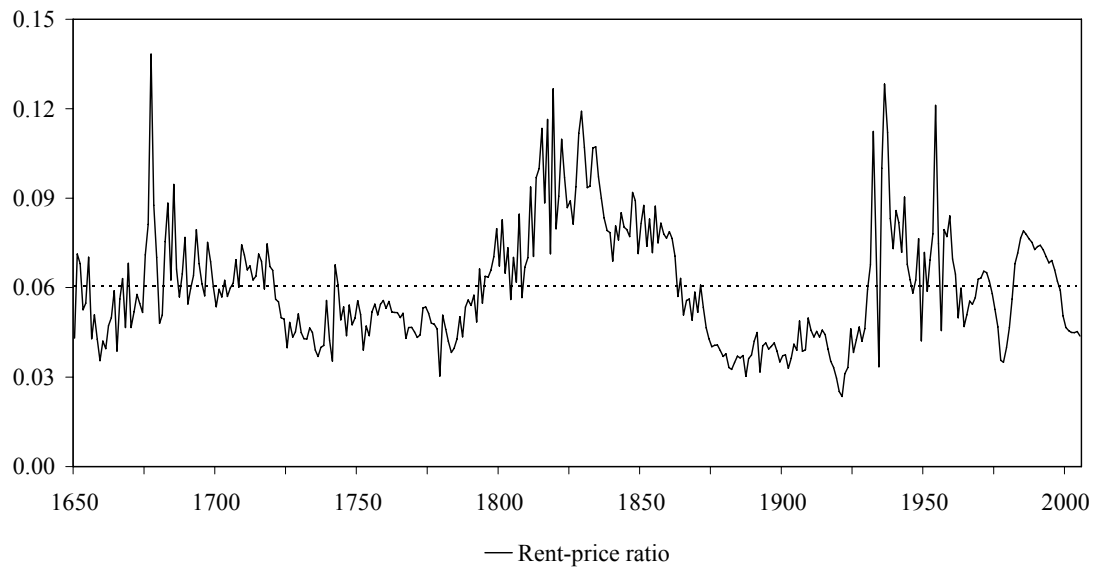
Figure 3:
Real Rents and House Prices, 1650-2005



Notes: Neither the real price nor the real rent index increases dramatically in 355 years. The real price and rent indices, starting both at 100 in 1650, reach respective levels of 278.79 and 251.13 in 2005. However, for most of the sample period the indices vary around 100. The upward climb of real rents and house prices started only in the 1950s, and they have now both reached the highest levels in history.

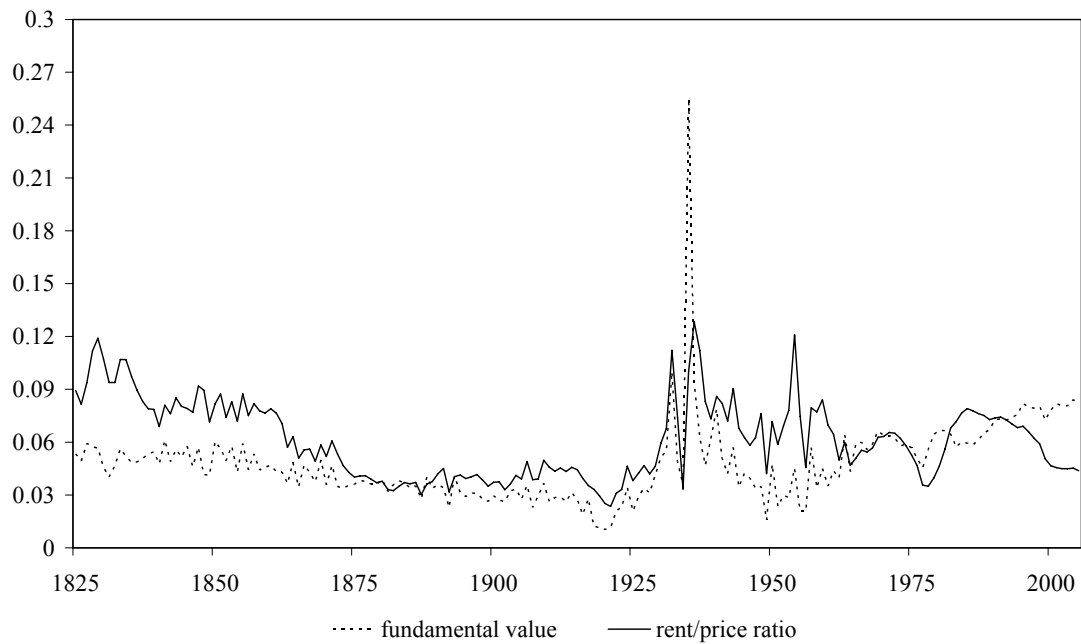
Sources: For the house price index: Van Eeghen, Rosegaarde Bisschop, and Wijnman (1976), NVM. For the rent index: Eichholtz and Theebe (2007), Van Riel (2006), Central Bureau of Statistics (1939, 1948, 1999, 2008).

