Fundamentals or Trends? A Long-Term Perspective on House Prices

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Abstract

This paper contributes to the discussion whether changes in house prices can be explained by fundamental factors or trends. Using a long-term time series of prices of houses along the Herengracht in Amsterdam, covering 350 years, we examine whether a fundamental factor (inflation, rent) or a trend (momentum) explain house prices and whether their explanatory power is constant or varies over time.

We find that agents in the housing market switch in their formation of expectations about future changes in house prices between fundamental and momentum strategies. Hence, house prices depend on fundamentals (at least in terms of reverting to inflation or rent) and momentum, and the importance of each of these factors driving house prices varies over time as agents focus more on the fundamental strategy in some periods and on momentum in other periods. Specifically, we show that agents base their expectations more on fundamentals during periods with economic slowdown and more on recent trends or momentum during periods of economic booms.

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1 Introduction

Empirical research has shown that house prices are predictable, persistently deviating from fundamental values, and are too volatile relative to fundamental values. House prices do not seem to be fully explained by fundamental determinants such as income, employment, construction costs, changes in the housing stock, credit availability, tax structures, demographics and interest rates (Farlow [2004] and **?**). Quiqley [1999] shows that such fundamental factors leave a large share of changes in real estate prices unexplained. Simple models of economic fundamentals explain only between 10 and 40 percent of changes in residential property prices. This is confirmed by Farlow [2004], who argues that the most plausible explanation for the dramatic increase in house prices during the last decades cannot be found in supply and demand fundamentals. House price volatility is higher than can be explained by changes in fundamentals.

The claim that house prices are predictable origins from the observations made by Case and Shiller [1989] who conclude that information relating to real interest rates (a fundamental) does not explain variation in house prices. Instead, they find positive serial correlation in price changes of single family homes, so changes in house prices seem to be explained by recent trends. Extended research (Case and Shiller [1990]) with additional fundamental forecasting variables leads to the same conclusion: the power of fundamentals to explain house price changes is low and price changes are serially correlated. Cutler et al. [1991] share the latter conclusion after finding a strong positive autocorrelation structure, reaching out for at least three years, for both residential real estate and farms in the U.S. (on average) and in a number of metropolitan areas. The observation that house prices are predictable is confirmed by results from outside the U.S. Englund and Ioannides [1997] provide evidence for predictability of house prices in 15 OECD countries. Levin and Wright [1997] show that past house price changes in the U.K. forecast future price changes.

From the above, one can conclude that variation in house prices can be explained partly by fundamental factors (with limited explanatory power) and partly also by recent trends in house prices. Clayton [1998] shows indeed that a number of instruments, including lagged returns and a measure of price deviation from a fundamental value, explain house price changes for apartments in Vancouver Canada. Clayton [1998] concludes that property may be overvalued in booming markets and that market value appraisals then may exceed intrinsic or fundamental values. **?** show, using house prices from the U.K., that actual prices display significant periods of over- and undervaluation relative to their fundamental house price model. The periods of over and under valuation suggest that house prices move away from their fundamentals in some periods and move back to their fundamentals in other periods. This can be explained by limits to arbitrage. **?** discuss that arbitrage is limited in the housing market due to high transaction costs, illiquidity of the housing market, heterogeneity and the fact that most houses are purchased for consumption reasons rather than investment motives and hence correction toward the true value is not immediate and price deviations from a fundamental, true, value may exist for long and often uncertain periods. Fundamentals can be seen as factors from which a true value can be derived and around which actual house prices hover by moving away from it during some periods and move back to it during others. Kouwenberg and Zwinkels [2010] observe such behavior for U.S. house prices and find indeed that a forecasting model that combines momentum and mean reversion (prices moving to a fundamental value) is able to outperform a range of benchmark models.

