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 estimate the deviation of house prices from fundamentals and find that these deviations can be persistent and long-lasting. Furthermore, 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.

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Manny economists and policy makers worry that asset price bubbles may quickly turn into busts, resulting in economic contraction. In the last few years, the world has seen that such fears can be justified. For example, house prices in the U.S. increased over 5 percent per year from 2000 to 2006 with some local markets experiencing increases of more than 20 percent per year. Then, from 2007 to 2009, the U.S. witnessed a significant correction to the housing market with aggregate real housing values declining 26 percent. The same holds for other countries. Spain and Ireland, for example, saw average house prices increase between 1997 and 2007 of nearly 190 percent and 240 percent, respectively. These countries have seen their house prices fall rapidly since then. More recently, the rapid rise in property values in China has raised concerns of a bubble forming there.[1] However, the housing market that experienced one of the biggest rises of all, South Africa, has merely stabilized.[2]

Although much of the popular press takes for granted that the recent house price increases seen around the world are evidence of a "bubble" in housing markets, economists note that actually recognizing an asset price bubble prior to a price crash is notoriously difficult. In fact, 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 had been 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 U.S. housing market. Himmelberg, Mayer and Sinai (2005) also examined the traditional metrics of housing market fundamentals, including the house price growth rates, price-to-income ratio, and rent-to-price ratio, and noted that the absence of interest rates in such analysis can lead to false conclusions. Their main conclusion, based on housing indices from 1980 to 2004, was that the cost of home ownership rose moderately relative to the cost of renting, even though larger deviations from fundamentals occurred in some markets.[3]

One 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 may be possible that bubble conditions are sustained, followed by gradual restoration of the equilibrium relationship.

This paper updates the time series of real house prices and rents first described in Eichholtz (1997) and Eichholtz and Theebe (2007) to investigate the behavior of house prices relative to fundamentals spanning a time period of 355 years. We find persistent and substantial deviations of market prices away from market fundamental values. 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. This convergence may take decades. The mechanism through which the market corrects mispricing appears to occur mainly through prices rather than through rents.

I. Literature review

A number of recent studies have explored the connection between prices and fundamentals. For example, Brunnermeier and Julliard (2008) studied the link between inflation and house prices, mainly based on quarterly data for the U.K. from 1966 to 2004. They examined 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 found 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 concluded that the latter component is strongly driven by movements in inflation. In addition, Gallin (2004), using U.S. data from 1970 to 2003, showed that long-horizon regressions support the use of the rent-price ratio as an indicator of housing market value.[4]

Other papers that studied the rent-price ratio as the yardstick for fundamental valuation are Ayuso and Restoy (2003), Zhou and Sornette (2003), Chung and Kim (2004), Black, Fraser and Hoesli (2006), Lai and van Order (2006), and Hott and Monnin (2006). In general these papers found 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 studied the Vancouver housing market for the period from 1979 to 1991.

On the theoretical front, Abreu and Brunnermeier (2001) derived a model indicating 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) showed 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.

Furthermore, Glaeser and Gyourko (2009) argue that arbitrage between the housing rental market and the owner occupied market is difficult. Rental homes tend to be very different from owner occupied ones, both in terms of location and in terms of the building itself, and households only rarely switch from the one housing type to the other. They conclude that the no arbitrage assumption is difficult to maintain in the short run.

To summarize, the current literature concerning house prices and fundamentals suggests that prices may deviate from fundamentals over longer periods of time, and that financial arbitrage between owning and renting is difficult in the short run. This suggests that it is meaningful to investigate the relation between house prices and fundamentals in the (very) long run. 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 40 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

House Prices

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). These data are from Van Eeghen, Bisschop, and Wijnman (1976), covering the period from 1650 through 1965. The dataset covers all transactions of dwellings on the Herengracht, one of the central canals in Amsterdam. As noted in Eichholtz (1997), the Herengracht was constructed between 1585 and 1660. By 1680, most of the lots on the canal were developed and from 1616 until the present day, the Herengracht has remained one of the most prestigious addresses in Amsterdam. The price index is computed following methods outlined in Bailey, Muth and Nourse (1963) and Case and Shiller (1987).[5] As we focus on the housing transactions alone, we disregard the beginning and end of the Eichholtz' (1997) sample period to compute an annual repeat sales index.[6]

Second, we augment the Herengracht index with house price data from the CBS, the Dutch national statistics bureau, and the NVM, the national organization of Dutch realtors, covering the period from 1965 through 2005. The CBS/NVM series covers approximately 60 percent of all housing transactions in the country, with relatively more weight in the western part of the Netherlands. The numbers denote median house prices for the year.

