That's What We Paid for It
The Spell of the Home Purchase Price through the Centuries

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January 23, 2013

Abstract

This paper is the first to provide empirical insights into the long-term nature of the loss aversion bias. Using a database of Amsterdam housing transactions spanning 324 years, the paper studies the question whether loss aversion was present in centuries past, whether its effects were stable across these centuries, and whether the psychological effect of the purchase price on selling behavior eroded with time and through the occurrence of important events.

The purchase price of the house is found to have been a psychological anchor, below which home owners were reluctant to sell, no matter whether they were male or female. This result holds for 17th and 18th century Dutch home owners as well as for those who followed in their wake, but loss aversion appears to have gotten more important over the centuries. The anchoring power of the purchase price was strong: it survived the death of the original owner when the house passed on to the heirs. It was however diminished by loss realizations in housing transactions in the direct vicinity, and even more so by the occurrence of wars involving foreign occupation. The aversion to a loss relative to the purchase price was also gradually reduced by the time passed since the purchase.

Acknowledgements

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Introduction

Loss aversion and anchoring are the bedrock of prospect theory (Daniel Kahneman and Amos Tversky, 1979, and Amos Tversky and Daniel Kahneman, 1991), under which people examine losses and gains relative to a reference point, and maximize a value function that is steeper for losses than for gains.

The last three decades have produced strong evidence for the importance of loss aversion in economic behavior (see, for example, Michael Haigh and John A. List, 2005). However, some scholars argue that these biases are likely to vanish under competitive pressures as decision makers gain experience (John A. List, 2003), while Steven D. Levitt and John A. List (2008) note that much of the evidence for behavioral biases is based on laboratory experiments, and express doubts whether they apply to decision makers in real markets.

Outside of the laboratory, loss aversion has now been shown in the stock markets (Hersh Shefrin and Meir Statman, 1985, Terence Odean, 1998), in the art market (Alan Beggs and Kathryn Graddy, 2009), in sports (Devin Pope and Maurice Schweitzer, 2011), in the housing market (David Genesove and Christopher Mayer, 2001), and in the commercial real estate markets (Alan Crane and Jay C. Hartzell, 2008, Sheharyar Bokhari and David Geltner, 2011).

Most of this empirical evidence is based on relatively short-term data, spanning only a few decades at most. In order to investigate whether the critique concerning the pervasiveness of behavioral biases holds sway, the researcher needs to look at data spanning a longer time, during which decision makers have had a chance to build up experience, and market forces have done their work. The presence of evidence for behavioral biases in data spanning more decades or even centuries would counter the notion that time eliminates behavioral biases.

We put the loss aversion bias to the test of time by analyzing 324 years of housing transactions on the *Herengracht*, a canal in Amsterdam. These transactions took place between 1650 and 1973. We investigate whether house owners on that canal were more reluctant to realize their losses than their gains, and whether that reluctance changed over the centuries.

The key issue when testing the empirical implications of prospect theory is the reference point. Kahneman and Tversky (1974) first showed that even a random number can serve as a mental anchor, but in the previously quoted studies of trading behavior, the reference point is usually the purchase price of the asset under consideration. Our study does so too, and we explicitly investigate the anchoring power of the purchase price. Odean (1998) notes that the reference point may be different

than the purchase price. On the housing market, other potential mental anchors could be the price estimate from an external property appraisal, or the value of a not-accepted offer to buy the house, or the more recent sales prices of houses nearby. Especially if a lot of time has gone by since the house was bought, the latter factors influencing the reference point are likely to become more important, possibly reducing the salience of the purchase price. One of the aims of our study is to see whether the purchase price was indeed a strong psychological anchor with which prospective sellers compared the sales price of their home, and to investigate whether its effect on behavior was affected by the passage of time and the incidence of major societal and personal events.

The results of this study show that loss aversion appears to be of all times. Although it did seem to get stronger during our sample period, it was already present in the 17th and 18th century. Between 1650 and 1799, homeowners on the *Herengracht* were 15 percent less likely to sell their home when it was valued at a loss than when it was valued at a gain. For the 20th century, that difference was 38 percent.

The purchase price appears to have been a powerful anchor. Indeed, even the passing away of the original owner and the transfer of the house to his heirs did not significantly diminish the aversion to sell the house at a loss relative to the original purchase price. However, the passage of time slowly reduced the psychological influence of the purchase price. The occurrence of wars also weakened the power of that reference point, but only when these wars involved occupation by a foreign power. Loss realizations on houses in the immediately surrounding area had a much stronger diminishing effect on the salience of the purchase price, suggesting the presence of a social side to loss aversion. Our results show that house sellers measure losses and gains in nominal, not real terms, confirming previous findings by Genesove and Mayer (2001). Lastly, the gender of the home owner did not affect the reluctance to sell at a loss. These results provide strong evidence for loss aversion and anchoring in real estate markets, involving large amounts of money.

The remainder of this paper starts with a data section. Sections II and III describe the estimation methods we use to establish the nature of loss aversion in historical housing transactions and provide the empirical results for each, Section IV provides a discussion regarding the interpretation of the main results, and Section V summarizes and concludes the paper.

I. The Data

The database used for this paper consists of housing transactions spanning the period between 1650 and 1973. It consists of all the transactions of houses on the *Herengracht*, one of the canals in Amsterdam.

