Loss-Aversion and Household Portfolio Choice

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Abstract

In this paper we empirically test if loss-aversion and reference points affect household non-participation in equity markets, heterogeneity in allocation to equity, and households' allocations between mutual funds and individual stocks. Using household survey data we obtain direct measures of each surveyed household's loss-aversion coefficient and reference points from questions involving various types of payoffs. We find that higher loss-aversion, and higher reference point adjustment to payoffs promised in survey questions, is associated with a lower probability of participation and lower allocations of wealth to equity. We also find that higher loss-aversion and reference points reduce the probability of direct stockholding by significantly more than the probability of owning mutual funds.

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Calibrated models of household portfolio choice with standard preferences suggest that in frictionless economies almost all households should own equity and that equity should comprise almost all of their financial wealth (Haliassos and Bertaut (1995), Heaton and Lucas (1997)). Empirical studies have found equity market participation rates and allocations much lower than is implied by these models (Bertaut (1998), Haliassos and Bertaut (1995), and Vissing-Jorgensen (2002)). Explanations for this divergence have focused on two explanations: frictions such as background risk and investment costs[1], and non-standard preferences such as loss-aversion.

Theoretical papers such as Ang, Bekaert and Liu (2004), Barberis Huang and Thaler (2006), Benartzi and Thaler (1995), Berkelaar, Kouwenberg and Post (2004), Gomes (2005), and Polkovnichenko (2005) show that if households are loss-averse they either will not participate in equity markets or will allocate considerably less of their wealth to equities. Loss-aversion implies that households frame events as either gains or losses relative to a reference point, and weight losses more heavily than gains. If households are sufficiently loss-averse the potential pain from losses may be sufficiently large that they choose to forgo the equity premium.

In this paper we empirically examine how loss-aversion and reference points affect household portfolio choice. Using the DNB economic survey conducted in The Netherlands we derive a measure of each household's loss-aversion coefficient and their reference points from a series of intertemporal choice questions based on work by Thaler (1981) and Loewenstein (1988). We then show that these measures have significant

[1] See Cocco, Gomes and Maenhout (2005), Davis, Kubler and Willen (2004), Viceira (2001), Vissing-Jorgenses (2002).

explanatory power for households' equity market participation decisions, asset allocation decisions, and the choice between mutual funds and direct stockholding.

We measure loss-aversion and reference points from survey questions involving the speed-up and delay of payoffs, both gains and losses. With standard utility functions, people will have a single discount rate across gains and losses, and across speed-up and delay. This property is strongly violated in people's responses to these questions and in experiments with actual payouts. The compensation most people require to delay receiving a sure gain is much higher than the amount they are willing to pay to expedite receipt of the same gain. Loewenstein (1988), Loewenstein and Prelec (1992), and Thaler (1981) show that a loss-averse individual who does not integrate payments with existing consumption plans, but rather frames the payments as gains and losses relative to a reference point, can have multiple discount rates. The predictions of the reference point model are supported by experiments conducted by Benzion, Rapoport and Yagil (1989), Loewenstein (1988), and Thaler (1981) among others.

To understand the intuition behind this finding consider an individual who expects to receive a gain immediately and is asked for the smallest amount he or she is willing to accept to delay the receipt of the gain for one year, termed the delay premium. In a second intertemporal choice problem the individual is promised a gain one year from now and then asked for the most he or she would be willing to pay to speed up receipt of the gain to today, termed the speedup cost. It is easy to prove that the delay premium and the speedup cost are equal for any individual who can borrow and lend at the risk-free rate, discounts expected utility, and integrates the payments of these choice problems with his current consumption and savings plan. With borrowing constraints, Loewenstein

and Prelec (1992) show that the discount rates for speedup and delay can be different, depending on to the concavity of the utility function, but it is quantitatively very small.

On the other hand, consider an individual who narrowly frames the intertemporal choice problem – i.e. does not integrate it with planned consumption and saving – and evaluates payoffs as gains or losses relative to a reference point. If the individual is asked to delay a gain, this represents a loss relative to the reference point and the individual will therefore demand a high delay premium. Now suppose that the same individual expects to receive a gain at a distant point in the future and is asked how much he or she is willing to pay at most for speed-up. Expedited receipt involves an immediate gain and a loss in the future. If loss-aversion and the reference point are sufficiently high, the pain of the loss dominates and the individual is not willing to pay at all for speed-up. This is frequently observed in the survey data; more than 60% of the respondents do not want to pay for speed-up of gains. On the other hand, some individuals with lower loss-aversion and/or reference points might be willing to pay a small cost for speedup. The key point is that the delay premium and the speed-up cost are not necessarily equal in a decision model with narrow framing, reference points, and loss-aversion.

The 1997-2002 waves of the DNB survey contains a series of 16 questions asking households how much they would be willing to pay to speed-up a gain or delay a loss, and how much compensation they would require to delay a gain or speed-up a loss. Following the model of Loewenstein (1988), we allow for the possibility that respondents have different reference points for immediate payoffs and future payoffs, i.e. for speed-up questions and for delay questions. Thus, our preference model has two reference points for each household in addition to their loss-aversion coefficient and rate of time

preference. We then estimate these parameters using the Generalized Method of Moments (GMM).

Clearly a key issue for this paper is the reliability of our measures of loss-aversion and reference points. We test the internal consistency of our measures in two ways. First, as we have multiple questions designed to measure the same set of latent variables, we use Cronbach's alpha - the standard psychometric test for reliability in these cases – and find strong evidence to support the notion that similar questions are consistently measuring the same underlying concepts. Second, there are simple, logical relations which must hold between many of the responses. We find that only a small percent of household responses violate these relations. Further we show that the responses to the DNB survey are both qualitatively and quantitatively similar to a large number of experimental studies. Finally, we discuss other potential explanations for the pattern of responses and show that among all alternatives, a model with reference points and loss-aversion is the only reasonable explanation consistent with the data.

We hypothesize that our empirical measure of loss-aversion – based on the 16 survey questions – is a proxy for the level of loss-aversion that the households experience when investing in actual markets. For the reference points, we hypothesize that they measure the individual's susceptibility of adjusting to hypothetical gains and losses, i.e. payoffs that exist only on paper. The potential relevance of these survey-based reference points for stock market participation and equity allocations becomes clear once we realize that investing in stocks typically involves frequent evaluation of paper gains and losses every time the individual checks his or her portfolio. A loss-averse investor who frequently updates the reference point to paper gains and losses cannot build up a cushion

of accumulated gains and therefore is likely to remain wary of the potential losses on risky assets like stocks. Berkelaar, Kouwenberg and Post (2004) show that the portfolio allocation to equity of loss-averse investors is lowest when the wealth is close to the reference point. Therefore we expect that individuals who easily adjust their reference level to hypothetical gains and losses will invest less in equity.

Using our loss-aversion and reference point measures we show that households with higher loss-aversion and higher estimated reference point adjustment are significantly less likely to participate in equity markets. For an average household if their estimated loss-aversion coefficient changes from the 25th to the 75th percentile, the probability of owning stocks increases by 25%, relative to the sample mean. The economic significance of the reference points is similar. These results are robust to controlling for a wide variety of variables used in previous studies, such as age, education, income, financial wealth, and unsecured debt.

We also find that our loss-aversion and reference point measures significantly predict household allocations of financial assets to equity. The economic effect of loss-aversion is more modest here, only causing a 2% increase in the allocation to equity relative to the sample mean. However, the economic effect of the estimated reference points is much larger, causing a 15% increase in allocations to equity relative to the sample mean.

We also show that loss-aversion and reference points affect the type of equity that households hold. Households with higher loss-aversion and reference points avoid investing in individual stocks to a greater extent than they avoid mutual funds. This is consistent with Benartzi and Thaler (1999) and Thaler, Tversky, Kahneman and Schwartz

(1997) who argue that the bundling of returns affects their attractiveness to loss-averse investors who are susceptible to framing effects.

This paper provides direct empirical evidence on the importance of loss-aversion and reference points for household decision making. To our knowledge it is the first paper to empirically measure the heterogeneity in loss-aversion and reference points across a representative sample of households from survey questions and use this information to explain household portfolio choice. Another contribution of this paper is our GMM approach for estimating individuals' loss-aversion coefficients and reference points from the survey questions. Previous empirical studies of loss-aversion in finance, such as Odean (1998) and Grinblatt and Han (2005), have tested the predictions of loss-aversion by identifying investors' current positions relative to their reference point, and using this to predict their subsequent behavior. In contrast, we measure the parameters of the household's utility function rather than their position upon the utility function.

The remainder of this paper is organized as follows. Section 1 outlines the theories and hypotheses tested in this paper. Section 2 describes the data source and the variables. Section 3 derives the measures of loss-aversion and reference points and discusses some of their features. Section 4 presents the results and a discussion of economic significance. Section 5 concludes.

1. Theory and Hypotheses

Heaton and Lucas (1997) calibrate a model of a representative household's portfolio choice using standard utility functions and parameter values drawn from the US economy. They find that all households should participate in equity markets and that, in

the absence of market frictions, they should allocate all of their financial wealth to equity. However, numerous empirical papers have shown that many households do not participate in the equity market, and many participants own only small amounts of equity.[2]

There are two broad streams of research attempting to explain these two puzzles: models based on market frictions such as participation costs, credit constraints[3], and background risk such as risky labor income[4]; and models based on non-standard preferences.