Rental Prices

The rental index is also constructed from multiple sources. For the first 200 years, from 1650 through 1850, we use data concerning residential rents for Amsterdam from Eichholtz and Theebe (2007). This series is a repeat market rent index, based on data reported in Lesger (1986) for a broad set of rental houses, varying in location and structural quality, and owned by the institutional investors of that time: orphanages, hospitals, and poor-relief boards. In all, this dataset covers 7,670 market rent observations for 1,055 properties scattered across an area that is currently the center of Amsterdam. The market rents are observed at the beginning of new rent contracts. For the period from 1650 to 1850, the average number of annual observations is 24.1, and the minimum is 4.

We could not extend the sample of individual rent observations beyond 1850, unfortunately, since sufficient numbers of rent records are not available in the archives for Amsterdam after that year. Thus, for the period following 1850 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).

Rent control was introduced in the Netherlands in 1916/17, as part of a broader government policy concerning prices of basic needs. The 1916 "Distributiewet" regulated distribution and prices of basic foods, while the "Huurcommissiewet" of 1917 introduced rent control, fixing rents at the 1916 level, but later allowing controlled house rents to rise with inflation. Interestingly, while nominal rents had indeed been going up before that, causing public pressure for government intervention, rents in real terms had in fact been going down. Between 1914 and 1916, real rents declined 22 percent. Most Dutch housing rents have been under the control of the government since then, so from 1916 onwards the rent index mostly reflects controlled rents, and partly rents freely set in the market.

Inflation and Interest Rates

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.

Besides house rents, we also use the market interest rate as a fundamental, and combine several sources that allow us to go back to 1783.[7] 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. From 1814 through 1955 we use the government bond yield index created by Eichholtz and Koedijk (1996) on the basis of perpetual bonds issued in 1814 and 1900. 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 data with a series of long government bond yields from the Central Bureau of Statistics (CBS) from 1956 onward.

355-year Indices

Figure 1 provides a graph of the house price and rent indices, in real terms. The indices follow each other closely over time, especially in their long-run movements. 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.

Real house 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 declined, but prices fell much further. Another example is the large peak in house prices around 1780, which corresponds to the fourth Anglo-Dutch war (Eichholtz, 1997). As noted above, the Dutch government enacted rent control laws in 1916 that had the effect of substantially reducing the volatility in the rental index during the 20th Century. Thus, the notable price movement that occurs in the late 1970s and early 1980s reflects a house price bubble followed by a bust while rents remained stable due to rent control.

The second striking observation from Figure 1 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 197.1 and 203.2 in 2005. However, for most of the sample period the indices vary around 100. However, 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. During this period, real prices declined on average by 1.6 percent per year. In contrast to bubble periods, we see a 33-year period of sustained price declines, implying a market implosion. Interestingly real rents declined also, but at a slower 1.3 percent per year 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. The upward climb of real rents and house prices only started in the 1950s; they have now both reached their highest levels ever.

III. House prices and fundamentals

As a first step, we investigate the price-rent ratio in order to calculate potential price deviations from market fundamentals. Figure 2 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.

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, the period 1781 through 1815 saw a dramatic rise in the rent-price ratio from 4.6 percent to 11.4 percent, suggesting that prices decreased relative to rents. However, during this period, rents and prices both declined at relatively similar rates: -3.9 percent and -1.9 percent, respectively. Thus, even with this small difference in relative declines, the rent-price ratio changed substantially.

In addition, Figure 2 shows that the rent-price ratio deviates from its long-run average for substantial periods of time. For example, focusing on the period prior to 1916 that is free of rent control regulations, we see that the ratio is below the long-run average for most of the eighteenth century, and above it for the first 60 years of the nineteenth century suggesting that a deviation of the rent-price ratio from its own average is not a guarantee for a quick reversion to the 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 still remains within historical range.[8]