Figure 1 shows a map of the center of Amsterdam depicting the canal (Gerrit de Broen, 1737). The first part of the canal was dug in 1585, and it was extended in 1612 and 1660. By the end of the 17th century, both banks of the canal had been fully built up, resulting in 614 separate dwellings. It has been among Amsterdam's most fashionable locations ever since.

----- Figure 1 -----

The source of the *Herengracht* transactions data is a book (Isabella van Eeghen, G. Roosegaarde Bisschop and H.F. Wijnman, 1976) that was commissioned on the occasion of Amsterdam's 750th anniversary as a city in 1975. The book contains a history of the construction and development of the *Herengracht*, as well as a history of each of the buildings located on the canal. These individual histories contain the names and sometimes the occupation of the owners, as well as information on the transfer of ownership either through purchase or inheritance.

This database has been used previously by Piet Eichholtz (1998), who has used the transactions prices in it to estimate a biennial constant quality house price index, and by Brent Ambrose, Piet Eichholtz and Thies Lindenthal (2013), who have used it to estimate an annual index, and who have subsequently analyzed the price behavior of that index in relation to housing market fundamentals, i.e. housing rents and interest rates.

However, these two studies have only used the transactions for which prices are available. We look at all transfers of home ownership, either through inheritance or through purchase, and we also include the transactions for which we do not have a price. Table 1, Panel A, provides key information about the dataset of houses on the canal, and about the housing transactions that took place on it between 1650 and 1973. The table shows that all 614 individual houses have traded in our sample period. The vast majority of homes traded at least once in each of the three subperiods 1650-1799, 1800-1899, and 1900-1973. The level of detail of the transaction records increases throughout the centuries, as the share of sales without price information falls from 36 percent in 1650-1799, to 24 percent in the 19th century and to 16 percent thereafter. In the first sub period, sales accounted for only 56 percent of all changes of ownership, leaving about 44 percent to bequests. The sales rates increased to 70 percent of all transactions in the 19th and 83 percent in the 20th century.

---- Table 1 ----

The owners of the dwellings on the *Herengracht* do not make up a representative sample of the Dutch population throughout the centuries. Since the *Herengracht* has been among the best addresses in

Amsterdam since it was dug, especially its middle section called de *Gouden Bocht* (Golden Curve), the buildings on the canal were expensive, and their occupants well off. The typical inhabitants of these houses were initially merchants, but that subsequently broadened to lawyers, doctors and other educated citizens (Van Eeghen, Roosegaarde Bisschop and Wijnman, 1976). These people were the professionals of their time, which suggests that the occupants of the *Herengracht* homes tended to be economically proficient, with a relatively strong understanding of concepts like risk and return.

We use a modified version of the repeat sales house price index that Ambrose, Eichholtz and Lindenthal (2013) created on the basis of the *Herengracht* data. We reduce excess variation in annual returns by using Bokhari and Geltner's (2012) frequency conversion technique, which was developed specifically to construct indices from low-frequency data. Using exactly the same data as in Ambrose et al. (2012) we create 10 repeat sales indices, all at 10-year frequencies but each starting in a different base year. Subsequently, a generalized inverse estimator converts the 10 base indices to one index at 1-year-frequency. The resulting index features less noise. Its variance in annual returns is only 8 percent of the variance of the traditional repeat sales index' annual returns. The index is visualized in Figure 2, with 1900 as base year. The graph shows a rather stationary development of house prices until the mid-20th century, with long-lasting periods of growing and falling prices. The second half of the 20th century clearly stands out, with unprecedented growth in nominal house prices.

---- Figure 2 ----

Panel B of Table 1 provides statistical information about this index: the average annual index return and the percentage of years with a positive return. The average annual growth rates of the canal-wide house price index over the 324 years covered by the sample period was 0.91 percent, with most of the price increase concentrated in the 20th century. Annual price growth averaged 0.38 percent in the first 150 years, increasing to 0.53 percent in the 19th century and to 2.60 percent in the 20th century. These growth rates are all in nominal terms. The percentage of years with a positive nominal return is 61.6, which is rather stable across sub-periods, varying between 60.1 percent and 62.9 percent.

In order to do the analysis in real terms, and to test whether people evaluate the reference point in nominal or in real terms, we need an index for inflation. We use a long-run consumer price index, based on different sources. Hubert 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 Arthur 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 resulting long-term consumer price index was also used in Ambrose, Eichholtz and Lindenthal (2013), and we refer to that publication for statistical information regarding the inflation index.

Figure 1 and Table 1 provide more information about the index in real terms. The graph shows that most of the index appreciation in the second half of the 20th century was due to inflation. The real index stays much closer to its long term average level. The last two columns of Panel B in Table 1 show that the mean annual return of the real index is 0.45 percent, and that average real house prices at the *Herengracht* went up in just over half of the years in the sample period (51.3 percent). In real terms, the 20th century turns out to be the worst sub-period, with an average annual return of -0.07 percent, and just 41.4 percent of years with a positive return.