This paper empirically tests the effect of one particular type of non-standard preferences – loss-aversion relative to a reference point – on the portfolio choices of households. See Figure 1 for an example of a loss-averse value function. Prospect theory, introduced in Kahneman and Tversky (1979), differs from the standard expected utility model in four ways: 1) Individuals frame events as gains and losses relative to a reference point, representing the status quo or an aspiration level. 2) Individuals are loss-averse meaning that losses are weighted about twice as heavily as gains, even for very small losses.[5] 3) Individuals are risk averse in the region of gains and risk seeking in the region of losses. 4) Individuals use subjective probability weights that overweight small objective probabilities. This paper is concerned with the first two features of prospect

[2] See for example Bertaut (1998), and Vissing-Jorgensen (2002).
[3] Davis, Kubler and Willen (2004) show that if there are frictions in the credit markets it is possible to get non-participation and realistic portfolio allocations. Vissing-Jorgensen (2002) presents evidence that some of the participation puzzle can be explained with fixed entry costs, which could include costs such as learning, fees, taxes etc.
[4] Theory articles such as Cocco, Gomes and Maenhout (2005), Heaton and Lucas (1997, 2000) and Viceira (2001) show that if a household's labor income has a high correlation with equity or a high standard deviation it is optimal hold a safer portfolio. Guiso, Jappelli and Terlizzese (1996), and Vissing-Jorgensen (2002) empirically demonstrate that households with high background risk are less likely to participate and hold less equity.
[5] For experimental evidence see; Kahneman and Tversky (1979), Loewenstein (1988), Thaler, Tversky, Kahneman and Schwartz (1997). Tversky and Kahneman (1991) provide a good review of the experimental evidence.

theory – loss-aversion relative to a reference point. Many authors use the term loss-aversion to mean a combination of features one, two and three, including the convex-concave shape of the utility function. In this paper loss-aversion refers only to the sudden increase in the slope of the value function for payoffs that fall below the reference point.

In the empirical work later in this paper we allow for heterogeneity in reference points. Some households may fully adjust their reference points to the hypothetical gains and losses mentioned in the survey questions, while others may only partially adjust. Since investments in stocks involve paper gains and losses which occur every time the investor looks at his or her portfolio, the adjustment of reference points to hypothetical payoffs is potentially important. Frequent adjustment of the reference point to paper gains and losses does not allow households to build up a cushion of past gains that protects them from the pain of future losses, and so they will find equity relatively unattractive.[6] This argument is related to the point of Benartzi and Thaler (1995) who argue that myopic loss-aversion causes investors who evaluate their portfolio frequently demand a higher equity premium.

Ang, Bekaert and Liu (2004), Gomes (2005), and Polkovnichenko (2005) show that stock market non-participation can be explained by loss-aversion. If households are loss-averse the potential pain from stock market declines outweighs the pleasure from gains even with a high equity premium. As a result, loss-averse households choose to avoid any exposure to equity. These theoretical papers lead to a clear, one-sided hypothesis for our study; greater levels of loss-aversion will result in a lower probability

[6] Note that in the case of large accumulated losses on an equity portfolio, a loss-averse investor also tends to invest more in stocks, in an attempt to break-even. Berkelaar, Post and Kouwenberg (2004) show that the portfolio weight of stocks of a loss-averse investor is a V-shaped function of the wealth level: when wealth is close to the reference point loss-aversion matters most and the demand for stocks is relatively low.

of participating in the equity markets. Ang, Bekaert and Liu (2004), Berkelaar, Kouwenberg and Post (2004), Benartzi and Thaler (1995) further show that loss-aversion will lead to lower portfolio allocations to equity. The increased sensitivity to losses decreases the benefit of owning equity and as a result loss-averse households choose to hold less of their wealth in equity.

Berkelaar, Kouwenberg and Post (2004) show that the portfolio weight of stocks of loss-averse individuals is lowest when their wealth is close to the reference level, while the proportion increases when wealth moves further away from the reference level. We therefore hypothesize that individuals who adjust their reference point more easily to portfolio gains and losses have lower allocations to equity. We use our estimated reference points – measuring adjustment to hypothetical gains and losses in the survey questions – as a proxy for adjustment to portfolio gains and losses. We expect that high estimated reference points are negatively related to equity market allocations and participation. Further, in all papers on loss-aversion and portfolio choice, the effect of loss-aversion is dependent on households forming reference points and framing outcomes as gains and losses relative to these reference points. This reinforces our empirical prediction that higher loss-aversion and reference points will be jointly negatively associated with lower equity allocations and equity market participation.

We also argue that loss-aversion will affect the type of equity that households choose to hold. Households with higher loss-aversion and estimated reference points will prefer mutual funds over owning individual stocks. Benartzi and Thaler (1999) and Thaler, Tversky, Kahneman and Schwartz (1997) argue that the presentation of returns affects the attractiveness of equities for loss-averse investors. Both articles show that

investors may refuse a sequence of individual risks but accept the same risks if they are presented as a package.

Consider the following simple example. An investor with a loss-aversion coefficient of 2.5 has an equally weighted portfolio of three equity securities. Suppose that in a given year two of the stocks increase in value by 10% and one stock decreases in value by 10%. The value of the portfolio has increased by 3.3% and an investor who frames at the level of the portfolio will have a gain from investing in stocks. However, if the investor frames at the level of individual stocks the pain from the single loss outweighs the pleasure of the two gains. Since mutual funds package equities in a way that encourages framing at the portfolio level, loss-averse investors will prefer to own mutual funds rather than individual stocks. Since higher reference points magnify the effect of losses, households with higher reference points will shun individual stocks to a greater extent than mutual funds.

2. Data

The data source for this paper is the CentER DNB survey, a household survey conducted by the CentER at Tilburg University in The Netherlands.[7] We use this dataset because it contains information about household wealth, income, financial assets and a set of questions from which we can extract measures of loss-aversion and reference points. This paper uses data from the 1997-2002 waves of the DNB survey as the questions used to measure loss-aversion are unavailable in other years. The DNB survey is conducted entirely online. To avoid the obvious sample-selection effect of limiting the

[7] This survey was previously called the CentER Savings Survey (CSS), and prior to that was called the VSB CentER Savings Project.

survey to households with internet access, the CentER provides all households with a set-top box, which allows internet access through a television and phone lines.

Alessie, Hochguertal and van Soest (2002) provide an excellent introduction to this data. Comparing the DNB survey results to national accounts data and microdata on household wealth published by Statistics Netherlands they find that it is generally representative of Dutch households. Although no household survey can ever be entirely free of potential biases caused by non-response these findings suggest that this problem is limited in the DNB survey.

To be included in this study in a given year, the household must have answered the General Information section of the Household module, the Assets and Liabilities module, the Health and Income module, and the Economic and Psychological Concepts module.

For all monetary variables, such as income and asset ownership, we aggregate within households and inflation adjusted to 1997 prices. For non-monetary variables we take the response of the self-identified household head.[8] If the household head's answer is not available we use the spouse's response. If neither the head, nor the spouse, responds, we drop the household from the sample. Summary statistics of the control variables used in this paper are presented in Table 1. This table shows results for all respondents, equity owners, and non-owners. We refer to Donkers and van Soest (1999) and Alessie, Hochguertal, and van Soest (2004) for an analysis of equity ownership in the earlier DNB survey waves 1993-1998, using a similar set of control variables.

[8] We follow the method of Alessie, Hochguertal, and van Soest (2002) for imputing amounts when a given variable is missing for a household. If the amount owned is available in both the prior and the subsequent year we use their mean in the current year. Otherwise, we estimate the amount owned with a random-effects linear model using age, education, income, and the number of assets owned (i.e. the number of stocks or mutual funds owned, if available).

2.1 Household Wealth and Income

Numerous authors have shown that wealth is an important determinant of portfolio allocation, i.e. Bertaut (1998), Vissing-Jorgensen (2002). As Panel A of Table 1 shows equity owners in this sample have greater wealth than non-participants. Vissing-Jorgensen argues that this is consistent with fixed costs of market entry, such as minimum investments or investment advising fees, as it is easier for wealthy households to pay these costs.

As in Alessie, Hochguertal, and van Soest (2002), total financial assets is defined as the sum of: all savings and checking accounts, bonds, stocks, mutual funds, money market funds, single-premium annuity insurance policies, cash value of life insurance, employer sponsored savings plans, money lent to friends and family, and other savings or investments not recorded elsewhere. Total financial assets is winsorized at the 99th percentile**.**

We define income as total income before taxes less dividends and interest income. This variable is highly skewed and winsorized at the 1st and 99th percentiles. Several studies have shown that equity ownership increases with income (i.e. Bertaut (1998), Haliassos and Bertaut (1995) and Vissing-Jorgensen (2002)). Donkers and van Soest (1999) and Alessie, Hochguertal, and van Soest (2004) find a significant positive relation between equity ownership and wealth, as well as income, in the DNB survey waves 1993-1998. As can be seen in Panel A of Table 1 equity owners have considerably higher incomes than non-owners.

2.2 Demographic and Other Control Variables

The DNB survey contains the standard demographic variables used in studies of household portfolio choice: age, employment status, and education.[9] Summary statistics of these variables are presented in Table 1.

We include indicator variables for the household head's employment status to control for background risk. Employment is measured with a series of indicator variables where the default is regular paid employment. The definitions that we use follow Alessie, Hochguertal, and van Soest (2002): Unemployed, Retired, Disabled, Self-Employed, and Other.

In studies using American data, the number of years of education is typically used as a control variable. This is not appropriate for this data set as The Netherlands has a Germanic education system in which the education stream is more important than the length of education. At a young age children are divided into different education streams depending on the results of standardized tests and input from parents. Lower education streams are designed for individuals who will not seek higher education or will attend vocational colleges. Accordingly, we use indicator variables for different education streams where the default is college education. This can be seen in Panel C of Table 1, University educated households and vocational education 2 households (white collar vocational education such as accounting and actuarial science) are more likely to participate.

[9] Davis, Kubler and Willen (2004) argue that borrowing constraints prevent young households from entering equity markets. Other authors, such as Cocco, Gomes and Maenhout (2005) argue that the life-cycle pattern of labor income will cause equity ownership to increase until shortly before retirement and then decrease.