Our analysis builds on the methods employed by Campbell and Shiller (1988 and 2001), Brunnermeier and Julliard (2008), and Campbell et al (2009). This approach assumes that interest rates and rents (or dividends) capture the fundamentals such as economic development, demographics, technological change, and wars and other disasters. Thus, as in Campbell et al (2009), 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):

$$R_{h,t+1} = \frac{P_{t+1} + L_{t+1}}{P_t} . \tag{1}$$

Taking logs and assuming the rent-price ratio is stationary, we can express (1) as

$$l_t - p_t = k + E_t\left[\sum_{j=0}^{\infty} \rho^j r_{h,t+1+j} - \sum_{j=0}^{\infty} \rho^j \Delta l_{t+1+j}\right] \tag{2}$$

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 $1 \big/ \left(1 + e^{\left(\overline{l-p}\right)}\right)$ with $\left(\overline{l-p}\right)$ the long-run average rent-price ratio, and k is a constant of linearization that equals $(1-\rho)^{-1}\left[\ln(\rho) + (1-\rho)\ln(1/\rho - 1)\right]$.

Campbell et al (2009) 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:

$$l_t - p_t = k + \sum_{\tau=1}^{\infty} \rho^{\tau-1}\hat{E}_t\left[i_{t+\tau}\right] + \sum_{\tau=1}^{\infty} \rho^{\tau-1}\hat{E}_t\left[\pi_{h,t+\tau}\right] - \sum_{\tau=1}^{\infty} \rho^{\tau-1}\hat{E}_t\left[\Delta l_{t+\tau}\right] \tag{3}$$

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 percent.[9] 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 $\left(\overline{l-p}\right)$. We then calculate ρ and k for each year based on our $\left(\overline{l-p}\right)$ 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(1) model over the period *t-1* to *t-40.* We chose a lag of 1 based on the Schwarz' Bayesian Information Criterion (SBIC) for the overall data series.[10]

Table 1 gives an overview of our VAR estimation results. For 181 years (Panel A: 1825-2005), we estimate VAR models based on information from a 40 year rolling window. The forecasting models cover the real interest rate (i), the housing risk premium (Π), and the change in real rents (Δl). The first section summarizes the coefficients for the real interest rate forecast model:

$$i_t = \alpha_0 + \alpha_i i_{t-1} + \alpha_\Pi \Pi_{t-1} + \alpha_{\Delta l} \Delta l_{t-1} + \varepsilon_t, \qquad (4)$$

while the second section describes the housing premia forecast model:

$$\Pi_t = \beta_0 + \beta_i i_{t-1} + \beta_\Pi \Pi_{t-1} + \beta_{\Delta l} \Delta l_{t-1} + \varepsilon_t. \qquad (5)$$

The results from the real rent change forecast model:

$$\Delta l_t = \gamma_0 + \gamma_i i_{t-1} + \gamma_\Pi \Pi_{t-1} + \gamma_{\Delta l} \Delta l_{t-1} + \varepsilon_t \qquad (6)$$

are displayed in the bottom section. Columns 1, 2, and 3 display the inter-quartile values for the estimated coefficients for i_{t-1}, Π_{t-1}, and Δl_{t-1}, respectively. Column 4 displays the results of the Wald test that none of the included regressors explains the dependent variable and the last column shows the distribution of the R^2 measure of model fit.

The performance of our VAR models is surprisingly good when compared to studies based on modern data. For example, we see that over half of the yearly estimated VAR models have Wald statistics that denote statistical significance at the 5 percent level, indicating that we can reject the null hypothesis that none of the model factors explain the dependent variable in over half of the years.

We find that the coefficient for the first lag of the real estate rate variable has (on average) the highest statistical significance. Bond yields in year *t*, for instance, are mainly driven by bond yields in period *t-1*. For example, we find that 50% of the yearly estimated coefficients for α_i are significant at the 5% level. In contrast, rents and prices do not have a strong impact with 0.6% and 7% of the yearly coefficients for $\alpha_{\Delta l}$ and α_{Π} significant at the 5% level, respectively. In the second section of Panel A we also note that interest rates are an important factor impacting housing premia (Π), which again is in line with previous work. For example, we see that 32% of the β_i yearly estimated coefficients are significant at the 5% level. We also find that the lagged housing premium has a significant impact on the current housing premium with 78% of the yearly estimated coefficients for β_{Π} significant at the 5% level. Like Case and Shiller (1989, 1990) we find the predictability of housing returns in the opposite direction. In our data, housing excess returns are reverting to their mean, as indicated by negative coefficients for its lagged values. Throughout the centuries, the coefficients on the lagged housing premium are becoming less negative. In the last 10 years of our sample, the coefficients turn positive, reconciling our findings with studies on modern data.