II. Paper Gains, Losses, and House Sales

We first employ a method to measure loss aversion that is similar in spirit to the one employed by Terence Odean (1998), but we have adapted it for the specific characteristics of the housing markets and of our sample. Odean (1998) uses 10,000 trading records of private traders at a discount brokerage to investigate whether they are less likely to realize their losses than their gains, which would be a sign of loss aversion. Odean first calculates paper gains or losses for stock investments by comparing the current market price for a particular share to the price at which an investor has initially purchased it. He then tests whether these paper gains or losses influence the likelihood of a divestment.

With real estate data, however, we are missing two crucial pieces of information to calculate paper gains and losses. First, home owners cannot sell their investment at any time they wish but have to find a counterparty who is willing to trade. That holds for stocks as well, but given the institutions of the stock market, finding a counterparty there is likely to be easier than in the housing market. We cannot track the bids home owners in our sample have evaluated as only transactions were recorded. We therefore assume that bids for a house arrive at a year-specific intensity λ_t, which is the same for all homes.

Second, no central market place provides price quotes for individual houses. Potential buyers make offers based on individual valuations unknown to us. We assume that their offers $O_{i,t}$ are distributed

around a fair market value which is the last transaction price $A_{i,t}$ adjusted for the changes in the canal-wide price index. Obviously, actual buyers' offers can and do deviate from these prices.

Loss aversion among home owners exists if the probability *P* of a purchase offer being accepted by an owner is higher if the highest offered price $O_{max,i,t}$ for house *i* in year *t* exceeds the price anchor $A_{i,t}$: $P(sale_{t,i} \mid O_{max,i,t} > A_{i,t}) > P(sale_{t,i} \mid O_{max,i,t} < A_{i,t})$. $O_{max,i,t}$ depends on both λ_t and the distribution of the individual offers.

Empirically, we first calculate paper gains or losses for each house on the canal and each year from 1650 through 1973. If the canal-wide index has a positive (negative) cumulative return since the last sale of a certain house, then we note a paper gain (loss) for that house. Using an index implies that we estimate the paper gains and losses for each individual house with error, and this also holds for the proportions of gains and losses realized.

We can quantify this error for 2,393 transactions where we know the purchase and subsequent sales prices. For this subset, the median realized return is 2.5 percent higher than the estimated return. In cases where our estimated paper gain or loss points in the wrong direction, it almost always involves a very small gain or loss. For the bigger index movements, our measure almost always points in the right direction. In 74.5 percent of all cases, the estimated indicator for paper losses or gains is pointing in the same direction of realized returns. For 14.5 percent, a paper loss is estimated while sellers were actually able to realize a gain. For 11 percent, a paper gain is estimated while sellers suffered a loss.

Overall, the noise in the estimate and the tendency to detect somewhat more paper losses than warranted by our sales data both make it less likely that the difference between the two proportions are statistically significant, making it more difficult to detect loss aversion, even if it is present.

Table 2 shows the average of the annual proportion of gains realized, and of the annual proportion of losses realized. It also provides the difference between the two, and the t-statistic of that difference. The first row of the table gives these numbers for the complete sample period from 1650 until 1973, followed by the three sub periods.

---- Table 2 ----

The table shows a positive and statistically significant difference between the proportion of gains realized (3.8 percent) and the proportion of losses realized (3.0 percent), suggesting that home owners are indeed loss averse. Economically, the difference is substantial: The sales rate for houses estimated

to have accumulated paper gains is 26 percent higher than the sales rate for houses at paper losses. This loss aversion is statistically very significant as well, as indicated by a t-value of 8.64.

Interestingly, we find evidence of loss aversion for each of the three sub-periods, so loss aversion is not a phenomenon that only appeared in modern economies. It affected human decision making in recent times, but also in that of our ancestors in the 17th,18th, and 19th century. However, we do find evidence that the loss aversion bias got stronger over time, since the difference in the annual sales rate widened as time progressed. In the first 150 years of the sample, the average sales rate for houses valued at a paper gain was almost 15 percent higher than for houses valued at a loss, while that difference had grown to 38 percent in the 20th century.

III. Logit Regressions

The analysis presented above provides a first look at the loss aversion bias, and it allows the researcher to study the bias in time. But to study the salience of the reference point in-depth, we estimate a logistic panel model equation with fixed time effects[1]:

$$(1)\ P_{i,t} = \beta_1 D_{paper\ loss} + \beta_2 \ln(\text{Years since purchase}) + \beta_3 \ln(\text{Years since purchase}) \cdot D_{paper\ loss} + \\ + \beta_4 \ln(\text{Years in possession}) + \varepsilon_{i,t}.$$

In this equation, the β's represent regression coefficients, while the error term is denoted by $\varepsilon_{i,t}$. In the initial setup of this model, the chance P of a sale of house i in year t is explained by a linear combination of the following variables:

- A dummy variable $D_{paper\ loss}$ which is set to 1 in case a house i is valued at an estimated paper loss in year t, and 0 otherwise. This variable captures loss aversion, if present.
- The natural logarithm of the years since purchase captures the 'age' of an existing purchase price anchor.
- The interaction term of the years since purchase with $D_{paper\ loss}$ studies the effect of the passing of time on the anchoring power of the purchase price.

[1] Ralph B. D'Agostino et al. (1990) show that Cox Proportional Hazard Rate models do not offer any advantages over plain logit regressions in this case, as both the base hazard rate of sales and the covariate are time-variant. Nevertheless, we did repeat the complete analysis using a hazard model as a robustness test. The results did not fundamentally differ from those presented in the paper.