The unavailability of a long high quality time series of house prices and fundamentals makes it difficult to examine conclusively the behavior of house prices in terms of trends and fundamentals. Do fundamentals and trends always have the same amount of explanatory power or does explanatory power vary over time such that trend beats fundamentals during some periods, while fundamentals rule during others? Combining the conclusion from Clayton [1998] that property may be overvalued in booming markets and that recent trends explain house price changes raises the suspicion that trend behavior might explain house prices better during periods of economic booms than in busts. This begs the question whether the state of the economy coincides with the explanatory power of fundamentals and trends. Our goal is to examine both questions using historical house prices covering a long period of time. We use the updated Herengracht Index, a long time series on house prices, first presented by Eichholtz [1997] in a biennial form and later by Ambrose et al. [2012] at an annual frequency. This annual Herengracht Index reflects the prices of houses along the Herengracht, one of the canals in Amsterdam, covering 357 years from 1649 through 2005. Covering the same period of time, we also have information about the general price level (consumer price index) and about house rents. Having prices and fundamentals, we have unique data that we can use to examine the power of recent trends and fundamental factors to explain variation in house prices over a very long period of time.

To examine whether the explanatory power of trends and fundamentals varies over time, we apply a heterogeneous agents approach as in Kouwenberg and Zwinkels [2010] and we question how agents form expectations about changes in house prices. Introduced by Frankel and Froot [1990], such a heterogeneous agents model allows for different agents in the economy to co-exist, differing in the way that they form expectations about future price changes. Typical heterogeneous agents models divide the market between two types of agents: trend followers and those who believe that prices revert around some fundamental value. This setting matches the observation from the literature we discussed before: that variation in house prices can be explained by both trends and fundamentals. In order to observe whether the explanatory power of each of these variables changes over time, we allow the agents in our model to change the approach (trend or fundamental) they apply as a basis for their expectations, as proposed by Brock and Hommes [1997] and Brock and Hommes [1998]. This setup allows us to observe how the fraction of agents that use either trends or fundamentals varies over time and to study how these fractions relate to the state of the economy.

Our choice for a heterogeneous agents model with switching agents is not unique for modeling house prices. This approach has been adopted by Dieci and Westerhoff [2009], Sommervoll et al. [2010] and Kouwenberg and Zwinkels [2010]. The latter paper empirically compares the merits of a heterogeneous agents model for house prices to other models. Using the Case / Shiller house price index, they find strong support for the heterogeneous agents model, both in- and out-of-sample. Our contribution to the literature is that we use the long history of prices from the Herengracht Index such that we can observe how trends and fundamentals explain variations in house prices over a long period of time and that we can thereby relate the importance of these variables to the state of the economy.

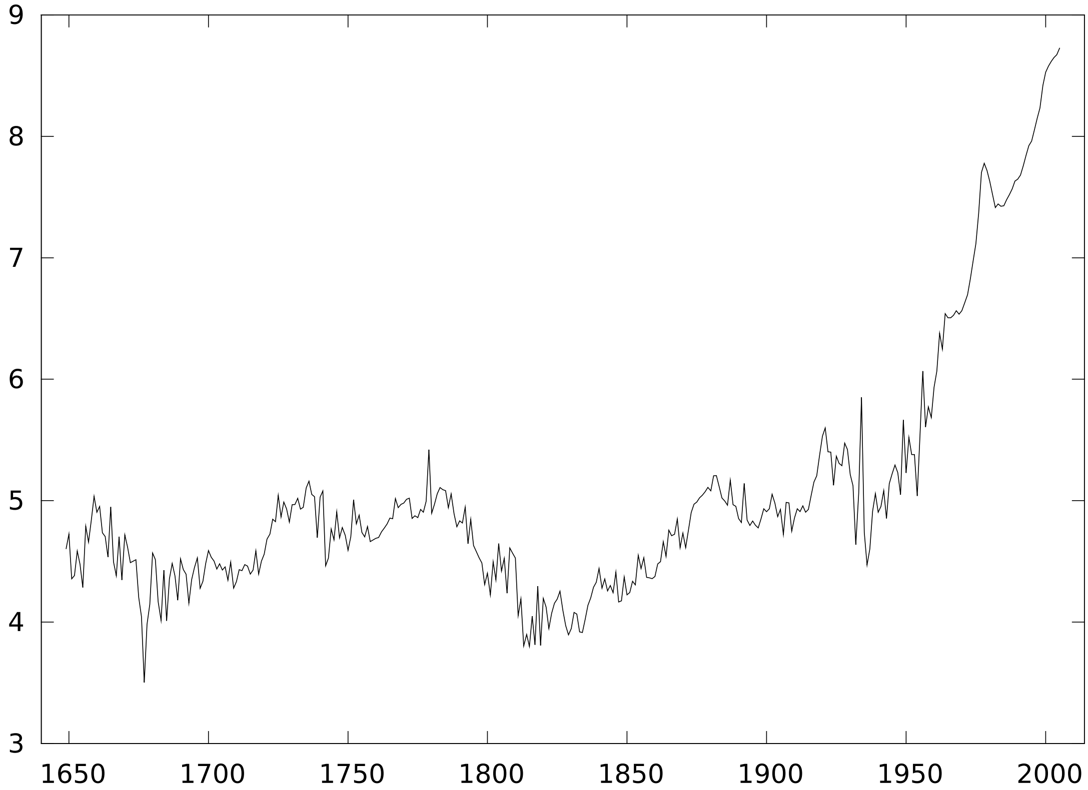
We proceed with a discussion of the data in the next section. After that, we present the heterogeneous agents model for house prices. We subsequently fit the model and use its outcomes to relate the importance of trends and fundamentals to the state of the economy. The last section presents conclusions and implications.