Table 1 also reports results for two sub-periods (from 1825 through 1915 and from 1916 until 2005) to investigate the possible role of rent control in our results; the first period reflects completely free rental markets, while the other covers the regulated period. The introduction of rent control altered the predictability of changes in rents. In our “free” century (1825-1915), changes in rents were hardly predictable. For example, the coefficients for lagged values of rent changes ($\gamma_{\Delta l}$) are negative and only significant at the 5% confidence level in 7 out of 91 years. In addition, the median R^2 for this model is 11%. In contrast, during the subset 1916-2005, the presence of rent control links the nominal rents to changes in CPI and thereby transmits the autoregressive properties of the inflation time series to rents. As a result, in the third section of Panel C we note that the coefficients for lagged changes in rents ($\gamma_{\Delta l}$) are now positive and 29% of the yearly coefficients are statistically significant at the 5% level. Furthermore, the median R^2 for this model increases to 33%.

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

$$\varepsilon_t = (l_t - p_t) - \left(\tilde{k}_t + \tilde{i}_t + \tilde{\pi}_t - \Delta\tilde{l}_t \right) \tag{7}$$

where □□, □□,□□, *Δ*□□ 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 3 shows that the theoretical rent-price ratio based on fundamentals follows the actual rent-price ratio through time. The correlation between annual changes of observed and fundamental rent-price ratios is 0.19. However, the estimated correlations increase for shorter intervals. For example, over the non-rent controlled period prior to 1916 the correlation between the observed and fundamental rent-price ratios is 0.56. However, in the second period (1916-2005), the correlation drops to -0.11. As a result, we see that the fundamentals-based ratio is less volatile during the crisis years of the inter-bellum, both in year to year changes and in long-term swings.

Figure 4 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 second half of the 19th century, the pricing error was continuously negative, indicating that actual rents were lower or the actual prices higher 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 World War I, 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 1940s. For both series, volatility shoots up, caused by huge swings in house prices and inflation.[11] 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.

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:

$$\Delta y_t = A_0 y_{t-1} + A_1 \Delta y_{t-1} + A x_{t-1} + \eta_t \tag{8}$$

where y_t is defined as $\begin{pmatrix} \ln(R) & \ln(P) \end{pmatrix}'$, and x_{t-1} includes exogenous variables influencing Δy_t. Matrix A_0 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 whether it 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. Since 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 when the rent-price ratio is relatively low (high).

Table 2 reports the estimated error correction coefficients for the full time-period as well as the rent-controlled (1916-2005) and non-regulated (1650-1915) periods. In general, we see that the error correction coefficients for prices are statistically and economically more significant than the coefficients for rents. For example, the estimated error correction coefficients for the 1650-2005 period is positive and significant (at the 1% level) for prices but is not statistically significant for rents. However, we do see that for the sub-period 1916-2005, both estimated coefficients are statistically significant at the 1% level with prices being positive and rents being negative. Thus, the results indicate that when prices diverge from fundamentals both rents and prices can be the mechanism for restoring equilibrium. However, the absolute magnitude of the price coefficients is 6 to 7 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. Furthermore, we find that the prominent role of prices in the error correction process becomes even stronger in the years 1916-2005, when rent regulation hinders rental adjustments.

Overall, the results indicate that our key finding holds in both periods. That is, when the rent-price ratio indicates a disequilibrium situation, this disequilibrium may persist for a long time before prices and rents correct. Furthermore, our analysis suggests that when they do converge, prices will adjust faster than rents.

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, we 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.

Several lessons arise from our analysis. First, house prices and rents are cointegrated, indicating that the same underlying fundamentals likely influence both. Second, our analysis of the rent-price ratio reveals sustained periods of "bubble" and "crisis" conditions that 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 ongoing debate concerning the recent price increases and subsequent corrections in many of the worldwide housing markets. Our study shows that bubble crashes are not always inevitable in the short run. While prices do revert back to fundamentals, this reversion may take decades with the move towards equilibrium more a fading out than a crash. As a result, markets like Amsterdam, Cape Town, and Paris that have been characterized by strong price gains in the last decade and were widely thought of as overvalued, may not necessarily experience the free fall seen in other markets.