- The natural logarithm of the number of years the house has been in possession of the owner, either due to a purchase, a bequest or a division of property.

We do not aspire to explicitly model differences in housing market liquidity caused by a changing political and economic climate, interest rate movements or any other general factors. Instead, year-to-year differences in the overall liquidity of the real estate market are controlled for by annual time fixed effects. The coefficients for the covariates therefore estimate in how far differences in these variables lead to deviations from the overall likelihood of a sale in a given year.

In subsequent estimations of (1) we also explicitly estimate the effect of inflation and the occurrence of important events on the anchoring power of the purchase price, distinguishing between events of a personal nature and events that affected society as a whole. First, we investigate the effect of loss-taking in houses nearby, the role of gender, and the passing away of the original owner. Then, we look at broadly shared experiences that may have eroded the salience of the purchase price: inflation, the occurrence of financial crises, the outbreaks of war, and occupations by a foreign power. We investigate whether these issues affect the emotional relevance by including in (1) the following additional variables as well as their interaction with $D_{paper\ loss}$.

The variable $D_{realized\ losses\ nearby}$ is a variable indicating whether relatively many houses close by are estimated to have sold at a paper loss in the year before. We consider houses to be 'close' if they are located on the same canal bank, subdivided into segments by crossing bridges. *Realized losses nearby* is defined as the number of sales at estimated paper losses divided by the total number of sales for this canal segment in the preceding year. The dummy variable D_{female} is set to 1 for all years in which a house is owned by a woman, and zero otherwise. The dummy variable $D_{inheritance\ since\ purchase}$ is set to 1 for all years after a house has been passed on to the next generation in a bequest. It is reset to 0 after a subsequent sale. Interacting these variables with $D_{paper\ loss}$ gives insight in the degree to which they diminish the anchoring power of the purchase price.

We include the natural logarithm of the change in CPI since the last sale to investigate whether inflation affects the willingness to sell at a loss. We define $D_{financial\ crisis}$, $D_{war\ since\ purchase}$ and $D_{occupation\ since\ purchase}$ as 1 for the years after the occurrence of a financial crisis, the outbreak of a war, or the beginning of an occupation by foreign troops, respectively. These variables are reset to 0 after a subsequent sale. Again, the interaction of these variables with $D_{paper\ loss}$ provides insight into their influence on the salience of the purchase price.

The comparison of homes within the same year but with either paper gains or losses requires that we observe variation in $D_{paper\ loss}$, which is not the case for years where the index reaches a new local maximum (minimum) because all $D_{paper\ loss}$ are then set to 0 (1). We therefore exclude years in which more than 90 percent or less than 10 percent of observations are flagged having accumulated paper losses. Without these extreme peak or trough years, 186 years remain in the sample.

Table 3 provides information regarding the key regression variables: the dummy for paper losses and the variables we use to investigate the salience of the purchase price as the reference point. These include the years since the purchase, the dummy for realized losses in the direct proximity of the dwelling, the gender dummy, the dummy for an inherited house, and dummies for societal shocks since the purchase of the house. The table shows that the average holding period for houses at the *Herengracht* was 18.5 years, that women were home owners in 17 percent of all house-years in the sample, and that wars and foreign occupations were relevant to many home owners over time, with dummy variables of 0.35 and 0.14, respectively.

---- Table 3 ----

Table 4 gives the estimation results of the model. The first column of the table presents the results for the base model. The estimated regression coefficients confirm the earlier findings in Table 2, and again show that loss aversion is present and pervasive in housing transactions. The likelihood of sale is negatively associated with the house being estimated to be at a paper loss. Keeping all other factors equal, the chance of observing a sale is 1.1 percent ($1-e^{-0.012}$) lower for houses flagged as being at paper losses. This evidence for loss aversion is not only economically but also statistically significant with a p-value below 0.01.

The longer a house has not been transacted, the lower the odds of observing a transaction in a particular year, as indicated by a negative -0.003 coefficient for *ln(Years in possession)*. This result is in line with Genesove and Mayer (2001), who find a negative relation between the time since purchase and the hazard rate of a sale.

The regression coefficient for *ln(Years since purchase)* is not statistically significant while the interaction term $ln(Years\ since\ purchase) \cdot D_{Paper\ loss}$ is positive and significant. This positive estimate indicates that the passage of time indeed reduces the psychological power of the purchase price. However, the small magnitude of 0.004 suggest that this power fades slowly.

In a further analysis using the base model setup – one for which we do not report the results in the table – we use the real house price index to calculate paper losses and gains. This leads to insignificant coefficients for $D_{paper\ loss}$ so home owners seem to determine gains and losses in nominal terms. This is in line with the findings of Genesove and Mayer (2001).

---- Table 4 ----

The next step in the analysis is to include additional explanatory variables in the model, with the aim to see how the aversion to selling at a loss relative to the purchase price is affected by important events. We report results of this extended analysis in the second column of Table 4.[2] We first present results for events affecting people individually.