2 Data

We use the Herengracht Index, a price index of houses located along one of the central canals in Amsterdam. The canal was dug in phases between 1585 and 1660, and most of the lots along it were developed by 1680 (see Eichholtz et al. [2012]). Until the present day, the Herengracht is one of the most prestigious locations in Amsterdam. For example, Herengracht 502, a house that was built in 1672, is the address of the majors residence.

The data spans the house prices for the period from 1649 through 2005. The index is based on a repeated measures regression, and only considers dwellings in residential use. The index is constructed by Eichholtz [2010]. We convert the data by taking the natural logarithm of the prices. Figure 1 shows a graph of the log prices of the Herengracht Index between 1649 and 2005.

Figure 1: The Herengracht index between 1649 and 2005 Log-prices on the left axis.



An augmented Dickey-Fuller test indicates that we cannot reject the presence of a unit root in the log-prices. We therefore proceed with the first differences of the log prices, which we will refer to as the annual returns. Table 1 shows summary statistics of the annual returns on the Herengracht Index.

The 356 annual return observations have a mean of 1.2% and a standard deviation of 19.7%. The returns are negatively skewed and have fatter tails than a normal distribution as the excess kurtosis is 3.8.

An inspection of the autocorrelation pattern of log-price changes reveals the presence of a first order moving average process in the data. Let p_t be the log-price of the Herengracht Index at year t and let Δp_t be the difference between the log-prices of the Herengracht Index in year t and year $t-1$. The MA(1) model then reads:

Table 1: Summary statistics

mean	0.012
median	0.024
minimum	-1.112
maximum	0.789
standard deviation	0.197
skewness	-0.435
excess kurtosis	3.820
n	356

$$\Delta p_t = \alpha + \epsilon_t + \theta \epsilon_{t-1}. \tag{1}$$

Table 2 reports the parameter estimates. As expected, the moving average parameter θ is significantly different from zero. An augmented Dickey-Fuller test reveals that the residuals of model 1 are stationary. We will therefore include a MA(1) term in the models that we present later in this paper.

Table 2: Parameter estimates for the MA(1) model: $\Delta p_t = \alpha + \epsilon_t + \theta \epsilon_{t-1}$.

parameter	estimate
α	0.012
	(0.006)
θ	-0.404
	(0.049)
LL	98.936
DW	1.982
n	356

For the same time period, we use the consumer price index series for the Netherlands. This consumer price index was developed by (**?**). The price index is based on the prices of a basket of consumer goods, including rye bread, beer, butter, meat, potatoes, peas, different kinds of fish, and various textiles. Important shifts in consumption patterns are incorporated in the index weights of these goods. Potato prices, for example, enter the index in 1792, since potato consumption quickly increased after 1770[1]. For the period between 1850 and 1913 we use a series constructed by 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.

The second fundamental we use is the rent level. The house rent series we use for that was previously used by Ambrose et al. [2012]. This index is also constructed from different sources. For the period from 1650 through 1850, we use the Amsterdam residential rent index constructed by Eichholtz et al. [2012]. Due to a lack of Amsterdam-specific data for the period after 1850, we use two national house rent indices for the remainder of the sample period. The first series covers the period from 1851 through 1913 and is from van Riel [2006]. It is based on records from the Dutch tax authorities. The second series concerns the period after 1914, and is based on a range of publications from the Dutch Central Bureau of Statistics.