Cocco (2005) and Yao and Zhang(2005) argue that home ownership has an important effect on equity ownership. Home ownership can crowd out investment in equities, particularity for younger, credit constrained households. Panel D of Table 1 shows that there is extensive homeownership in the sample and that equity owners and wealthier households are more likely to own homes.

There are a number of theoretical papers, such as Davis, Kubler and Willen (2004) and Cocco, Gomes and Maenhout (2005), which argue that credit constraints are an important factor in household portfolio choice. To control for credit constraints we use the ratio of unsecured debt to total financial assets.[10] This ratio varies widely across households and is markedly higher for non-equity owners.

2.3 Equity Ownership

The key dependent variable for the remainder of this paper is publicly traded equity which includes publicly traded stocks and mutual funds. Mutual fund ownership includes balanced funds so this variable will include fixed income ownership for some households.[11] To study household portfolio allocations to equity we use the ratio of equity to total financial assets.

The first column of Table 2 shows the proportion of the population holding equity over time. Column two shows portfolio allocations to equity for all equity market participants. Allocations generally follow the market's rise and fall during this time period.

[10] Unsecured debt is the sum of: private loans, extended lines of credit, debt with mail-order firms, loans from family and friends, student loans, credit card debt, and other debt not reported elsewhere.
[11] The Netherlands has a system of employer pensions that cover the vast majority of employees. For legal reasons over 99% of these pensions are defined benefit plans, and thus tax deferred equity investment in retirement accounts is not a significant issue during this time period.

3. Measuring Loss-Aversion

In addition to demographic information, income and wealth, the DNB survey also contains an "Economic and Psychological Concepts" module. This module consists of a series of questions based on work by Thaler (1981) and Loewenstein (1988), showing that reference points and loss-aversion affect intertemporal choice. Thaler shows that individuals discount gains and losses at different rates. Loewenstein shows a related result; individuals will demand more to defer receipt of a payment than they will pay to expedite receipt. This pattern of responses implies intransitivity and is thus incompatible with standard preferences, but as we will demonstrate this pattern of responses is consistent with a loss-averse value function.

3.1 The Questions

The DNB survey includes 16 questions about intertemporal choice which vary across four dimensions: delaying versus speeding-up a payment, gains versus losses, the timing of the decision, and the size of the payment. For example, the delay and speed-up of a gain (lottery winning) questions, where the time peiod is one year, and the payment amount is 1,000 guilders are as follows:

1. Imagine that you win a prize of ***f***1,000 (€454)[12] in the National Lottery. The prize is to be paid out today. Imagine however, that the lottery asks if you are prepared to wait A YEAR before you get the prize. There is no risk involved in this wait.

[12] In 1997-2001 the question asks for a response based on ***f*** (Dutch guilders) 1,000. This is approximately $500 US dollars through most of the sample period. In 2002, after The Netherlands switched to the euro, the question is asked as given above, including both guilders and the equivalent amount in euros. The capitalization of certain words follows the original questionnaire.

How much extra money would you ask to receive AT LEAST to compensate for the waiting term of a year? If you agree on the waiting term without the need to receive extra money for that, please type 0 (zero).

2. Imagine that you receive notice from the National Lottery that you have won a prize worth ***f*** 1,000 (€454). The money will be paid out after A YEAR. The money can be paid out at once, but in that case you receive less than ***f*** 1,000 (€454).

   How much LESS money would you be prepared to receive AT MOST if you would get the money at once instead of after a year? If you are not interested in receiving the money earlier or if you are not prepared to receive less for getting the money earlier, please type 0 (zero).

The first question frames the decision as the delay of a gain while the second question frames the decision as the speed-up of a gain. The survey asks similar questions for a three month decision period and for 100,000 guilders, for a total of eight questions involving a gain. These eight questions are then repeated asking for compensation and payments required to delay or speed-up a loss, where the loss comes from a tax assessment.[13] The questions are repeated in each year of the survey from 1997 to 2002[14].

3.2 Loss-Aversion and Intertemporal Choice

In this section, we derive equations that link the answers to the 16 survey questions about intertemporal choice to the parameters of the value function of prospect theory. The approach for deriving the equations follows Loewenstein (1988) and Tu (2004). Based on the available empirical and experimental evidence in Loewenstein (1988), Loewenstein and Prelec (1992), and Thaler (1981), we assume that individuals do

[13] In all cases the counterparty is the government of The Netherlands. This is done to eliminate risk from the decision.

[14] Donkers and van Soest (1999) test the relationship between the implied discount rates from similar questions in the 1993 and 1995 waves of the survey and risky asset holdings. They find a significant positive relationship in one year and an insignificant relationship in another.

not integrate the payoffs mentioned in the 16 questions with existing consumption plans, but rather evaluate them as gains and losses relative to a reference point

We first consider the case where an individual will receive a given amount X in the present. The individual is willing to delay the receipt of X to time T, if the payment is increased by the amount P_{DG}.[15] Hence, the individual is indifferent between receiving $(X, 0)$ and $(0, X + P_{DG})$. We assume that the individual evaluates payoffs at time 0 relative to a reference point of R_{DG}, with $0 < R_{DG} \leq X$. The individual has either completely ($R_{DG} = X$), or partially ($0 < R_{DG} < X$), adjusted to receiving the amount X at time 0, and therefore will experience a loss of $-R_{DG}$ when the payment is delayed. On the other hand, delay leads to a gain of $X + P_{DG}$ at time T. We assume the individual has a reference point of 0 for evaluating payoffs at time T, as no payment was initially expected at time.

Let $\delta(T)$ denote the individual's discount factor of utility for a period of length T and $V(X)$ the function used to evaluate payoffs in excess of the reference point**.** **F**or the delay of gain question the individual chooses a premium such that the utility of both alternatives – delay and no delay – is equal:

$$V(X - R_{DG}) + \delta(T)V(0) = V(0 - R_{DG}) + \delta(T)V(X + P_{DG}) \qquad (1)$$

We use the value function of prospect theory for V, but to simplify the analysis, we follow Barberis and Huang (2001) and Barberis, Huang and Santos (2001) and set the curvature parameter of the value function equal to one, i.e. we use a piece-wise linear specification:

[15] Throughout this paper the subscript *DG* refers to delay of gain, *DL* refers to delay of loss, *SG* refers to speed-up of gain, and *SL* refers to speed-up of loss.

$$V(x) = \quad x\,, \quad \text{if } x \geq 0\,, \tag{2}$$

$$= \quad \lambda x\,, \quad \text{if } x < 0\,,$$

where $\lambda > 1$ implies loss-aversion. Using this specification of the value function, equation (2) can be written as:

$$X - R_{DG} = -\lambda R_{DG} + \delta(T)(X + P_{DG}) \tag{3}$$

$$P_{DG} = [\,(\lambda - 1)R_{DG} + X(1 - \delta(T))\,] \,/\, \delta(T) \tag{4}$$

Let $p_{DG} = P_{DG} / X$ and $r_{DG} = R_{DG} / X$, then the following equation expresses the relative delay payment p_{DG} as a function of the loss-aversion parameter and the discount rate:

$$p_{DG} = [\,(\lambda - 1)r_{DG} + (1 - \delta(T))\,] \,/\, \delta(T) \tag{5}$$

Assuming $\lambda > 1$ and $0 < \delta(T) \leq 1$, the payment is positive and bounded.

For the remaining categories the payoffs and utilities from choosing to transact in the present or in the future are shown in Table 3. For each decision type we equate the utility from acting in the present and in the future, and follow the procedure outlined above – shown in the Appendix – to arrive at the following set of equations.

$$p_{DL} = [(1 - \lambda)(1/\lambda)r_{DL} + (1 - \delta(T))\,] \,/\, \delta(T) \tag{6}$$

$$p_{SG} = (1 - \lambda)\delta(T)r_{SG} + (1 - \delta(T)) \tag{7}$$

$$p_{SL} = (\lambda - 1)(1/\lambda)\delta(T)r_{SL} + (1 - \delta(T)) \tag{8}$$

Note that the indifference payments p_{SG} for speed-up of gains and p_{DL} for delay of losses can become negative, for example when $\lambda > 1$ and $\delta(T) = 1$. Take the case of speed-up of gains and note that loss-averse individuals with a reference point equal to X, will experience a considerable loss at time T for speed-up. Even with no payment required for speed-up, $P_{SG} = 0$, the gain of X at time 0 might not make up for the perceived loss at time T. In such cases the individual will actually demand compensation

to consider speed-up. The speed-up questions in the DNB Survey are framed such that only non-negative payments for speed-up are allowed. However, the question explicitly asks respondents to type zero when they are not willing to pay for speed-up. Given this option we can safely assume that loss-averse respondents who want to be compensated to consider speed-up of gains ($P_{SG} < 0$) will fill in zero as their answer to the question. In line with the framing of the question, we therefore define the relative speed-up payment as in (7), as long as it is positive, and zero otherwise:

$$p_{SG} = \max\{ (1 - \lambda)\delta(T)r_{SG} + (1 - \delta(T)), 0 \} \qquad (9)$$

A similar argument can be made for the delay of losses payment, resulting in the following delay of losses equation:

$$p_{DL} = \max\{ [(1 - \lambda)(1/\lambda)r_{DL} + (1 - \delta(T))] / \delta(T), 0 \} \qquad (10)$$

Loewenstein (1988) argues that individuals' reference points will adjust more closely to payments expected immediately than at some future date as immediate payments are more salient than distant ones. Following this logic we assume that the reference points satisfy:

$$-X \leq -R_{DL} \leq -R_{SL} < 0 \text{ and } 0 < R_{SG} \leq R_{DG} \leq X \qquad (11)$$

3.3 Descriptive Statistics and Reliability

3.3.1 Descriptive Statistics

Before beginning estimation we check the answers to the 16 DNB survey questions for two types of errors. First, some respondents answer zero to each of the 16 questions in a particular year. In total 345 of the 7590 (4.5%) responses are all-zero. We discard these observations, as they probably indicate that the respondent did no want to

spend time and thought on answering the questions.[16] Second, we check the data for implausibly high responses. Fortunately, the frequency of implausibly large answers is relatively small. We winsorize the data at *X* for the delay of gain category and at 50% of *X* for the other categories as this amount to approximately 2% of the responses for each category.[17]

Table 4 shows descriptive statistics of the winsorized responses. Generally, respondents require high compensation to delay gains. On average respondents require 246 guilders additional compensation to delay a gain of 1,000 guilders for one year. Only 5.3% of the respondents agree to delay the payment without any compensation. On the other hand, respondent are willing to pay only 38 guilders to speed-up a 1,000 guilders gain due in one year. Further, about 62.4% of the respondents are not willing to pay to speed-up a gain of 1,000 guilders. The large divergence in answers to the questions about delay and speed-up of gains indicates intransitivity and is a clear violation of the traditional discounted expected utility framework, which predicts that the discount rates for all 16 questions are either equal (assuming borrowing and lending at the same rate) or very close to each other (without borrowing).