Misery appears to love company. Losses previously realized by neighbors reduce a home owner's reluctance to accept a loss himself. The coefficient for *Realized losses nearby* does not show any significant effect for houses at paper gains but have a positive coefficient (0.006) when interacted with $D_{paper\ loss}$. This suggests the presence of a social dimension to loss aversion: It is easier to justify a loss to oneself and others if one can refer to others who have experienced similar adversities. As far as we can tell, this is the first evidence of a social aspect to loss aversion.

These findings hold up under alternative definitions for *Realized losses nearby*. Besides realized losses on the 15 nearest neighboring dwellings left and right, we also look at the 10 and 20 nearest neighbors on both sides, and at all houses located within the same segment between two bridges on the same side of the canal. We find coefficients of comparable magnitude and direction no matter which of these specifications we use.

As for gender, we find that it does not matter for the salience of the purchase price. Neither the coefficient for D_{female}, nor its interaction with $D_{paper\ loss}$ are significant. This implies that women are not more or less likely than men to sell their home, and nor are they more or less likely to sell it at a loss. In principle, it is possible that the lack of significance is caused by the lower number of observations for women owners, but this is unlikely. For the interaction term, on which we focus our attention, the coefficient is 0.000.

[2] The table only shows the results for the full model. To control for possible multicollinearity, we have included the variables one by one to see whether the inclusion of a subsequent variable affected the coefficient for an existing one. They sometimes did, but not in a statistically or economically significant way.

Our data enable us to investigate whether the spell of the purchase price passed on to the next generation after a bequest. It turns out that heirs were suffering as much from loss aversion as their predecessors: the coefficients for $D_{inheritance\ since\ purchase}$ interacted with $D_{paper\ loss}$ are not significant at any conventional level of confidence, and since bequests were common, covering about one third of all ownership transfers, this lack of significance is not likely to be caused by a lack of observations. So the anchoring power of the price paid by the parents seem to be strong enough to transcend their demise, still casting a spell on their children.

We now turn to the effect of collective experiences, and first test whether the power of anchors depends on changes in consumer prices indirectly. A rapid change in the general price level observed by home owners could erode the perceived relevance of old price points. Our estimates tell a different story, however. When overall consumer prices since the purchase have moved up (*CPI change*), the influence of pricing anchors is reinforced. Households are less willing to accept a loss for their home if prices for other goods have increased.

Societal turmoil may affect the relevance of the psychological relevance of the purchase price. For example, the Second World War, with its five years of foreign occupation and hardship in the Netherlands, may well have reduced the psychological importance of events preceding it. Indeed, the purchase price of a house may have seemed trivial compared to the traumatic experiences of the war.

It turns out that wars do annihilate price anchors, but not all wars. Generally, the outbreak of wars did not lead to a reduction in market liquidity, as can be inferred from the lack of statistical significance of the coefficient for $D_{war\ since\ purchase}$. And since the coefficient for the interaction of that dummy with $D_{paper\ loss}$ is not significantly different from zero either, wars in general did not 'reset' price anchors. That makes sense, since many of these wars were fought elsewhere, both on land and at sea. So for the average home owner, they were unlikely to affect daily life very significantly.

That was different for the wars that involved foreign occupation. These events could be perceived as the beginnings of a new era. For the *Herengracht* canal, the most severe shocks were the three foreign invasions of 1672, 1795, 1810, and 1940. These events negatively affected market liquidity, but more important for our study, they also reduced the psychological significance of the home purchase price. In the aftermaths of these devastating experiences, prices from the 'old era' (before the occupation) did not seem to matter in the new epoch (after the occupation): The coefficient for $D_{occupation\ since\ purchase}$

interacted with $D_{paper\ loss}$ is big enough to offset the estimated effect of loss aversion and is statistically significant.

IV. Discussion

Capuchin monkeys, with whom humans shared common ancestors as much as 40 million years ago, display loss aversion behavior (Keith Chen, Venkat Lakshminarayanan, and Laurie Santos, 2011). This suggests that loss aversion is a hardwired trait of human behavior. That finding makes it perhaps not very surprising that our ancestors in the 17th century were affected by the loss aversion bias.

On the other hand, Joseph Henrich's (2000) seminal work shows that the degree to which human beings diverge from the model version of Homo Economicus is culture-dependent, and it is likely that Dutch culture has changed during the last three centuries. So perhaps the fact that we find increasing loss aversion is a sign of cultural change.

But perhaps it could be explained by rational motivations. Genesove and Mayer (2001) find that the home mortgage's loan-to-value ratio significantly reduces the willingness to sell at a loss, so credit considerations seem to play a role in selling behavior. It seems likely that they play a role in our data as well, but we do not have comprehensive statistical information regarding housing finance in Amsterdam to do any formal tests. Even so, we do have relevant information about housing finance in Dutch history, allowing us to address credit constraints as a potential explanation for our findings.

There was already a functioning mortgage market in the Netherlands in the late medieval period, despite the absence of a banking system. Jan Luiten van Zanden, Jaco Zuijderduijn and Tine de Moor (2012) provide a detailed analysis of the local credit market in Edam, a medium sized city just north of Amsterdam. They show that property rights were well protected, and that real properties were commonly used as collateral as early as in the 15th century, with interest rates around 6 percent. The loans, named *kustingen*, were made between households, and credit was available to rich and poor households alike, no matter whether the household was led by a woman or a man. There was also a lively secondary market in loans. Throughout the 19th century household-to-household loans remained the dominant form of mortgage lending. So we cannot explain the increase in loss aversion over the centuries by the development of the mortgage market: that market already existed before our sample period.