One of the implications of this analysis is that it is decidedly difficult to know when, or even if, an asset price bubble will collapse. The results suggest that it is unwise to use perfect hindsight to criticize lenders who originated mortgages at the peak of the market and subsequently suffered significant losses due to borrower defaults since historical trends show that it is possible for price bubbles to slowly deflate over long periods such that the losses may not have occurred. Finally, our results imply that lengthy periods of little or no house price appreciation are also possible. Thus, those looking for a speedy recovery in the housing market after the crisis may be disappointed.

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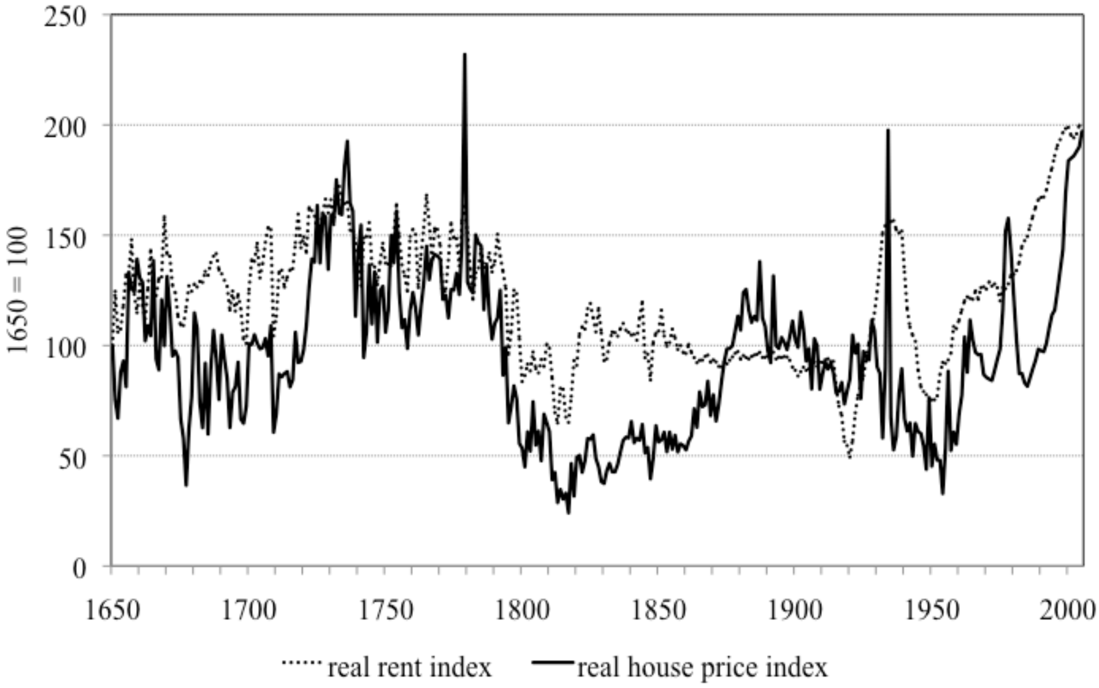
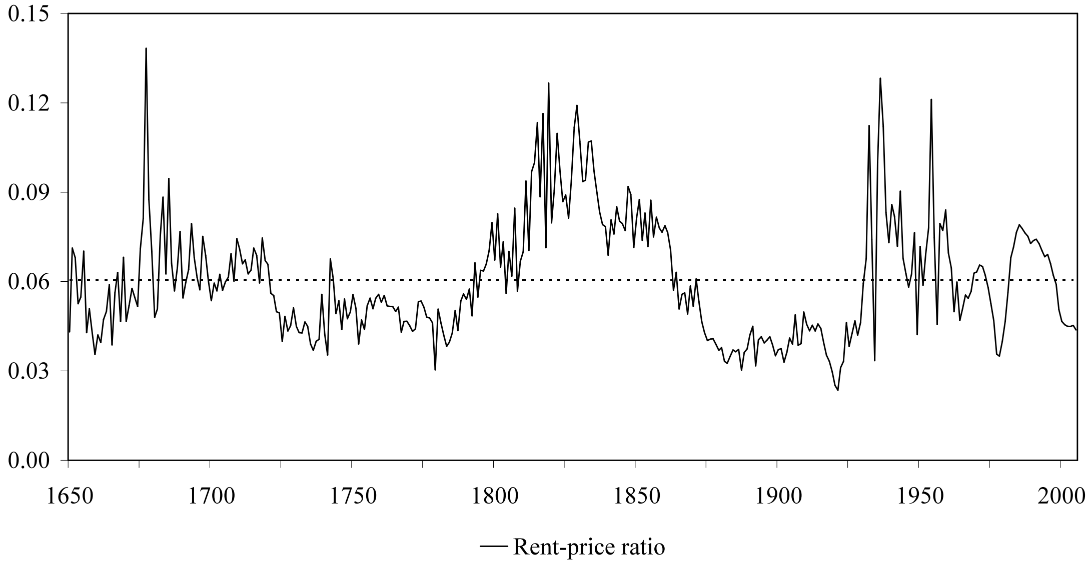
Figure 1:
Real rents and house prices, 1650-2005



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 197.1 and 203.2 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.