In general respondents are willing to pay very little to delay losses. For example respondents will pay only 39 guilders on average to delay a loss of 1,000 guilders for one year, with 56% of the respondents not willing to pay at all. On the other hand, respondents require a loss reduction of 100 guilders on average to accept speeding up a

[16] Within our preference framework an all-zero response is only possible when the individual is not loss-averse ($\lambda = 1$) and has a discount rate of zero ($\delta = 1$).

[17] The payments asked for in the speedup questions reduce the payoff X (gain or loss), and therefore theoretically the answer should be less than or equal to X. Only 0.1% of the respondents violate this constraint in their answers to speed-up questions. We decided to set the cutoff point for winsorizing the answers at the level 0.5X, as this roughly coincides with the 98th percentile for the two speed-up questions and the delay of losses question. However, the answers for delay of gains questions are typically much larger compared to the other questions, and there the 98th percentile lies roughly at 1 times X.

loss of 1,000 guilders expected in one year, while about 24% of the respondents do not require a reduction.

3.3.2 Reliability

The validity of our measures of loss aversion and reference points is crucial for this study. Fortunately, the DNB Survey consists of four sets of closely related questions and we can check the consistency of answers to these sets of related questions. For example, there are four questions about delay of gains, with a gain of either 1,000 or 100,000 guilder, and with a horizon of either three months or one year. Although we expect some variation in the relative compensation p_{DG} as a function of the amount at stake and the horizon, the four answers should satisfy certain basic constraints. For example, if a respondent asks for no compensation to delay a payment of 1,000 guilders for one year, but demands 500 guilders to delay the same amount for three months, this would indicate a judgment error or lack of concentration. Table 5 displays the frequency of responses where the answer to a question with a horizon of three months is larger than the answer to the same question with a horizon of 12 months (related questions are compared in pairs of two, and frequencies averaged). Further, Table 5 displays the frequency of responses where the answer to a question with a payoff of 1,000 guilder is larger than the answer to the same question with a payoff of 100,000 guilder. The overall frequency of both types of errors is 2.8% and 1.9%, respectively, indicating that the majority of respondents avoid these kinds of judgment errors.

In survey-based research, Cronbach's alpha (Cronbach, 1959) is frequently used to measure the reliability of a set of questions intended to measure the same underlying

latent variable. Cronbach's alpha is a function of the average cross-sectional correlation of the respondents' answers to a set of theoretically related questions. Most researchers consider empirical values of alpha above 0.70 as an acceptable level of reliability (Nunnally 1978). We expect an individual's scaled answers to the four questions about speed-up of gains (p_{SG}, i.e. the premium divided by the size of the payoff) to reflect the individual's underlying preference for speeding up gains (the underlying latent variable), apart from some small variations caused by changes in time horizon and the payoff amount. Table 5 reports Cronbach's alpha for the four sets of related questions (DG, DL, SG and SL) for each survey year (1997-2002), as well as the average over six years. All alpha estimates are above 0.70 and the average alpha for each set of questions is above 0.80. Hence, it is clear that the responses to related questions are not random, but closely related with acceptable levels of reliability.

3.3.3 Discussion of Alternative Explanations

It is important to establish that not only are the data consistent with preferences based on loss-aversion and reference points, but that other potential explanations fail. If households have standard preferences and there is a single market interest rate for both borrowing and lending, then all households should report a rate equal to the market interest rate for each of the 16 questions. If there is a wedge between borrowing and lending rates then all households should report a single rate for lending transactions (as all household can lend at the same risk-free interest rate), but possibly households will report heterogeneous borrowing rates. However with standard preferences households should be internally consistent and report a single borrowing rate per household. This is

overwhelmingly rejected by pairwise t-tests[18]. This implies that on average the households' responses are intransitive.

If there are borrowing constraints that prevent households from accessing credit markets it is possible to get some variation across rates for a given individual due to the concavity of the utility function. Concavity predicts that households will report higher rates for losses than gains, as the utility function is steeper for losses than gains. However the largest rates are reported for the delay of gain questions not loss questions, in direct violation of this prediction. The effect of concavity should be stronger for the 100,000 guilder questions than the 1,000 guilder questions, as 1,000 guilders is a small enough amount that most households will be close to risk neutral once the 1,000 guilders is integrated with current wealth. There is no evidence to support this prediction either.

Concavity of the utility function also fails to explan the magnitude of the intra household range of reported rates. For a calibrated power utility function a household with median wealth, no access to credit markets, and a risk aversion coefficient of 3 would have only a 0.47% annualized difference in rates across responses to the 1,000 guilder questions. Even assuming a risk-aversion coefficient of 50 this implies at most a difference across rates of 2% for a given household. In the data there is an average difference across rates of over 20% implying that the variation in responses predicted by a standard utility function is too small by many orders of magnitude.

Benzion, Rapoport and Yagil (1989) discuss one potential explanation they call the implicit risk story. Perhaps respondents believe that there is some counterparty risk and thus wish to accelerate gains while delaying losses. However, implicit risk should

[18] Even assuming households face different borrowing rates for 1,000 guilders and 100,000 guilders there is strong evidence that households report different intra household borrowing rates across 1,000 guilder questions, and across 100,000 guilder questions, depending on the framing of the question.

affect delay and speed-up of gains questions symmetrically and delay of losses and speed-up of losses symmetrically. This is flatly rejected by the data.

There are two additional issues sometimes raised in response to survey questions: that households respond at random to survey questions, or that households respond to hypothetical questions differently than they would respond to real situations. The questions asked in the DNB survey have been asked in numerous prior studies, such as Benzion, Rapoport and Yagil (1989), Loewenstein (1988), Shelley (1993) and Thaler (1981) all of whom find similar results to the DNB survey. This suggests responses are not random but measure some systematic characteristic of preferences. Loewenstein (1988) asks questions similar to those in the DNB using both real and hypothetical rewards, and finds similar results in both cases. Post, van der Assem, Baltussen and Thaler (2007) find evidence consistent with prospect theory among contestants on the game show "Deal or No Deal" who are playing for substantial stakes.

3.4 Estimation

3.4.1 Notation and assumptions

To simplify the discussion in this section we begin by introducing the following extended notation to describe the survey data: $P_{DG,i,t}(X, T)$ denotes the payment that individual i wants to receive for the delay of a gain of size X (1,000 or 100,000 guilder) over a period of time T (three months or one year), measured in survey year t (1997 through 2002). We define the relative amount as $p_{DG,i,t}(X, T) = P_{DG,i,t}(X, T) / X$.

Our aim is to keep the specification of the empirical preference model parsimonious, as for each survey participant we have a limited number of data points.

We assume that the preference parameters vary from individual to individual, but do not depend on the survey year t. For the discount rate $\delta_i(X, T)$ we use the specification $\delta_i(X, T) = \delta_i^T$ For the reference points, $R_{DG,i}(X, T)$, we assume that they do not depend on the time horizon: $R_{DG,i}(X)$. We further reduce the number of parameters by assuming that the reference point is a linear function of the payoff size: $R_{DG,i}(X) = X\, r_{DG,i}$.

As the panel is not balanced, not every household has answered the questions in each of the six years from 1997 through 2002. We use n_i to denote the number of years that individual i provided answers to the full set of 16 questions. Throughout the paper, a summation over time t, denoted by Σ_t, is presumed to include only the n_i years with full data availability for individual i.

3.4.2 Generalized Methods of Moments Estimation

Our aim is to estimate the loss-aversion parameter (λ_i), discount rate (δ_i) and reference points ($r_{SG,i}$, $r_{DG,i}$, $r_{SL,i}$ and $r_{DL,i}$) of individual i from his or her indicated speed-up and delay payments ($P_{SG,i,t}(X,T)$, $P_{DG,i,t}(X,T)$, $P_{SL,i,t}(X,T)$ and $P_{DL,i,t}(X,T)$). The preference parameters should satisfy the following feasibility conditions:

$\lambda_i > 0$, $0 < \delta_i \leq 1$, $-1 \leq -r_{DL,i} \leq -r_{SL,i} < 0$, and $0 < r_{SG,i} \leq r_{DG,i} \leq 1$.