The typical loans had a maturity of 2 to 12 years, and were gradually amortized over that period. A Dutch mathematics handbook by Jacob van der Schuere (1643) shows that *kustingen* were amortized in

equal annual portions over their life time. These loan characteristics suggest that the loan-to-value ratio was of limited importance as an explanation of loss aversion: initial loan-to-value ratios were low by modern standards (Marjolein 't Hart, Joost Jonker and Jan Luiten van Zanden, 1997), and the life of the typical loan was quite a bit shorter than the average holding period for the houses on the *Herengracht*, which was 18.5 years.

And even if the home-owners on the canal rolled over their old loans in new ones, credit constraints were unlikely to play a role. These were the most wealthy citizens of the country, so if the value of the house fell short of the balance of the loan, the money (or credit) required to fill the gap would probably have been available. Jan de Vries and Ad van der Woude (1995, p. 684) provide detailed information about the asset composition of the bequests of rich citizens in Leiden, Gouda and Hoorn in the 18th century. On average, the home's share in these bequests was around 5 percent, with cash positions around 2.5 percent. Bonds, for which there was a liquid secondary market, amounted to 50 percent, approximately. So if house prices would fall short of outstanding mortgage loans for this type of home owners, financing the gap would not have been much of a problem. Since the *Herengracht* has remained a fashionable address for Amsterdam's richest citizens also in the 20th century, credit constraints are not a likely explanation for the occurrence, nor the increase, of loss aversion.

Another rational explanation of our finding could be mean reversion (Odean, 1998). If house prices would follow a mean reverting process, it would be rational for a house owner to just wait for a price recovery instead of realizing a loss. We cannot use our own index to study the house price process: the index estimation method introduces positive autocorrelation in the index, so any conclusions derived from studying it would be biased. But house price indices that are based on large numbers of transactions, and for which more standard repeat sales estimation techniques are used, turn out to display positive autocorrelation as well (see Karl E. Case and Robert J. Shiller, 1989), which implies that mean reversion in house prices is an unlikely explanation for our findings.

V. Concluding Remarks

This paper provides the first long-run historic evidence of loss aversion in a key asset market. By employing a database of housing transactions spanning the period between 1650 and 1973, this paper shows that loss aversion appears to have been present throughout the ages, but has gotten stronger. We find loss aversion in all sub-periods, but 20th century home owners on Amsterdam's *Herengracht* were

more reluctant to sell their houses at a loss relative to the purchase price than their forebears in the 19th, 18th, and 17th century had been.

Gender did not affect the reluctance to sell at a loss, and the force of the purchase price as a mental anchor seemed to remain strong even after the house had been in possession of the same person for a long time: the years that passed since the purchase of the house only slowly affected the likelihood of a sale. In fact, the psychological value of the purchase price was so big that it transcended the death of the first owner, and was passed on to his heirs: we see the same association between price since last sale and the likelihood of a sale even if we control for the fact that the house has been inherited.

An important finding of this paper is that the reluctance to sell at a loss seems to be diminished by loss-taking in houses nearby. This could be interpreted as a social dimension of loss aversion: to come to peace with ones losses, it probably helps if the neighbors have gone through the same painful experience before.

The psychological power of the purchase price is confirmed by our subsequent analysis, in which we include important common experiences in the regression: inflation, financial crises and wars. But for one exception, these events did not noticeably affect the relation between price since last sale and the likelihood of a sale. The exceptions were wars that involved occupation by a foreign power. These seem to have put an end to the spell of the purchase price, and caused a clean mental slate.

These results provide compelling evidence for the existence of loss aversion. Even long-run economic forces do not seem to nullify its effect on human behavior. The purchase price of a house has been a very important determinant of the decision to sell it or keep it throughout the centuries. Only the neighbors and enemy occupation could change that.