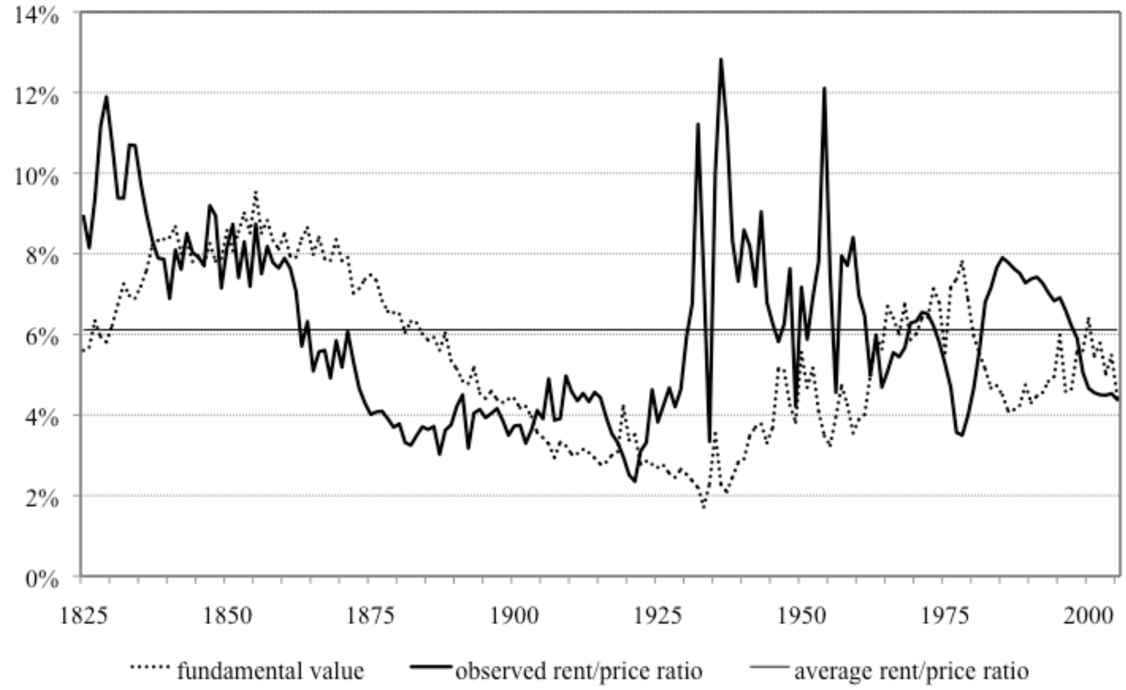
Sources: Prices 1650-1965 (Eichholtz, 1997), 1965-2005 (NVM, 2008);
Rents 1650-1850 (Eichholtz and Theebe, 2007), 1851-1913 (Van Riel, 2006), 1914-2005 (CBS, 1993, 1948, 1999, 2008)

Figure 2:
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 3:
Rent-price ratio and theoretical counterpart based on fundamentals