Loewenstein (1988) argues that reference points for delay will be larger than reference points for speed-up, because individuals will adjust more strongly when the default is for a payment to happen immediately rather than at some future date. However, we are not aware of theoretical arguments or empirical evidence that suggest reference points are different depending on whether the payoff in the question involves gains or losses. Following Loewenstein we therefore assume that individuals have one

reference point $r_{D,i}$ for questions involving delayed payoffs ($r_{DL,i} = r_{DG,i} = r_{D,i}$) and one reference point $r_{S,i}$ for questions involving speed-up of payoffs ($r_{SL,i} = r_{SG,i} = r_{S,i}$). This leaves us with four parameters to estimate from the following 16 equations:

$$\Sigma_t\, p_{DG,i,t}(X,T)/n_i - \max\{\,[(\lambda_i - 1)(r_{D,i} + (1-\delta_i^{T})]\delta_i^{-T},\, 0\,\} = 0 \qquad (12)$$

$$\Sigma_t\, p_{SG,i,t}(X,T)/n_i - \max\{\,[(1-\lambda_i)\,\delta_i^{T}(r_{S,i} + (1-\delta_i^{T})]\,,\, 0\,\} = 0$$

$$\Sigma_t\, p_{DL,i,t}(X,T)/n_i - \max\{\,[(1-\lambda_i)(1/\lambda_i)(r_{D,i} + (1-\delta_i^{T})]\,\delta_i^{-T},\, 0\,\} = 0$$

$$\Sigma_t\, p_{SL,i,t}(X,T)/n_i - \max\{\,[(\lambda_i - 1)(1/\lambda_i)\delta_i^{T}\,(r_{S,i} + (1-\delta_i^{T})],\, 0\,\} = 0,$$

for $X \in \{1{,}000;\ 100{,}000\}$, $T \in \{0.25,\ 1\}$ and $t \in \{1997,\ 1998,\ \ldots.,\ 2002\}$

subject to $\lambda_i > 0$, $0 < \delta_i \leq 1$ and $0 < r_{S,i} \leq r_{D,i} \leq 1$.[19]

We estimate system (12) for each individual i separately using the Generalized Methods of Moments (GMM).[20] Let $u_{SG,i}(X,T)$, $u_{DG,i}(X,T)$, $u_{SL,i}(X,T)$ and $u_{DL,i}(X,T)$ denote the errors in the 16 moment equations, for a given set of preference parameters, for individual i. We minimize the sum of the squared errors to estimate the parameters: $\Sigma_X \Sigma_T\, [u_{SG,i}(X,T)^2 + u_{DG,i}(X,T)^2 + u_{SL,i}(X,T)^2 + u_{DL,i}(X,T)^2]$.[21]

[19] Please note that we explicitly exclude the case $r_{S,i} = r_{D,i} = 0$, as the loss-aversion parameter λ_i would then become unidentified in system (12).

[20] The number of unknown parameters in system (12) is four, while the number of moment conditions is 16. The mean of each moment condition is estimated with $n = 1$ up to $n = 6$ yearly observations. On average the four parameters are estimated with 41 answers to speed-up and delay questions, as 2.6 survey years are on average available per household. The number of observations ranges from 16 - for households with only year of survey data available – to 96 for households with six years of data.

[21] We set the weighing matrix for the errors equal to an identity matrix. We do not attempt to estimate the covariance matrix of the errors, e.g. as part of a 2-stage GMM estimation procedure, as this implicitly involves estimating (16x17)/2 = 136 additional unknown parameters in the covariance matrix.

3.4.3 Estimation Results

Using the winsorized data we estimate the four unknown preference parameters (λ_i,, δ_i, $r_{S,i}$, $r_{D,i}$) by minimizing the squared errors of system (12), consisting of 16 moment equations, subject to the constraints $\lambda_i > 0$, $0 < \delta_i \leq 1$ and $0 < r_{S,i} \leq r_{D,i} \leq 1$.[22]

Table 6 displays the estimation results, using each household's mean response to the questions, averaged over the survey years 1997 through 2002, as the dependent variable. The average loss-aversion estimates λ_i across the 2,877 households is 2.18 which is close to the loss-aversion estimate of 2.25 found by Tversky and Kahneman (1992). The histogram in Figure 2 shows that the distribution of loss-aversion estimates is skewed to the right, with a high concentration of probability mass at the median estimate of 1.28 and a long tail to the right. To check the robustness of the results, we also report estimates using the median response across all years as the dependent variable. Using the median response as the dependent variable in the moment fitting equations has little impact on the estimates.[23]

The average discount factor δ_i of the household is equal to 0.933, implying a discount rate of about 7% per year. The average reference point $r_{D,i}$ for the delay of payoffs (both gains and losses) is equal to 0.52, with a median 0.34. This distribution is bi-modal, with about half of observations close to zero and the other half close to one. According to the fitted preference model, half of the households respond as if they have almost completely adjusted to the payoffs at time 0 mentioned in the delay questions,

[22] As constrained optimization in practice is limited to equality constraints and inequality constraints ($\leq$ and $\geq$), we model the strict inequality constraint $\lambda_i > 0$ as $\lambda_i \geq 0.1$, and $\delta_i > 0$ as $\delta_i \geq 0.1$. The lower bound for λ_i and δ_i is set at 0.1 – away from zero – because the inverse of these parameters ($1/\lambda_i$ and $1/\delta_i$) occur in the moment equations, and near-zero values might lead to error propagation and numerical instability. For the reference points, we model $r_{S,i} > 0$ as $r_{S,i} > 0.01$. We impose an upper bound of 40 on the loss-aversion parameter λ_i for similar reasons.

[23] The results are similar if we use the median estimates in the empirical tests of the effect of loss-aversion and reference points.

while the other half displays a very low degree of adjustment, indicating substantial heterogeneity in the degree of reference point adjustment to hypothetical gains and losses within the population. The average reference point $r_{S,i}$ for speed-up of future payments is 0.30, with a median of 0.05.

Although we have estimated reference points for delay and speed-up separately, in our later empirical work we use the sum of the speed-up and delay reference points as a single summary measure of how much each household adjusts their reference points to hypothetical gains and losses.

4. Results

In this section we estimate the relation of loss-aversion and estimated reference points with equity ownership. We show that households with higher reported loss-aversion and households who more easily adjust their reference points to hypothetical gains and losses, are less likely to participate in the equity market, allocate less wealth to equities, and avoid direct stockholding to a greater extent than mutual funds.

4.1 Participation

To test if loss-aversion and reference points affect households' equity market participation decisions we use a random-effects panel probit model on the full unbalanced panel. Table 7 shows the estimation results where the dependent variable equals one if the household owns equity. The first two columns show results with few control variables while columns three and four include control variables typically used in household portfolio studies. We include the first two columns because many of the

standard control variables: wealth, education, income, homeownership, and consumer debt, are themselves choice variables. As choice variables they are potentially endogenous and partially determined by loss-aversion. Endogeneity problems of this type exist in all empirical studies of portfolio choice although they are typically ignored. Columns one and two include only preference parameters, age, and time-effects and should thus be free of any endogeneity problems. Since the results are reasonably stable across both specifications this does not appear to be a significant problem for this study.

Column one shows the effect of loss-aversion on household equity market participation. The coefficient is negative and significant as predicted by theory. Households with higher loss-aversion coefficients are reluctant to own equity. Column two is similar but includes our measure of adjustment to hypothetical gains and losses, defined as the sum of the reference point for delay question and the reference point for speed-up questions. As predicted in the hypotheses section the coefficient on this variable is negative and significant. Households that more strongly adjust their reference points to the hypothetical gains and losses mentioned in the survey questions are less likely to participate in equity markets.

Columns three and four show the effect of loss-aversion and reference points while controlling for numerous variables previously identified as affecting portfolio choice. While the significance of the coefficients on loss-aversion decrease they are still significant. However, the coefficient on reference points is now insignificant.

The estimates also indicate that loss-aversion is economically significant. For a homeowner, in 2002, with a university education, and setting all other variables equal to their mean, if loss-aversion changes from the 25^{th} percentile to the 75^{th} percentile this

results in a change in the probability of owning stocks of between 3% and 4% depending on the specification. While this may seem low, this represents approximately a 20% to 30% increase relative to the mean probability of owning equity[24]. This is economically comparable to changing age by 15 years in the first two columns or changing wealth by 10% in the second two columns.

After fixing loss-aversion and other variables at their means, the estimates in columns two and four suggest that for a home owning household, in 2003, with a university education, if reference points change from the 25th% to the 75th% this will result in approximately a 3% increase in the probability of owning equity.

Coefficients on the control variables are generally consistent with existing findings in the household portfolio literature and results reported for the 1993-1998 waves of the DNB survey in Donkers and van Soest (1999) and Alessie, Hochguertal, and van Soest (2004). Wealthier, home owning, higher income households are more likely to participate in equity markets. Unlike many other empirical studies age is not significant. This may be because age is highly correlated with several other variables, notably the retirement indicator variable, in the employment effects category. The ratio of unsecured debt to total financial assets is significant. This is intuitively reasonable as for indebted households paying off consumer debt is their best investment opportunity.

Overall, the results in this section support the hypothesis that loss-aversion has a significant impact on household participation. Households with a higher level of loss-aversion are unwilling to risk the pain that comes from declines in equity prices and so

[24] While the unconditional probability of owning equity is around 25%-30%, the probability of owning equity is quite low for households with total financial assets near the median value. This is caused by the fact that equity ownership is concentrated among wealthier households.

are less willing to own risky assets. There is also weaker evidence that households that more easily adjust to hypothetical gains and losses are less willing to own equity.

4.2 Portfolio Allocations

Having examined the effect of loss-aversion and reference points on equity market participation our next step is to test their effect on portfolio allocation. There are two main methods of examining allocations: sample selection models as in Vissing-Jorgensen (2002), or tobit models as in Poterba and Samwick (2003) and Rosen and Wu (2004). Sample selection models require identifying variables that affect the participation decision but not allocation. It is difficult to identify any variables meeting this requirement and so we use a random effects panel tobit model to explore the allocation decision.

Table 8 shows the panel tobit results. The first two columns show the results of estimation with few control variables. The coefficients on loss-aversion and reference points are both significant and negative as predicted by theory. When the full set of control variables is included in columns three and four loss-aversion becomes insignificant, but reference points remain significant.