Figure 4:
Rent-price Ratio, 1650-2005



Notes: Information on both rents and prices are available for only very few houses and years at the same time in our sample, so we do not observe the rent-price ratio directly. We therefore rescale the aggregated rent-price ratio based on the rent and house price indices to 4.5% in 2001, which is the annual rental yield direct return on Dutch residential real estate as stated in the ROZ/IPD index for this year (ROZ, 2007).

Figure 5:
Rent-price Ratio and Theoretical Counterpart Based on Fundamentals



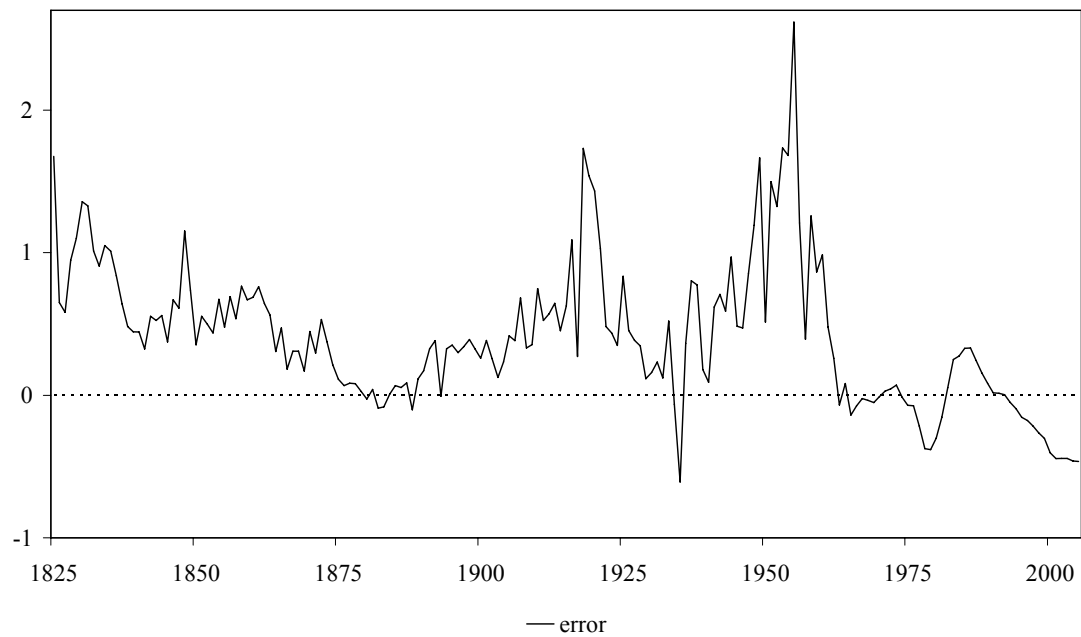
Notes: The theoretical rent-price ratio is expressed as

$$l_t - p_t = k + \sum_{\tau=1}^{\infty} \rho^{\tau-1} \hat{E}_t[l_{t+\tau}] + \sum_{\tau=1}^{\infty} \rho^{\tau-1} \hat{E}_t[\pi_{h,t+\tau}] - \sum_{\tau=1}^{\infty} \rho^{\tau-1} \hat{E}_t[\Delta l_{t+\tau}]$$

where $r_{h,t}$ is the log return to housing, p_t is the log house price, l_t is the log rent, Δl_{t+1} is $l_{t+1} - l_t$, ρ is defined as $1/(1 + e^{(\bar{l}-p)})$ with $(\bar{l}-p)$ the long-run average rent-price ratio, and k is a constant of

linearization that equals $(1 - \rho)^{-1}[\ln(\rho) + (1 - \rho)\ln(1/\rho - 1)]$. \hat{E}_t is the conditional expectation computed from a τ -period VAR forecast.