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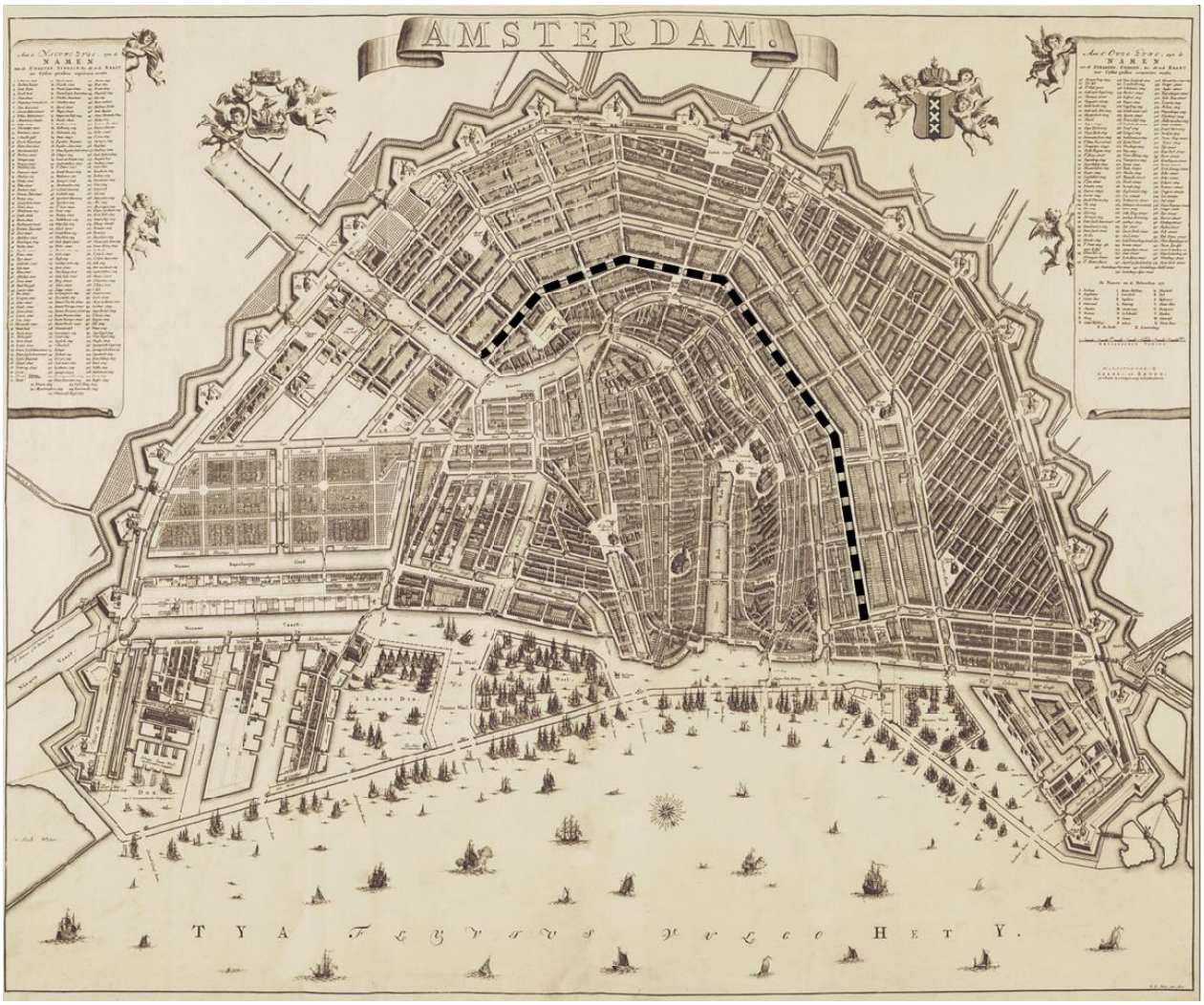
Figure 1: Map of *Herengracht* Canal and Amsterdam in 1737



Notes: Historical map of Amsterdam by Gerrit de Broen (1737). The dashed line marks the *Herengracht* canal (added by authors).