The economic significance for loss-aversion implied by these estimates is modest. Holding all other variables fixed at their means, a home owning, university educated household in 2001 would hold between 1.5% and 3% more of their total financial assets in equity if their loss-aversion coefficient changed from the 75^{th} percentile to the 25^{th} percentile. However, the economic significance of the reference points is very high.

Changing the reference point measure from the 75th% percentile to the 25th% implies an increase in the percentage of financial assets allocated to equity of around 15%.

The signs and significance of the coefficients on the control variables are similar to earlier findings in the household portfolio choice literature. Wealth, home ownership, and income are positively related to the share of wealth invested in equities, while consumer debt is negatively related to equity allocations.

4.3 Equity Type

In this subsection we examine the effect of loss-aversion and reference points on households' investment choices between mutual funds and direct stock holdings. Benartzi and Thaler (1999) and Thaler, Tversky, Kahneman and Schwartz (1997) argue that the bundling of returns affects their attractiveness to a loss-averse investor. If a household is loss-averse and frames at the level of each individual stock, the pain from losses on individual stocks may outweigh the pleasure from gains, even if the overall portfolio return is positive. A mutual fund effectively integrates the gains and losses from individual stocks into a single reported return. Thus loss-averse households subject to narrow framing and loss-aversion will place a higher value on owning a mutual fund than they would put on directly owning the component securities. As frequent adjustment of reference points to unrealized gains and losses magnifies the impact of loss-aversion, we expect the estimated reference points to have a similar negative effect on the likelihood of owning individual stocks (compared to mutual funds).

In Table 9 and 10 we show the results of a multinomial probit regression where households are divided into four categories: no equity, mutual funds only, mutual funds

and individual stocks, and individual stocks only. No equity ownership is the default category and parameter estimates are shown for the other three groups.

The results in Panel A of Table 9 show that both loss-aversion and reference points have a significant negative relationship with all three types of equity ownership. The hypotheses for this subsection are not about the significance of the coefficients themselves, but about the significance of the differences between coefficients moving from no equity, to mutual funds, to direct equity. Accordingly we conduct Wald tests to examine if there are significant differences between the coefficients across equity type. The Wald tests in Panel B show that the coefficients on loss aversion become more negative by statistically significant amounts moving from mutual funds to the mutual funds and individual stocks category, and significantly decrease again when moving to individual stocks. The coefficients on reference points are also more negative for households directly owning equity than for households exclusively owning mutual funds. However there is no significant difference between the reference point coefficients on direct ownership only compared with direct equity and mutual fund ownership.

Table 10 shows similar results to Table 9 but includes a larger number of control variables. The coefficients for loss-aversion and reference points in Panel A are always negative but only significant for the two categories which include direct equity investment. The Wald tests show that increased loss-aversion reduces the likelihood that a household holds individual stocks much more than it decreases the likelihood of holding mutual funds only. An increase of the estimated reference points reduces the probability that a household invests in individual stocks more than it reduces the probability of investing only in mutual funds. Overall the results support the hypothesis

that investors with greater loss-aversion and higher reference points shun direct stockholdings to a greater extent than they shun mutual funds.

The coefficients on the control variables confirm that wealthier, home-owning households are more likely to own all categories of equity. Consumer debt has a significant negative effect only for the mutual fund only category, which is probably due to the lower levels of debt of direct equity holders and the small variation in debt within these two categories. Alessie, Hochguertal, and van Soest (2004) study the dynamics of stocks and mutual funds ownership in the 1993–1998 DNB survey waves and report similar results for the controls income, financial wealth and age.

5. Conclusion

Despite the high equity premium many households choose not to participate in the equity markets, and across participating households there is great heterogeneity in allocations to equity. These empirical facts are difficult to reconcile with normative results obtained from models using standard utility functions. One proposed explanation for these facts is that households do not in fact have standard utility functions but are loss-averse and frame payoffs as gains and losses relative to a reference point. In this paper we empirically test how loss-aversion and reference points affect household portfolio choice.

We use a unique dataset from The Netherlands which contains data on household portfolios and as well as a series of questions which allow us to directly estimate each household's loss-aversion coefficient and level of reference point adjustment to paper gains and losses. We derive our behavioral measures from a series of questions asking

for rates of time preference across gains versus losses and speeding up versus delaying transactions. These questions are based on experimental work by Loewenstein (1988) and Thaler (1981) who show that loss-averse individual's discount rates will vary depending on the framing of intertemporal choices.

We then use these measures of loss-aversion and reference point adjustment to test how these behavioral factors affect household portfolio choice. We find that households with higher loss-aversion and higher estimated reference points are less likely to participate in equity markets, and allocate less of their financial wealth to equities. We also find that households with higher loss-aversion and higher reference points avoid direct stockholding to a greater extent than mutual funds. Overall, the results indicate that loss-aversion and reference point adjustment are potentially important features of households' investment decision making process with the ability to explain puzzling features of empirical household financial behavior.

APPENDIX

Delay of Losses

Individuals select the delay payment such that they are indifferent between both alternatives:

$$V(-(X - R_{DL})) + \delta(T)V(0) = V(-(0 - R_{DL})) + \delta(T)V(-(X + P_{DL})) \quad \text{(A1)}$$

Using the piecewise linear specification of the value function, equation (A1) can be written as:

$$-\lambda(X - R_{DL}) = R_{DL} - \lambda\delta(T)(X + P_{DL}) \quad \text{(A2)}$$

$$\lambda\delta(T)P_{DL} = (1 - \lambda)R_{DL} + \lambda X(1 - \delta(T)) \quad \text{(A3)}$$

Let $p_{DL} = P_{DL} / X$ and $r_{DL} = R_{DL} / X$, then we find:

$$p_{DL} = [(1 - \lambda)(1/\lambda)r_{DL} + (1 - \delta(T))\ ] / \delta(T) \quad \text{(A4)}$$

Speedup of Gains

Individuals have chosen the speedup premium such that they are indifferent between both alternatives:

$$V(0) + \delta(T)V(X - R_{SG}) = V(X - P_{SG}) + \delta(T)V(0 - R_{SG}) \quad \text{(A5)}$$

Using the specification of the value function, equation (A5) can be written as:

$$\delta(T)(X - R_{SG}) = (X - P_{SG}) - \lambda\delta(T)R_{SG} \quad \text{(A6)}$$

$$P_{SG} = (1 - \lambda)\delta(T)R_{SG} + X(1 - \delta(T)) \quad \text{(A7)}$$

Let $p_{DG} = P_{DG} / X$ and $r_{DG} = R_{DG} / X$, then we find:

$$p_{SG} = (1 - \lambda)\delta(T)r_{SG} + (1 - \delta(T)) \quad \text{(A8)}$$

Speedup of Losses

Individuals will select the speed-up payment such that they are indifferent between both alternatives:

$$V(0) + \delta(T)V(-(X - R_{SL})) = V(-(X - P_{SL})) + \delta(T)V(-(0 - R_{SL})) \quad \text{(A9)}$$

Using the specification of the value function, equation (A9) can be written as:

$$-\lambda\delta(T)(X - R_{SL}) = -\lambda(X - P_{SL}) + \delta(T)R_{SL} \quad \text{(A10)}$$

$$\lambda P_{SL} = (\lambda - 1)\delta(T)R_{SL} + \lambda X(1 - \delta(T)) \quad \text{(A11)}$$

Let $p_{SL} = P_{SL} / X$ and $r_{SL} = R_{SL} / X$, then we end up with:

$$p_{SL} = (\lambda - 1)(1/\lambda)\delta(T)r_{SL} + (1 - \delta(T)) \quad \text{(A12)}$$

Assuming $\lambda > 1$ and $0 < \delta(T) \leq 1$, the payment for speed-up of losses is positive.

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Table 1

Summary Statistics

Panel A – Control Variables			
Variable	Full Sample	Equity Owners	Non-Owners
Total Financial Assets	71,179	144,070	35,793
	(30,480)	(87,871)	(17,358)
Income	53,253	64,997	47,551
	(51,281)	(63,235)	(45,588)
Age	49.9	52.7	48.6
	(49)	(52)	(47)
Panel B - Employment Status			
Variable	Full Sample	Equity Owners	Non-Owners
Regular Employment	65.2%	60.8%	67.4%
Unemployed	1.5%	1.0%	1.7%
Retired	15.9%	20.4%	13.8%
Disabled	8.8%	10.2%	8.2%
Self Employed	1.8%	1.9%	1.7%
Other	6.8%	5.8%	7.3%
Panel C – Education			
Variable	Full Sample	Equity Owners	Non-Owners
Low Education	4.9%	4.0%	5.2%
Intermediate/ Low Education	11.3%	9.7%	12.0%
Intermediate/High Education	10.5%	12.0%	9.8%
Vocational 1	30.7%	24.4%	33.8%
Vocational 2	25.0%	28.8%	23.2%
University Education	17.6%	21.1%	16.0%
Panel D – Other Control Variables			
Variable	Full Sample	Equity Owners	Non-Owners
Home Owner	57.3%	68.6%	51.8%
Unsecurred Debt to Total Financial Assets	89.8%	19.3%	124.0%

This table contains summary statistics for variables used in this paper. Means (medians) are shown for the full sample as well as for equity owners, and non-owners. The means and medians are pooled across households and time-periods. All monetary values are inflation adjusted to 1997 levels.

Table 2

Equity Ownership

Year	Proportion of Population Holding Equity	Equity/ TFA
Pooled	28.38	37.34
1997	28.26	35.66
1998	25.54	38.90
1999	30.84	38.94
2000	25.87	41.42
2001	29.93	39.34
2002	29.73	31.24

This table shows the proportion of the population holding equity pooled across all years and by each year in the first column. In the second column it shows the average allocation of total financial assets (TFA) to equity among households that hold equity, both pooled across all years and by each year.