3 A heterogeneous agents model for changes in house prices

In this section, we develop the heterogeneous agents model to examine the research questions: "Do fundamentals and trends always have the same amount of explanatory power?" and "Does the state of the economy coincide with the explanatory power of fundamentals and trends". We have based our model on the ones in Frankel and Froot [1990], Brock and Hommes [1997], Brock and Hommes [1998], Dieci and Westerhoff [2009], Sommervoll et al. [2010] and Kouwenberg and Zwinkels [2010].

We assume that agents apply one out of two different approaches to formulate expectations about future house price changes. One approach is to assume that house prices revert around a fundamental value (mean reversion). We refer to this approach as the fundamental strategy. The other approach is that house prices extend the recent price trend. We refer to this approach as the momentum strategy. We now discuss how expectations are formulated in both strategies.

We first analyze the fundamental strategy. Let $E^f_{t-1}\{\Delta p_t\}$ be the (log) price change Δp_t between time $t-1$ and t that is expected at time $t-1$ when the fundamental strategy is applied. E^f_{t-1} is the expectation operator for the fundamental strategy using the information available at time $t-1$. As we discussed above, we separately use inflation and house rents as fundamental variable. We assume that house prices move in line with inflation or house rents under the fundamental strategy. If house prices rose more than inflation or rents over the past years, one would expect house prices to decrease and vice versa based on the fundamental strategy. Under

[1] **?** provides additional information regarding the consumer price index and its composition over time.

the fundamental strategy, we assume that agents form their expectations based on the n_f years moving average of the annual differences between the returns on houses Δp_t and inflation (or house rents) π_t, measured as the change in the log consumer price index (or the house rent index):

$$E_{t-1}^{f}\{\Delta p_t\} = \alpha_f \frac{1}{n_f} \sum_{i=1}^{n_f} (\Delta p_{t-i} - \pi_{t-i}). \tag{2}$$

We expect the parameter α_f to be negative, as this would be consistent with mean reversion. It implies that house prices are expected to decrease when house prices have risen faster than inflation or house rents. The parameter α_f can be seen as a speed of mean-reversion: the higher α_f is in absolute terms, the faster agents believe that house prices correct after deviating from inflation or house rents under the fundamental strategy.

Agents that apply the momentum strategy are assumed to base their expectations on the recent trend in house prices. Let $E_{t-1}^{m}\{\Delta p_t\}$ be the change in the log house price between $t-1$ and t as expected at time $t-1$. The expectation is based on the n_m years moving average of house price changes. We formulate the expected house price according to the momentum strategy as:

$$E_{t-1}^{m}\{\Delta p_t\} = \alpha_m \frac{1}{n_m} \sum_{i=1}^{n_m} \Delta p_{t-i}. \tag{3}$$

We expect the parameter α_m to be positive as that is consistent with extrapolating the trend in house prices over the recent n_m periods.

Having specified the expected price changes under the fundamental and momentum strategies, we assume that a fraction $w_{f,t}$ of all agents in the real estate market apply the fundamental strategy at time t and that a fraction $w_{m,t}$ of all agents apply the momentum strategy. We then assume that the 'market' expected change in the log price of houses equals the weighted average over the expectations over all agents. The market expected change in house prices between $t-1$ and t, $E_{t-1}\{\Delta p_t\}$, then equals

$$E_{t-1}\{\Delta p_t\} = w_{f,t-1} E_{t-1}^{f}\{\Delta p_t\} + w_{m,t-1} E_{t-1}^{m}\{\Delta p_t\}. \tag{4}$$

Substituting equations 2 and 3 into equation 4 and assuming that all agents only use the two strategies at any moment in time, such that $w_{m,t} = 1 - w_{f,t}$, we rewrite equation 4 as

$$E_{t-1}\{\Delta p_t\} = w_{f,t-1} \frac{\alpha_f}{n_f} \sum_{i=1}^{n_f} (\Delta p_{t-i} - \pi_{t-i}) + (1 - w_{f,t-1}) \frac{\alpha_m}{n_m} \sum_{i=1}^{n_m} \Delta p_{t-i}. \tag{5}$$