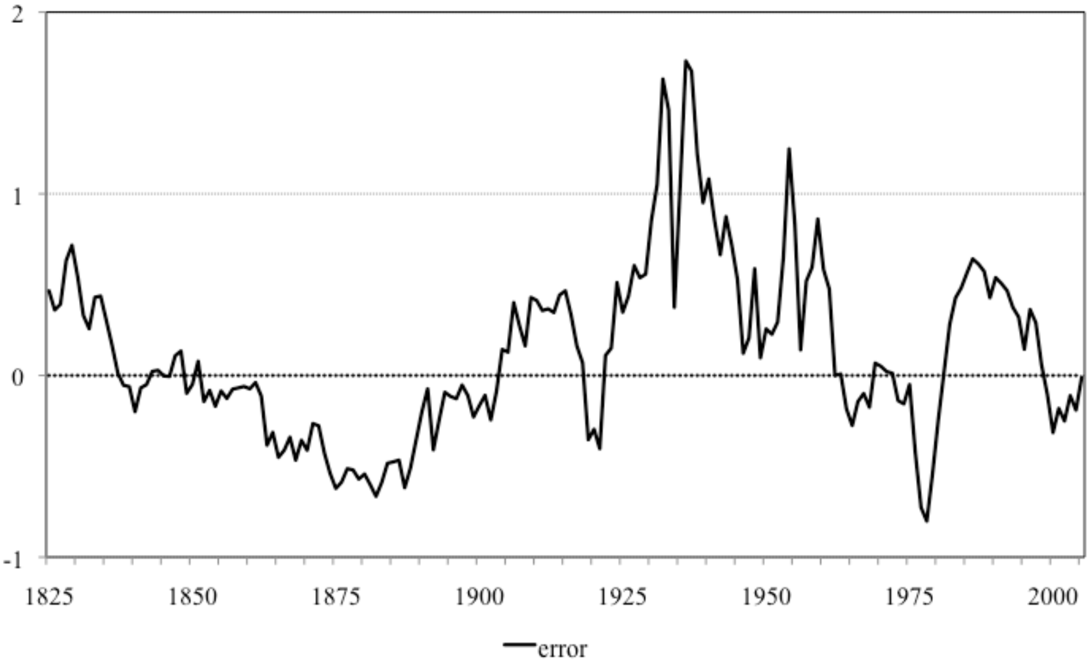


Notes: The theoretical rent-price ratio is expressed as

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

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 $1/\left(1+e^{\left(\overline{l-p}\right)}\right)$ with $\left(\overline{l-p}\right)$ 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 4:
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

,

Where □□, □□,□□, Δ□□ denote our calculated approximations of the constant of linearization, the future real rate, future housing risk premium, and future rental growth, respectively.

Table 1:
Summary of VAR estimation results

Dependent variable		coefficient estimates i_{t-1}	Π_{t-1}	Δl_{t-1}	p-value (Wald)	R^2
Panel A: 1825-2005						
i_{t-1}	25th percentile	0.344	-0.049	-0.137	0.000	0.127
	Median	0.459	-0.015	0.016	0.007	0.235
	75th percentile	0.577	0.002	0.095	0.121	0.332
	Frac. of years sig. at 5%	0.503	0.072	0.006	0.564	NA
Π_t	25th percentile	-1.531	-0.529	-0.021	0.000	0.118
	Median	-1.120	-0.399	0.318	0.008	0.229
	75th percentile	-0.577	-0.304	0.867	0.148	0.340
	Frac. of years sig. at 5%	0.320	0.779	0.155	0.613	NA
Δl_t	25th percentile	0.062	-0.053	-0.214	0.000	0.103
	Median	0.194	-0.018	0.030	0.035	0.177
	75th percentile	0.379	0.016	0.438	0.204	0.331
	Frac. of years sig. at 5%	0.127	0.133	0.182	0.519	NA
Panel B: 1825-1915						
i_{t-1}	25th percentile	0.295	-0.112	-0.241	0.066	0.107
	Median	0.366	-0.048	-0.115	0.119	0.128
	75th percentile	0.469	-0.023	0.041	0.187	0.153
	Frac. of years sig. at 5%	0.484	0.088	0.011	0.154	NA
Π_t	25th percentile	-1.281	-0.577	0.128	0.000	0.232
	Median	-0.858	-0.522	0.343	0.001	0.286
	75th percentile	-0.366	-0.396	0.839	0.007	0.394
	Frac. of years sig. at 5%	0.429	0.967	0.264	0.912	NA
Δl_t	25th percentile	-0.005	-0.116	-0.260	0.070	0.095
	Median	0.171	-0.048	-0.180	0.169	0.112
	75th percentile	0.440	0.052	-0.049	0.239	0.150
	Frac. of years sig. at 5%	0.165	0.253	0.077	0.187	NA
Panel C: 1916-2005						
i_{t-1}	25th percentile	0.441	-0.013	-0.021	0.000	0.267
	Median	0.537	-0.003	0.047	0.000	0.327
	75th percentile	0.641	0.018	0.118	0.002	0.431
	Frac. of years sig. at 5%	0.522	0.056	0.000	0.978	NA
Π_t	25th percentile	-2.268	-0.401	-0.122	0.018	0.096
	Median	-1.391	-0.309	0.185	0.138	0.121
	75th percentile	-0.810	-0.236	1.078	0.233	0.202
	Frac. of years sig. at 5%	0.211	0.589	0.044	0.311	NA
Δl_t	25th percentile	0.086	-0.030	0.105	0.000	0.252
	Median	0.197	-0.005	0.438	0.000	0.331
	75th percentile	0.320	0.009	0.529	0.004	0.407
	Frac. of years sig. at 5%	0.089	0.011	0.289	0.856	NA