Table 3

Utility from Intertemporal Tradeoffs

Decision Type	Action	Payoffs $t = 0, t = T$	Utility
Delay Gain	No Delay	$X–R_{DG}$, 0	$V(X – R_{DG}) + \delta(T)V(0)$
	Delay	$0–R_{DG}$, $X + P_{DG}$	$V(0 – R_{DG}) + \delta(T)V(X + P_{DG})$
Delay Loss	No Delay	$–(X – R_{DL})$, 0	$V(–(X – R_{DL})) + \delta(T)V(0)$
	Delay	$–(0–R_{DL})$, $–(X+P_{DL})$	$V(–(0–R_{DL}))+\delta(T)V(–(X+ P_{DL}))$
Speedup Gain	No Speed-up	0, $X – R_{SG}$	$V(0) + \delta(T)V(X – R_{SG})$
	Speed-up	$X – P_{SG}$, $0 – R_{SG}$	$V(X – P_{SG}) + \delta(T)V(0 – R_{SG})$
Speedup Loss	No Speed-up	0, $–(X – R_{SL})$	$V(0) + \delta(T)V(–(X – R_{SL}))$
	Speed-up	$–(X–P_{SL})$, $–(0–R_{SL})$	$V(–(X –P_{SL}))+\delta(T)V(–(0– R_{SL}))$

This table shows the payoffs and resulting utility for each type of decision and each possible action.

Table 4

Descriptive Statistics of the Payments for Delay/Speed-up of Gains/Losses – Winsorized Data

	Question	Horizon	Amount	Type of Payment	Mean	Median	Std. Dev.	% Zero answers
1	DG	3m	1,000	Receive extra	10.2%	4.0%	20.2%	18.8%
2	DG	12m	1,000	Receive extra	24.6%	10.0%	28.5%	5.3%
3	DG	3m	100,000	Receive extra	7.7%	2.0%	19.8%	7.0%
4	DG	12m	100,000	Receive extra	16.7%	10.0%	24.9%	2.4%
5	DL	3m	1,000	Lose more	1.8%	0.0%	6.8%	68.6%
6	DL	12m	1,000	Lose more	3.9%	0.0%	8.4%	56.1%
7	DL	3m	100,000	Lose more	1.2%	0.0%	5.5%	49.3%
8	DL	12m	100,000	Lose more	2.7%	0.5%	6.6%	43.4%
9	SG	3m	1,000	Receive less	1.8%	0.0%	7.4%	75.7%
10	SG	12m	1,000	Receive less	3.8%	0.0%	9.4%	62.4%
11	SG	3m	100,000	Receive less	1.7%	0.0%	7.3%	58.8%
12	SG	12m	100,000	Receive less	3.2%	0.1%	8.4%	48.4%
13	SL	3m	1,000	Loss reduction	5.2%	2.5%	7.7%	27.5%
14	SL	12m	1,000	Loss reduction	10.0%	7.5%	11.5%	24.1%
15	SL	3m	100,000	Loss reduction	3.1%	1.0%	6.8%	22.9%
16	SL	12m	100,000	Loss reduction	6.5%	5.0%	9.0%	22.7%

This table shows summary statistics of the responses to the 16 questions asked in the DNB survey about the speed-up and delay of gains and losses. "DG" refers to questions about the delay of a gain (lottery prize), "DL" to questions about the delay of a loss (tax assessment), while "SG" and "SL" refer to speed-up of a gain and speed-up of a loss, respectively. The time-period mentioned in the questions – i.e. for delay and speed-up – is either three months or one year, as indicated in the 3rd column. The size of the payoff X mentioned in the questions is either 1,000 Dutch guilders or 100,000 guilders, as indicated in the 4th column. In the DNB survey households are asked to indicate the minimum amount they want to receive to accept delay of a gain (DG) and speed-up of a loss (SL), and instructed to write "0" if they do not require compensation to accept DG or SL. Households are asked to indicate the maximum amount they are willing to pay to speed-up gains (SG) and delay losses (DL), and instructed to write "0" if they do not want to consider SG or DL at any price. The last four columns of the table show descriptive statistics of the winsorized household answers to the 16 questions, including the proportion of households that give "0" as their answer to a particular question.

Table 5

Frequency of Suspect Responses and Reliability Estimates

Panel A: Average Frequency of Suspect Responses		
	P(1000) > P(100,000)	P(3m) > P(12m)
DG	0.015	0.011
DL	0.034	0.016
SG	0.020	0.017
SL	0.044	0.034

Panel B: Cronbach's Alpha							
	Average	1997	1998	1999	2000	2001	2002
DG	0.919	0.888	0.896	0.921	0.967	0.948	0.893
DL	0.894	0.909	0.936	0.847	0.891	0.914	0.868
SG	0.885	0.885	0.832	0.871	0.878	0.925	0.916
SL	0.821	0.798	0.763	0.839	0.781	0.875	0.870

This table shows the reliability of the responses to the survey questions used to extract our measure of loss-aversion and estimate reference points. Panel A shows the frequency that answers to 1,000 guilder questions are larger than for 100,000 guilder questions and the frequency of answers for delay/speedup questions with a three month horizon exceeding the answers for equivalent questions with a 12 month horizon. Panel B shows Cronbach's alpha for related questions. Cronbach's alpha is shown both for average responses across all years and for each year individually.

Table 6

Estimation Results
Mean and Median Response per Household as Dependent Variable

	Panel A: Household Mean Response					Panel B: Household median response				
	λ_i	δ_i	$r_{D,i}$	$r_{S,i}$	$r_{Si} + r_{Di}$	λ_i	δ_i	$r_{D,i}$	$r_{S,i}$	$r_{Si} + r_{Di}$
Mean	2.182	0.933	0.518	0.301	0.786	2.107	0.935	0.540	0.312	0.844
Median	1.280	0.945	0.335	0.050	0.443	1.193	0.949	0.482	0.054	0.692
Std. Dev.	2.836	0.053	0.447	0.404	0.770	2.957	0.054	0.448	0.411	0.780
5% percentile	1.004	0.826	0.010	0.010	0.02	1.003	0.826	0.010	0.010	0.02
95% percentile	5.581	0.996	1.000	1.000	2	5.171	0.997	1.000	1.000	2
% = Lower bound	0.1%	0.0%	6.2%	32.4%	5.8%	0.1%	0.0%	6.2%	32.6%	5.8%
% = Upper bound	0.1%	3.8%	43.9%	21.4%	20.1%	0.2%	4.1%	46.4%	22.9%	22.6%

This table shows descriptive statistics of the estimated preference parameters: λ_i is the loss-aversion coefficient, δ_i is the discount factor of utility, $r_{D,i}$ is the reference point with respect to delay and $r_{S,i}$ is the reference point with respect to speed-up. Panel A shows results where the dependent variable is the mean response to the questions across all years with valid answers. Panel B shows results where the dependent variable is the median response across all years. The % lower and upper bound show the percentage of the estimates that reach the lower and upper bound respectively.

Table 7

Random Effects Probit Model of the Participation Decision

Variable	1	2	3	4
Loss-Aversion	-0.052	-0.080	-0.044	-0.059
	(2.33)**	(3.20)***	(1.89)*	(2.29)**
Reference Point		-0.222		-0.129
		(2.87)***		(1.50)
TFA / 1000			0.026	0.026
			(20.19)***	(20.15)***
TFA/1000000 Squared			-0.029	-0.029
			(14.41)***	(14.38)***
Homeowner			0.457	0.458
			(4.56)***	(4.57)***
Debt to TFA			-0.051	-0.050
			(2.81)***	(2.78)***
Income / 1000			0.004	0.004
			(2.01)**	(1.98)**
Income/1000000 Squared			-0.003	-0.002
			(0.22)	(0.21)
Age	0.085	0.085	-0.006	-0.006
	(3.56)***	(3.53)***	(0.22)	(0.22)
Age Squared	-0.084	-0.088	0.126	0.120
	(2.45)**	(2.48)**	(0.45)	(0.42)
Employment Effects	No	No	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
Education Effects	No	No	Yes	Yes
Constant	Yes	Yes	Yes	Yes

*,**,*** Significant at the 10%, 5%, 1% level respectively. N=6552

This table shows random effects probit estimates of the participation decision. The dependent variable equals one if the household owns equity. Financial variables are measured across all members of the household. Other variables, such as age, employment, and loss-aversion, are measured as the value given by the household head. Z-scores are shown in parentheses below parameter estimates.

Table 8

Random Effects Tobit Model of the Allocation Decision

Variable	1	2	3	4
Loss-Aversion	-0.006	-0.009	-0.002	-0.005
	(2.18)**	(3.03)***	(0.67)	(1.47)
Reference Point		-0.026		-0.027
		(2.58)***		(2.26)**
TFA / 1000			0.003	0.003
			(20.76)***	(20.78)***
TFA/1000000 Squared			-0.004	-0.004
			(16.40)***	(16.39)***
Homeowner			0.049	0.049
			(3.12)***	(3.14)***
Debt to TFA			-0.145	-0.145
			(8.03)***	(8.01)***
Income / 1000			0.001	0.001
			(2.59)***	(2.58)***
Income/1000000 Squared			-0.001	-0.001
			(0.65)	(0.64)
Age	0.014	0.014	-0.001	-0.001
	(4.38)***	(4.41)***	(0.17)	(0.16)
Age Squared	-0.084	-0.088	0.027	0.025
	(2.74)***	(2.83)***	(0.68)	(0.63)
Employment Effects	No	No	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
Education Effects	No	No	Yes	Yes
Constant	Yes	Yes	Yes	Yes

*,**,*** Significant at the 10%, 5%, 1% level respectively. N=6552

This table shows random effects tobit estimates of the asset allocation decision. The dependent variable is the proportion of total financial assets allocated to equity. Financial variables are measured across all members of the household. Other variables, such as age, employment, and loss-aversion, are measured as the value given by the household head. Z-scores are shown in parentheses below parameter estimates.