Figure 6:
Rent-price Ratio Error ε in Logs, 1825-2005



Notes: The rent-price ratio error represents the price deviations from fundamentals and is calculated as

$$\varepsilon_t = (l_t - p_t) - \left(\tilde{k}_t + \tilde{i}_t + \tilde{\pi}_t - \tilde{\Delta}l_t \right),$$

where \tilde{k} , \tilde{i} , $\tilde{\pi}$, $\tilde{\Delta}l$ denote our calculated approximations of the constant of linearization, the future real rate, future housing risk premium, and future rental growth, respectively.

Table 1:
Changes in Nominal House Prices, Rents and Interest Rates

Period	Period characterization	$\Delta_1 \ln(\text{Price})$		$\Delta_1 \ln(\text{Rent})$		Interest rates (in %)	
		Mean	Std.	Mean	Std.	Mean	Std.
1650-2005	–	0.0116	0.1973	0.0111	0.0434	4.79	0.08
1650-1670	Strong economy, rapid urbanization, expanding city	0.0054	0.2676	0.0007	0.0479	-	-
1671-1720	Economic slowdown, slow population growth	-0.0032	0.2058	0.0037	0.0302	-	-
1721-1780	Economic slowdown, stable population	0.0056	0.1719	0.0013	0.0327	-	-
1781-1814	Economic crisis, shrinking population	-0.0293	0.1911	-0.0094	0.0620	5.68	1.80
1815-1850	Economic stabilization, modest population growth	0.0091	0.1808	0.0034	0.0434	4.945	0.64
1851-1913	Strong economy, increasing population	0.0116	0.1219	0.0016	0.0396	3.67	0.53
1914-1945	Turmoil economy, stable population	0.0082	0.3118	0.0196	0.0300	3.9759	0.6839
1946-1973	Very strong economy, increasing population	0.0573	0.2597	0.0571	0.0382	4.76	1.60
1974-2005	Strong economy, increasing population	0.0594	0.0913	0.0484	0.0241	7.15	1.90

Notes: This table provides means and standard deviations of changes in the natural logarithms of nominal house prices and house rents, as well as the nominal interest rate. Separation between periods is based on the economic development of Amsterdam, population growth, and city expansion. Interest rates are available for the period 1796-2005.

Sources: See the text for index sources. For period demarcations see De Vries (1984), Van Zanden (1994), Spies et al (1993), De Vries and Van der Woude (1995), and Burger (2006).

Table 2:
Changes in Real House Prices, Rents, and Interest Rates

Period	Period characterization	$\Delta_1 \ln(\text{Price real})$		$\Delta_1 \ln(\text{Rent real})$		Real interest rates (in %)	
		Mean	Std.	Mean	Std.	Mean	Std.
1650-2005	–	0.0022	0.2065	0.0021	0.0894	0.03	0.08
1650-1670	Strong economy, rapid urbanization, expanding city	0.0078	0.2193	0.0089	0.1216	-	-
1671-1720	Economic slowdown, slow population growth	-0.0059	0.2350	0.0010	0.0861	-	-
1721-1780	Economic slowdown, stable population	0.0045	0.2114	-0.0029	0.0917	-	-
1781-1814	Economic crisis, shrinking population	-0.0386	0.2168	-0.0186	0.1098	5.94	8.00
1815-1850	Economic stabilization, modest population growth	0.0134	0.2025	0.0077	0.0916	5.05	8.40
1851-1913	Strong economy, increasing population	0.0094	0.1267	-0.0006	0.0352	3.38	3.93
1914-1945	Turmoil economy, stable population	-0.0081	0.2125	0.0033	0.1575	1.30	15.52
1946-1973	Very strong economy, increasing population	0.0129	0.2702	0.0127	0.0887	-0.08	8.76
1974-2005	Strong economy, increasing population	0.0246	0.0898	0.0136	0.0246	3.5730	2.3907

Notes: This table provides means and standard deviations of changes in the natural logarithm of real house prices and house rents, as well as the real interest rate. Separation between periods is based on the economic development of Amsterdam, population growth, and city expansion. Interest rates are available for the period 1724-2005.

Sources: See the text for index sources. For period demarcations see De Vries (1984), Van Zanden (1994), Spies et al (1993), De Vries and Van der Woude (1995), and Burger (2006).