So far, we have not mentioned why we include the subscript t in the fraction $w_{f,t}$. By doing so, we allow that agents have the possibility to change in their investment strategy over time; i.e. they may switch between applying the momentum and the fundamental strategies. We apply the endogenous selection of strategies introduced by Brock and Hommes [1997] to describe how agents switch. The fraction of agents that apply a specific strategy at time t depends on the so-called relative fitness of that strategy as observed at time $t-1$. Let $u_{f,t}$ be the fitness of the fundamental strategy at time t and let $u_{m,t}$ be the fitness of the momentum strategy. Then, the fraction of agents that apply the fundamental strategy is described by the following multinomial logit probability

$$w_{f,t} = \frac{e^{\gamma u_{f,t}}}{e^{\gamma u_{f,t}} + e^{\gamma u_{m,t}}}. \tag{6}$$

The parameter $\gamma > 0$ in equation 6 is an intensity of choice parameter. It measures how sensitive agents are to selecting the optimal strategy. The limiting case $\gamma = 0$ corresponds with the situation in which agents will not switch between strategies. In this case, $w_{f,t} = w_{m,t} = 1/2$ for all times t. The other extreme case $\gamma = +\infty$ corresponds with the situation in which all agents choose the optimal forecast based on the observed fitness. Brock and Hommes [1997] propose realized profits as a natural candidate for fitness and we implement this measure for fitness in this paper[2]. We assume that the agents include the average performance over the last n_u periods of time in their fitness measure, where performance is seen as the average annual profit an agent would have made in case the agent acted in line with the sign of his or her expectation. Let $sgn(x)$ be the sign of x. Then, the fitness of the fundamental strategy at time t equals

$$u_{f,t} = \frac{1}{n_u} \sum_{i=1}^{n_u} \Delta p_t sgn(E^f_{t-1}\{\Delta p_t\}), \tag{7}$$

and the fitness of the momentum strategy at time t equals

$$u_{m,t} = \frac{1}{n_u} \sum_{i=1}^{n_u} \Delta p_t sgn(E^m_{t-1}\{\Delta p_t\}). \tag{8}$$

The above equations describe the expected change in house prices as a time-varying weighted average over fundamental and momentum based expectations. In order to fit the model to the data, we assume that agents make no systematic forecasting errors such that the expectations differ from the actual observations by an IID(0,1) error term. The following set of equations encompasses the model that we test empirically:

[2]Another measure for fitness could be the forecast error of the strategies.

$$
\begin{aligned}
\Delta p_t &= c + w_{f,t-1}\frac{\alpha_f}{n_f}\sum_{i=1}^{n_f}(\Delta p_{t-i} - \pi_{t-i}) + \\
&\quad (1 - w_{f,t-1})\frac{\alpha_m}{n_m}\sum_{i=1}^{n_m}\Delta p_{t-i} + \sigma\epsilon_t + \theta\epsilon_{t-1} \\
w_{f,t} &= \frac{e^{\gamma u_{f,t}}}{e^{\gamma u_{f,t}} + e^{\gamma u_{m,t}}} \qquad (9) \\
u_{f,t} &= \sum_{i=1}^{n_u}\Delta p_t sgn(E_{t-1}^{f}\{\Delta p_t\}) \\
u_{m,t} &= \sum_{i=1}^{n_u}\Delta p_t sgn(E_{t-1}^{m}\{\Delta p_t\})
\end{aligned}
$$

For estimation purposes, we include a constant term c in equation 9 and the parameter σ measures the standard deviation of the error term. The six parameters in the model (c, α_f, α_m, γ, σ, and θ) are estimated using maximum likelihood assuming that the error term ϵ in equation 9 is normally distributed. In the estimation procedure, we do not restrict the sign of any of the parameters, except for σ which is restricted to be positive.

The following section presents the parameter estimates.