Figure 2: House Price Index for *Herengracht*, 1650-1973

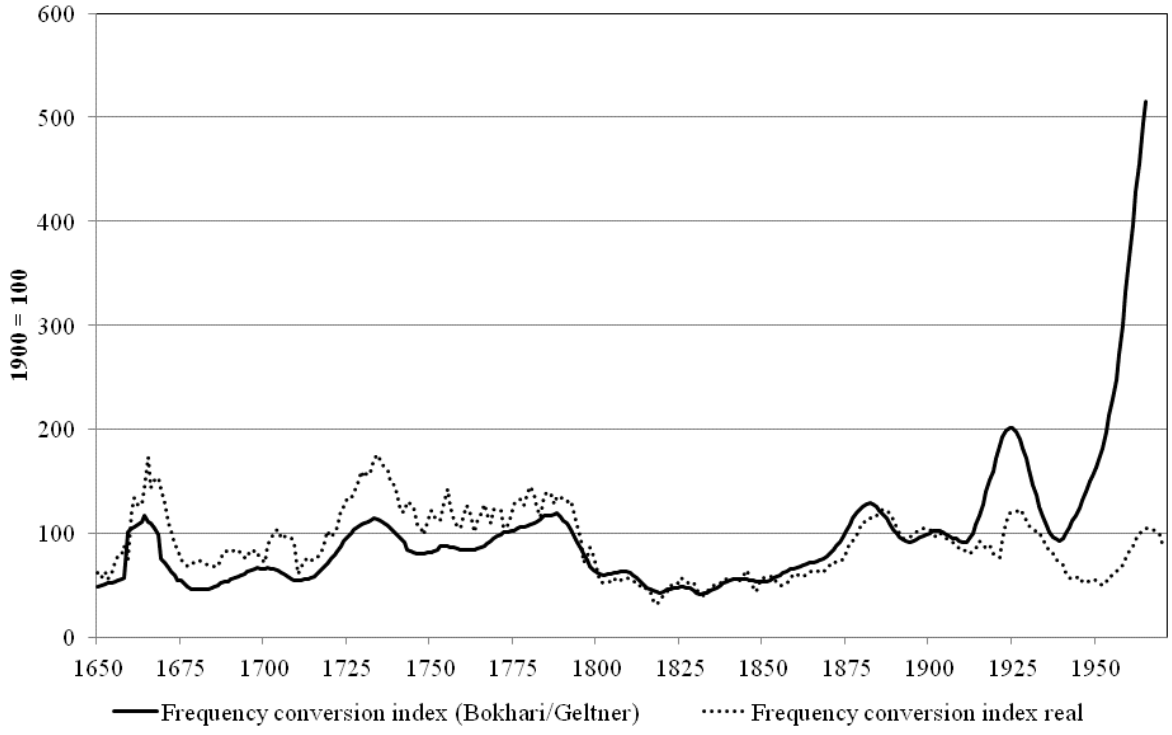


Table 1: Descriptive Statistics for Sales Sample and Index

A: Sales Sample				
Period	*# houses with transactions*	*# sales total*	*# sales with price*	*# bequests*
1650-1973	614	6644	4919	3273
1650-1799	606	2437	1565	1912
1800-1899	608	2175	1651	950
1900-1973	593	2032	1703	411
B: House Price Index				
	Mean annual return (nominal)	*% years with positive nominal return*	*Mean annual return (real)*	*% years with positive real return*
1650-1973	0.91%	61.60%	0.45%	51.25%
1650-1799	0.38%	60.10%	0.52%	49.33%
1800-1899	0.53%	62.00%	0.72%	61.00%
1900-1973	2.60%	62.90%	-0.07%	41.43%

Table 2: Annual Sales Rates for Houses with Unrealized Paper Gains and Losses

Period	Annual sales rate for houses valued at …		Difference	t-value
	paper losses	paper gains		
1650-1973	3.01%	3.80%	0.79%	8.64
1650-1799	2.19%	2.51%	0.32%	2.30
1800-1899	3.23%	4.09%	0.87%	6.24
1900-1973	3.92%	5.42%	1.49%	6.17

Notes: We flag a house as having accumulated "paper gains" ("paper losses") whenever the overall house price index experienced positive (negative) cumulative returns since the house's last sale.

Annual sales rates for each sub-period are calculated by dividing the number of sales at paper gains (or losses) for the given time period by the number of years each house was marked at paper gains (or losses). The third column presents the difference of columns1 and 2, and the fourth column the t-statistic for this difference.

Table 3: Means for Explanatory Variables

Variable	*Mean value*
$D_{paper\ loss}$	0.52
Years in possession	18.47
$D_{realized\ losses\ nearby}$	0.24
D_{female}	0.17
$D_{inheritance\ since\ purchase}$	0.29
$D_{war\ since\ purchase}$	0.35
$D_{occupation\ since\ purchase}$	0.14

Notes: $D_{Paper\ loss}$ is defined as 1 for house *i* in a given year *t* if the cumulative return of the overall price index since the last sale of house *i* is negative – and 0 otherwise.

We segment houses along the canal by subdividing each bank into "natural blocks", each separated by crossing bridges. $D_{realized\ losses\ nearby}$ is defined as 1 for house *i* in year *t* if more than average realizations of paper losses took place in the block of house *i* in year *t-1*.

D_{female} is set to 1 for all years after a house has been purchased or inherited by a woman and to 0 whenever a home is owned by a male head of household. $D_{inheritance\ since\ purchase}$ is set to 1 for all years *t* after house *i* has been inherited. Whenever a sale takes place, the variable is set back to 0 for subsequent years. In a similar fashion, $D_{war\ since\ purchase}$ is set to 1 whenever the Netherlands has been involved in a war. Again, the variable is reset to 0 for all houses that have traded since that disruptive event. $D_{occupation\ since\ purchase}$ is constructed accordingly, but uses occupation by foreign troops as criterion.

Table 4: Estimates from Logistic Panel Regressions

Variables	*Base Model*		*Full Model*	
General				
$D_{\text{paper loss}}$	-0.010 [0.004]	**	-0.011 [0.004]	**
log(years since purchase)	0.002 [0.001]		0.003 [0.002]	
log(years since purchase) · $D_{\text{paper loss}}$	0.004 [0.002]	**	0.003 [0.002]	*
log(years in possession)	-0.003 [0.001]	**	-0.002 [0.001]	*
Neighbor Effect				
Realized losses nearby			-0.004 [0.003]	
Realized losses nearby · $D_{\text{paper loss}}$			0.009 [0.003]	**
Gender Effect				
D_{female}			0.002 [0.003]	
D_{female} ·$D_{\text{paper loss}}$			0.000 [0.004]	
Inheritance Effect				
$D_{\text{inheritance since purchase}}$			0.000 [0.002]	
$D_{\text{inheritance since purchase}}$ · $D_{\text{paper loss}}$			0.002 [0.003]	
General Price changes				
log(CPI change)			0.014 [0.007]	**
log(CPI change) · $D_{\text{paper loss}}$			-0.024 [0.008]	***
Societal Shock:War				
$D_{\text{war since purchase}}$			-0.002 [0.004]	
$D_{\text{war since purchase}}$ · $D_{\text{paper loss}}$			0.001 [0.004]	
Societal Shock: Occupation				
$D_{\text{occupation since purchase}}$			-0.023 [0.006]	***
$D_{\text{occupation since purchase}}$ · $D_{\text{paper loss}}$			0.017 [0.006]	***

Notes: Standard errors in parentheses. All regressions with fixed time effects. The stars ***, ** , * indicate significance at 1%, 5% and 10% confidence levels.