Table 3:
Unit Root Tests for Levels of Real Rent and House Price Indices

Lag	Log(Real Rent Index)		Log(Real House Price Index)		Log(Price-Rent Ratio)	
	ADF	PP	ADF	PP	ADF	PP
1	6.44 (0.9999)	7.32 (0.9999)	0.79 (0.9999)	0.24 (0.9999)	-4.36 (0.0005)	-5.58 (0.0001)
2	5.81 (0.9999)	7.18 (0.9999)	1.28 (0.9999)	0.57 (0.9999)	-3.59 (0.0067)	-5.46 (0.0001)
3	5.58 (0.9999)	7.17 (0.9999)	1.76 (0.9999)	0.86 (0.9999)	-3.06 (0.0315)	-5.44 (0.0001)
4	4.6 (0.9999)	7.04 (0.9999)	1.92 (0.9999)	0.99 (0.9999)	-2.91 (0.0461)	-5.56 (0.0001)
5	3.7 (0.9999)	6.83 (0.9999)	2.04 (0.9999)	1.09 (0.9999)	-2.75 (0.0667)	-5.68 (0.0001)
6	3.55 (0.9999)	6.68 (0.9999)	1.59 (0.9999)	1.01 (0.9999)	-3.01 (0.0358)	-5.89 (0.0001)

Notes: For each series we present the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test statistics for 1-6 lags. Numbers in parentheses are asymptotic p-values.

Table 4:
Unit Root Tests for First Differences of Real Rent and House Price Indices

Lag	Log(Real Rent Index)		Log(Real House Price Index)	
	ADF	PP	ADF	PP
1	-10.08 (<0.0001)	-15.35 (<0.0001)	-17.42 (<0.0001)	-26.7 (<0.0001)
2	-8.14 (<0.0001)	-15.47 (<0.0001)	-14.35 (<0.0001)	-27.39 (<0.0001)
3	-6.17 (<0.0001)	-15.58 (<0.0001)	-11.57 (<0.0001)	-28.08 (<0.0001)
4	-4.89 (<0.0001)	-15.77 (<0.0001)	-9.97 (<0.0001)	-28.48 (<0.0001)
5	-4.38 (<0.0001)	-16.03 (<0.0001)	-7.76 (<0.0001)	-28.62 (<0.0001)
6	-3.62 (<0.0001)	-16.27 (<0.0001)	-7.54 (<0.0001)	-28.48 (<0.0001)

Notes: For each series we present the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test statistics for 1-6 lags. Numbers in parentheses are asymptotic p-values.

Table 5:
Error Correction Coefficients for Rents and Prices

Specification	Error correction coefficients	
	ΔP	ΔR
1650-2005 no exogenous variables	0.120 (3.56)	-0.018 (-1.20)
1783-2005 bond yields as exogenous variables	0.081 (2.26)	-0.023 (-2.46)

Notes: t-values in parentheses.

The signs of all error correction coefficients are in line with expectations. For prices, the error correction coefficients are statistically significant at the 5% confidence level. For rents, the coefficient in the specification including bond yields is significant as well.

Endnotes

¹ For example, see Remarks by Chairman Alan Greenspan to the American Bankers Association Annual Convention, Palm Desert, California (via satellite), September 26, 2005 (<http://www.federalreserve.gov/boardDocs/Speeches/2005/200509262/default.htm>).

² In addition, Higgins and Osler (1998) provide additional evidence that regional housing bubbles occurred around 1989.

³ The use of the rent-price ratio as a measure of price movement relative to fundamental value is motivated by the similar use of the dividend-price ratio in stock market research (e.g. Leamer, 2002; and Campbell and Shiller, 2001)

⁴ We cannot observe the rent-price ratio directly, as information on both rents and prices are available for only very few houses and years at the same time in our sample. We therefore rescale the aggregated rent-price ratio based on indices to 4.5% in 2001, which is the rental yield for that year on Dutch residential real estate as stated in the ROZ/IPD index for this year (ROZ, 2007). We find our results to be robust for different scales.

⁵ We checked the robustness of our results under several VAR specifications, changing the number of lags and different length of data on which the VAR is based. This did not markedly change the results.

⁶ In the actual rent-price ratio series, the direct impact of changes in the CPI cancels out. Expectations on future changes, however, are still incorporated into prices and to a lesser extent into rents.