4 Results

The parameter estimates depend on the exact settings for the parameters n_f, n_m, and n_u that cannot be directly estimated from the data. As can be seen from equations 2, 3, 7, and 8 these numbers represent the number of historical periods of time that are included in the fundamental (n_f) and momentum (n_m) strategy to determine expectations about the change in the next period's price of houses and the number of periods over which the fitness is being calculated (n_u). We assume that each of these parameters can obtain the integer values 1 through 20 (referring to a one-year through twenty-years look-back period) and we estimate the parameters for all 8,000 combinations of n_f, n_m, and n_u. We use the Schwartz information criterion to select the optimal setting for n_f, n_m, and n_u[3]. Table 3 shows the parameter estimates for different settings.

The first column headed 'switching' in table 1 contains the estimates for that setting for n_f, n_m, and n_u that yields the highest Schwartz criterion. This setting is: $n_f = 14$, $n_m = 14$, and $n_u = 2$. Apparently, both the fundamental and momentum strategy base expectations on

[3]Using the Hannan-Quinn criterion instead of the Schwartz criterion leads to the same optimal setting.

Table 3: Parameter estimates

parameter	switching	no switching	no switching	switching
n_f	14	14	10	10
n_c	14	14	16	16
n_u	2	–	–	2
c	0.002	0.005	0.004	0.002
	(0.502)	(0.991)	(0.706)	(0.441)
σ	0.174	0.181	0.180	0.177
	(43.242)	(42.320)	(41.302)	(40.404)
α_f	-1.830	-1.386	-1.403	-1.465
	(-9.034)	(-4.501)	(-3.966)	(-5.860)
α_c	1.363	1.446	1.751	1.316
	(5.871)	(4.043)	(4.303)	(4.044)
γ	18.563	—	—	12.464
	(1.279)			(1.222)
θ	-0.600	-0.456	-0.4380	-0.485
	(-15.466)	(-11.607)	(-10.487)	(-11.164)
DW	1.9344	1.990	2.0147	2.027
LogLik	118.012	103.255	106.615	111.824
$2\Delta LogLik$		29.514		10.418
Akaike	-224.024	-196.509	-203.230	-211.649
Schwarz	-200.757	-177.121	-183.841	-188.383
Hannan-Quinn	-214.769	-188.798	-195.517	-202.395

Asymptotic t-values are in parenthesis.

observations over the last fourteen years. The setting $n_u = 2$ implies that agents evaluate the fitness of both strategies over the last two years when choosing which strategy to apply. The parameter estimates conditional on this optimal setting show evidence for the existence of heterogeneous expectations in the housing market as the estimate for α_f is negative (-1.830) and significantly different from zero and the estimate for α_m is positive (1.363) and significantly different from zero. The negative estimate for α_f is consistent with the view that house prices revert around a fundamental value (mean reversion); a negative α_f implies that house prices are expected to decrease after house prices have increased more than consumer prices or rents over the last years. The positive estimate for α_m implies that the momentum strategy based expectations extends the current price trend. Without going into details here, we also observe the same signs for the α parameters for the alternative settings listed in table 3; the signs of the estimates are robust indicating the existence of both strategies being applied in the housing market.

The results show that agents use fundamental and trend strategies to formulate expectations in house prices and, as a consequence, house prices changes depend on both fundamental factors and trends; an observation consistent with the recent literature on house price changes we discussed before. The estimate for the intensity of choice parameter γ is positive but not significantly different from zero. Although this parameter reflects the agents willingness to switch strategy, we cannot clearly observe whether agents do switch between the fundamentalist and chartist strategies from γ only as the fraction of agents that apply a strategy depends on a logistic transformation of fitness and γ (see equation 6).

To assess whether switching behavior is apparent, we test whether the fit of the model with the optimal setting in which we allow for switching behavior is better than the fit of a model with the same setting, but in which switching is not allowed. The results for the latter model are listed in the column headed 'no switching' for the optimal setting (14, 14, −). We apply a likelihood ratio test to determine which model fits the data better. Table 3 shows that the log-likelihood of the original, allowing switching, model is 118.012 and of the alternative, no switching, model it is 103.255, and the likelihood ratio test statistic, $2\Delta LogLik$ as in table 3, equals 29.514. As this statistic is χ^2 distributed with one degree of freedom, the difference between the log-likelihoods of both models implies that the model that allows for switching fits the data significantly better.