Table 9

Multinomial Probit Model of the Equity Type Decision

Panel A: Multinomial Probit Model Estimates			
Variable	Mutual Funds Only	Mutual Funds and Stocks	Individual Stocks Only
Loss-Aversion	-0.022	-0.058	-0.15
	(1.96)**	(5.56)***	(6.60)***
Reference Point	-0.102	-0.185	-0.194
	(2.78)***	(4.35)***	(4.31)***
Age	0.037	0.042	0.038
	(2.87)***	(2.89)***	(2.69)***
Age Squared / 1000	-0.258	-0.235	-0.185
	(2.10)**	(1.75)*	(1.42)
Year Effects	Yes	Yes	Yes
Constant	Yes	Yes	Yes
Number of Observations	903	599	556
Panel B: Wald Test of Significant Differences in Coefficients			
Loss-Aversion – difference with Mutual Funds Only		0.004	0.000
Loss-Aversion – differences with Individual Stocks Only	0.000	0.000	
Reference Points – difference with Mutual Funds Only		0.044	0.035
Reference Points – differences with Individual Stocks Only	0.035	0.436	

*,**,*** Significant at the 10%, 5%, 1% level respectively.

This table shows results from a multinomial probit model. In the first column of Panel A the dependent variable equals one if the household owns mutual funds but has no direct stockholdings. In the second column of Panel A the dependent variable is one if the household owns both mutual funds and individual stocks. In the third column of Panel A the dependent variable equals one if the household owns individual stocks but does not own any mutual funds. No equity is the excluded category (4,494 observations). Panel B shows one-sided p-values of Wald tests for the difference between the coefficients on loss-aversion (reference points) in the three categories. The null hypothesis for the "Mutual Fund Only" Wald tests is that the coefficient in "Mutual Funds Only" category is less than or equal to the coefficients in the categories "Mutual Funds and Stocks" and "Individual Stocks Only", respectively. The null hypothesis for the "Individual Stocks Only" Wald tests is that the coefficient in "Individual Stocks Only" category is greater than or equal to the coefficients in the categories "Mutual Funds and Stocks" and "Mutual Funds Only", respectively.

Table 10
Multinomial Probit Model of the Equity Type Decision

Panel A: Multinomial Probit Model Estimates			
Variable	Mutual Funds Only	Mutual Funds and Individual Stocks	Individual Stocks Only
Loss-Aversion	-0.012	-0.029	-0.124
	(0.97)	(1.73)*	(4.86)***
Reference Point	-0.071	-0.145	-0.16
	(1.71)*	(2.67)***	(3.15)***
TFA / 1000	0.016	0.02	0.015
	(23.39)***	(26.73)***	(19.04)***
TFA/1000000 Squared	-0.023	-0.022	-0.016
	(18.61)***	(17.36)***	(12.42)***
Homeowner	0.277	0.259	0.261
	(4.23)***	(3.04)***	(3.43)***
Debt to TFA	-0.049	-0.138	-0.013
	(2.80)***	(1.43)	(1.20)
Income / 1000	0.006	0.002	0.003
	(4.26)***	(1.36)	(1.75)*
Income/1000000 Squared	-0.022	-0.005	-0.003
	(2.80)***	(0.55)	(0.33)
Age	-0.024	-0.031	-0.011
	(1.58)	(1.72)*	(0.65)
Age Squared / 1000	0.213	0.213	0.159
	(1.42)	(1.22)	(1.02)
Employment Effects	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes
Education Effects	Yes	Yes	Yes
Constant	Yes	Yes	Yes
Number of Observations	903	599	556
Panel B: Wald Test of Significant Differences in Coefficients			
Loss-Aversion – difference with Mutual Funds Only		0.154	0.000
Loss-Aversion – differences with Individual Stocks Only	0.000	0.000	
Reference Points – difference with Mutual Funds Only		0.109	0.059
Reference Points – differences with Individual Stocks Only	0.059	0.410	

*,**,*** Significant at the 10%, 5%, 1% level respectively.

This table shows results from a multinomial probit model. In the first column of Panel A the dependent variable equals one if the household owns mutual funds but has no direct stockholdings. In the second column of Panel A the dependent variable equals one if the household owns both mutual funds and individual stocks. In the third column of Panel A the dependent variable equals one if the household owns individual stocks but does not own any mutual funds. No equity is the excluded category (4,494 observations). Panel B shows one-sided p-values of Wald tests for the difference between the coefficients on loss-aversion (reference points) in the categories. . The null hypothesis for the "Mutual Fund Only" Wald tests is that the coefficient in "Mutual Funds Only" category is less than or equal to the coefficients in the categories "Mutual Funds and Stocks" and "Individual Stocks Only", respectively. The null hypothesis for the "Individual Stocks Only" Wald tests is that the coefficient in "Individual Stocks Only" category is greater than or equal to the coefficients in the categories "Mutual Funds and Stocks" and "Mutual Funds Only", respectively.

Figure 1

Prospect Theory Value Function

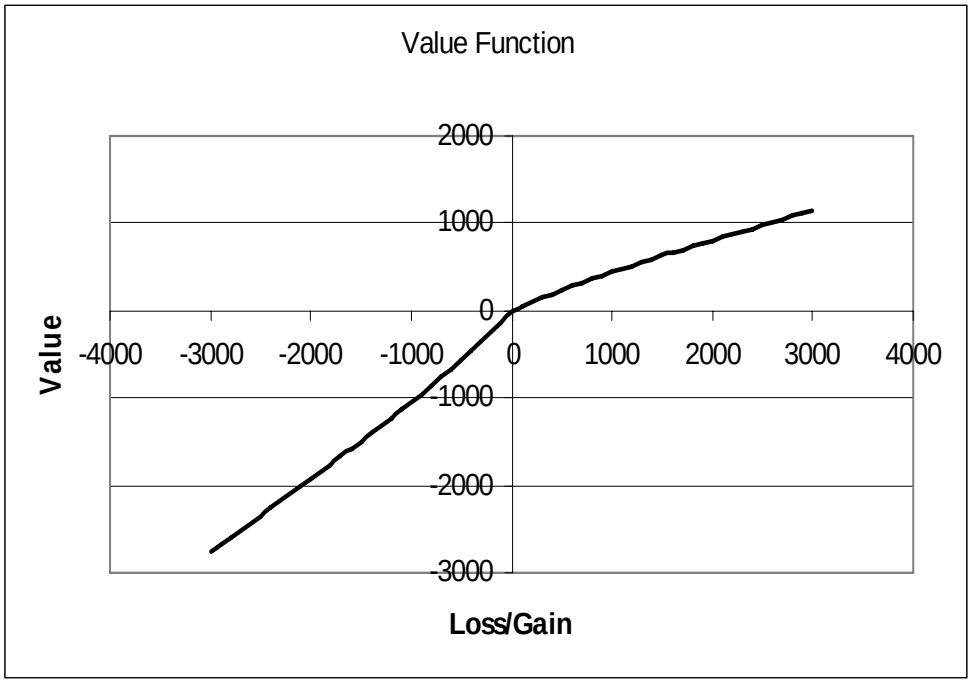
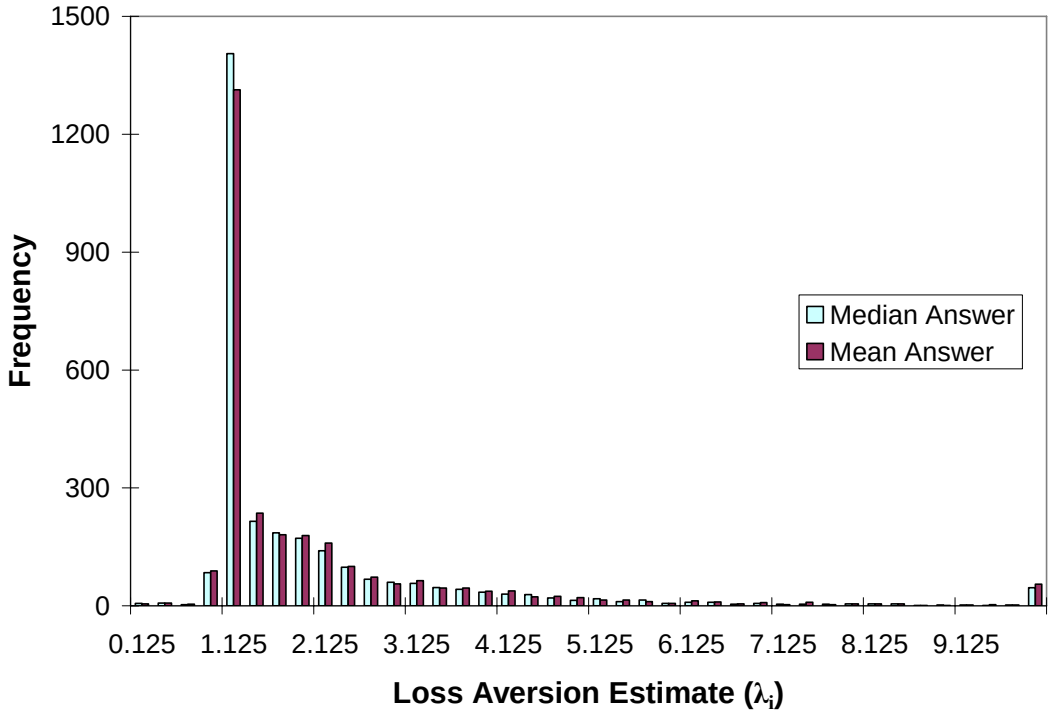


Figure 2

Histogram of Loss-aversion Estimates



The figure shows the histogram of the loss-aversion estimates (λ_i) of 2,877 households.