Note: For 181 years (1825-2005), we estimate a VAR model based on information from a 40 year rolling window. The forecasting models cover the real interest rate *i*, the housing risk premium *Π,* and the change in real rents *Δl.* The first panel summarizes the coefficients on the real interest rate forecast model $i_t = \alpha_0 + \alpha_i i_{t-1} + \alpha_\Pi \Pi_{t-1} + \alpha_{\Delta l} \Delta l_{t-1} + \varepsilon_t$, while the second panel describes the housing premia forecast model $\Pi_{t-1} = \beta_0 + \beta_i i_{t-1} + \beta_\Pi \Pi_{t-1} + \beta_{\Delta l} \Delta l_{t-1} + \varepsilon_t$. The results from the real rent change forecast model $\Delta l_{t-1} = \gamma_0 + \gamma_i i_{t-1} + \gamma_\Pi \Pi_{t-1} + \gamma_{\Delta l} \Delta l_{t-1} + \varepsilon_t$ are displayed in the bottom panel. Column 4 displays the results of the Wald test that none of the included regressors explains the dependent variable. The last column shows the distribution of the R^2 measure of model fit.

Table 2:
Error correction coefficients for real rents and real prices

	Error correction coefficients			
Time period	$\Delta \ln(P)$		$\Delta \ln(R)$	
1650-2005	0.154	***	-0.023	
	(0.042)		(0.017)	
1650-1915	0.134	*	-0.054	*
	(0.068)		(0.032)	
1916-2005	0.182	***	-0.038	***
	(0.073)		(0.015)	

Notes: Standard errors in parentheses.
*, **, *** indicate significance of coefficient at the 10%, 5%, 1% confidence level.

The signs of all error correction coefficients are in line with expectations. For prices, the error correction coefficients are statistically and economically more significant than the coefficients for rents. This means that deviations in the rent-price ratio are mostly corrected for by price adjustments, not changes in rents. The role of prices in the error correction becomes even stronger in the years 1916-2005, when rent regulation hinders rent adjustments.

Endnotes

[1] For a discussion of current Chinese housing markets, see Mufson (2010).

[2] The effect that such housing market declines have on recessions is the subject of recent research in economics. For example, Helbling and Terrones (2003) document 20 severe housing market declines in 14 countries over the period 1970 to 2002. For the period from 1960 to 2007, Claessens et al (2008) look at 122 recessions and 114 episodes of house price decline, of which 28 were characterized as busts. Both papers show that these housing market declines generally overlapped or coincided with recessions, and that recessions coinciding with housing market declines resulted in output losses roughly two to three times as big as other recessions. In fact, Claessens et al (2008) conclude that the extent of the house price decline most consistently influences the depth of a recession, even after taking into account other financial variables like credit availability and equity prices.

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

[4] 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)

[5] Additional details regarding the data are available in the online appendix located at: http://www.personal.psu.edu/bwa10/House%20Prices%20and%20Fundamentals%20On-line%20Appendices.pdf.

[6] The annual average number of transactions per year is 10.9 and the standard deviation is 6.8. The annual number of transactions is relatively high in the latter half of the nineteenth century and in the twentieth century. For 1945, we do not have any transactions, and the index observation for that year is an interpolated value.

[7] Although incidental observations of the government bond rate are available prior to 1783, we are unable to construct a continuous annual time-series prior to 1783.

[8] We formally test for the presence of unit roots in the rent and price indices. The Dickey-Fuller test statistics indicate that both series contain unit roots and are thus non-stationary. The first differences, however, are stationary.

[9] 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.

[10] We checked the robustness of our results under several VAR specifications, changing the number of lags and the time period on which the VAR is based. This did not markedly change the results. Results from additional robustness and specification checks are available at the on-line appendix located at: http://www.personal.psu.edu/bwa10/House%20Prices%20and%20Fundamentals%20On-line%20Appendices.pdf.

[11] 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.