For now, we conclude that agents change their strategies over time based on the fitness of each strategy, but the estimates that we discussed so far are derived under the assumption of the optimal setting for n_f, n_f, and n_u that was obtained under the assumption that switching is allowed. To check the robustness of our results, we also estimate the parameters under the assumption that agent cannot switch. To do so, we selected the optimal setting for the model while keeping the value of γ equal to zero. The optimal setting and the parameter estimates under this assumption can be observed from the third column in table 3 headed 'no switching'. The optimal setting is 10 years for n_f and 16 years for n_m. The parameter n_u does not apply here as fitness of each strategy is irrelevant when switching is not allowed. To obtain whether allowing to switch strategies fits the data better we compare the log likelihood of this setting with the log likelihood obtained after estimating a model in which n_f and n_m were kept at 10 and 16 respectively but in which switching is allowed. This gave an optimal setting for n_u equal to 2, consistent with our previous results. The parameters of the latter model are listed in the fourth column of table 3. Allowing for switching yields a higher log-likelihood and the likelihood ratio test statistic equals 10.418. Again, allowing for switching fits the data significantly better. We therefore conclude that the result that agents switch their strategy over time is robust and we treat the parameter estimates in the first column in table 3 as the best fit.

The estimates from the first column in table 3 shows that agents switch in their expectations formation between fundamental and momentum strategies. Hence, house prices depend on fundamentals (at least in terms of reverting to inflation or rents) and momentum and the importance of each of these factors driving house prices varies over time as agents focus more on the fundamental strategy in some periods and on momentum in other periods. This becomes more clear from the graph in figure 2, which shows the fraction of agents that adopt a fundamental strategy, $w_{f,t}$, over time. The graph clearly shows that the fraction of agents that adopt a fundamental strategy varies strongly over time. Between approximately 1890 and 1960, more than 50% of the agents in the housing markets applied a fundamental strategy on average. In that period, house prices were driven mostly by the fundamental factors that we examine here. Since the end of the 1990's, the fraction of agents using the fundamental strategy did not exceed 30%. House prices were predominantly driven by the momentum strategy, and agent expectations appeared to be predominantly based on extending the recent price trend. This behavior also occurred during the 1790's and between 1870 and 1890 approximately. The graph clearly shows that the latter half of the 20th century, on which most empirical studies of the housing markets are based, was historically unique: trend chasing was more important in that period than in the years before. This illustrates the importance of a long timeframe to study the dynamics of house prices.

The first part of table 4 provides summary statistics of the fundamentalists weights $w_{f,t}$. In an average year, 55.9% of all agents apply the fundamental strategy and 44.1% of the agents adopt the momentum strategy. We therefore conclude that agents behavior in terms of expectation formation is more often based on fundamental information than on momentum in the long-run. The standard deviation of the fundamental strategy weights equals 35.5%.

So we find that agents in the housing market apply momentum and fundamental strategies to formulate expectations on future changes in house prices and that their behavior, in terms of which strategy they use, varies over time in line with the success of each strategy. This brings us to the already mentioned conclusion of Clayton [1998] that property may be overvalued in booming markets and that recent trends explain house price changes. So trend chasing behavior may explain house prices better during periods of economic booms than in busts. We use our results to examine the hypothesis that trend explains house prices better during periods of

Figure 2: The fraction of agents that apply the fundamental strategy between 1649 and 2005 (The grey bars are the fundamental strategy weights (left axis) and the black line represents the annual log prices of the Herengracht index (right axis)

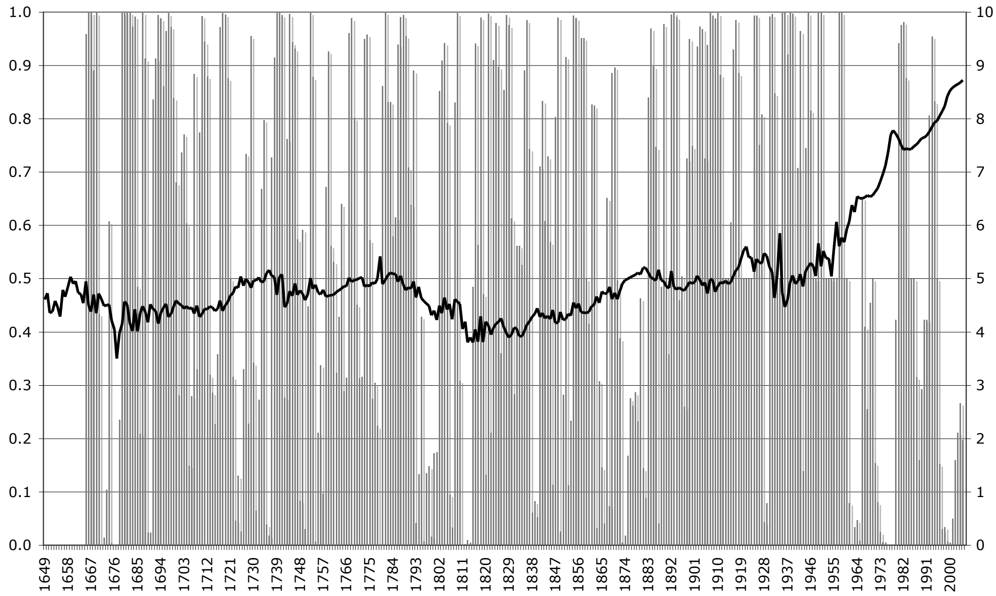


Table 4: Summary statistics of the fraction of agents that apply the fundamental strategy.

statistic	
mean	0.559
st.dev.	0.355
period	**average**
strong economy	0.517
economic slowdown	0.580
strong -/- slowdown	-0.063
(p-value)	(0.065)

economic booms. To do so, we define indicator variables to identify periods in our sample with economic booms and busts. We use the same period economic characterization as Eichholtz [2010] do for Amsterdam between 1650 and 2005. That paper divides the whole sample period in eras characterized by a strong or very strong economy, (1650-1670, 1851-1913, 1946-1973, 1974-2005), by economic slowdown (1671-1720, 1721-1780, 1781-1814, 1914-1945) and by stabilization (1815-1850).

The bottom part of table 4 shows the averages of the fraction of agents that apply the fundamental strategy during periods with a strong economy and economic slowdown. During the strong economic periods, 51.7% of the agents applied the fundamental strategy whereas 58.0% of the agents applied the fundamental strategy during periods with economic slowdown. The lower fraction of agents that apply the fundamental strategy during a strong economy is in line with Clayton [1998]'s claim that trends or momentum explain house prices better during economic booms. To test the significancy of this result, we performed a single sided t-test and we find that the difference between the average fraction of agents that use the fundamental strategy during an economic boom and bust is -0.063. The t-test for the hypothesis that this value is lower than zero yields a p-value of 6.5%. We conclude, with 93.5% confidence, that agents base expectations more on fundamentals during periods with economic slowdown and more on recent trends or momentum during periods of economic booms.

5 Concluding remarks

We have been the first to analyze the importance of fundamental and momentum factors in explaining house price dynamics over a long period of time. This paper uses a long-term price index of houses along the Herengracht in Amsterdam, covering 357 years. We examine whether a fundamental factor (inflation, rent) or a trend (momentum) explain house prices and whether the explanatory power is constant or varies over time. We use a heterogeneous agents model for house prices to model changes in house prices in which we assume that agents base their expectations on fundamentals or trends. We allow these agents to switch between strategies over time and we show that they do so based on the recent success of each strategy.

We find that agents in the housing market switch in their formation of expectations about future changes in house prices between fundamental and momentum strategies. Hence, house prices depend on fundamentals (at least in terms of reverting to inflation or rents) and momentum and the importance of each of these factors driving house prices varies over time, as agents focus more on the fundamental strategy in some periods and on momentum in other periods. We also show that agents base their expectations more on fundamentals during periods with economic slowdown and more on recent trends or momentum during periods of economic booms.

The implication of our results is that house prices cannot be seen to be driven by either fundamental variables or recent trends alone. Instead, both fundamentals and trends explain variation in house prices and the importance of both factors varies over time. During periods with economic booms agents focus more on recent price trends, which potentially leads to overvalued house prices during these periods. During periods with economic slowdown, house prices correct after they have increased more than inflation or rents recently, at least according to our model. However, it should be noted that we examine the house prices of only one city, even one street, and we only have two fundamental variables (consumer price levels and house rents). Additional research covering other countries and different fundamentals is needed for further analysis of this problem.

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