Prospect Theory and Loss Aversion

Prospect theory

Evidence on loss aversion from the stock market

A field experiment on the endowment effect and market experience

Myopic loss aversion and the equity-premium puzzle

ORIGINAL PROSPECT THEORY (Kahneman and Tversky Econometrica 1979)

Original Prospect theory with two non-zero outcomes.

“Regular prospects” (i.e. $p_1+p_2<1$, or $x_1\geq 0\geq x_2$, or $x_1\leq 0\leq x_2$):

$V=w(p_1)v(x_1) + w(p_2)v(x_2)$

Strictly positive and strictly negative prospects (i.e. $p_1+p_2=1$ and $x_1>x_2>0$, or $x_1<x_2<0$):

$V=v(x_2) + w(p_1)[v(x_1)-v(x_2)]=w(p_1)v(x_1) + [1-w(p_1)]v(x_2)$

V=value of the prospect

x_i=outcome in state i relative to the reference point (x=0)

p_i=probability of state i

v(x)=value function over outcomes that is reference dependent (differs for gains and losses); concave above the reference point ($v''(x)\leq 0$) and convex below the reference point ($v''(x)\geq 0$). The value function is steeper for losses than for gains.

w(p)=probability weighting function that transforms probabilities to decision weights (equal for gains and losses). The decision weight is an increasing function of p and lies between 0 (p=0) and 1 (p=1), but in general the decision weight is not equal to p (the probability weighting function overweights small probabilities and underweights large probabilities) and w(p)+w(1-p) is not in general equal to 1.

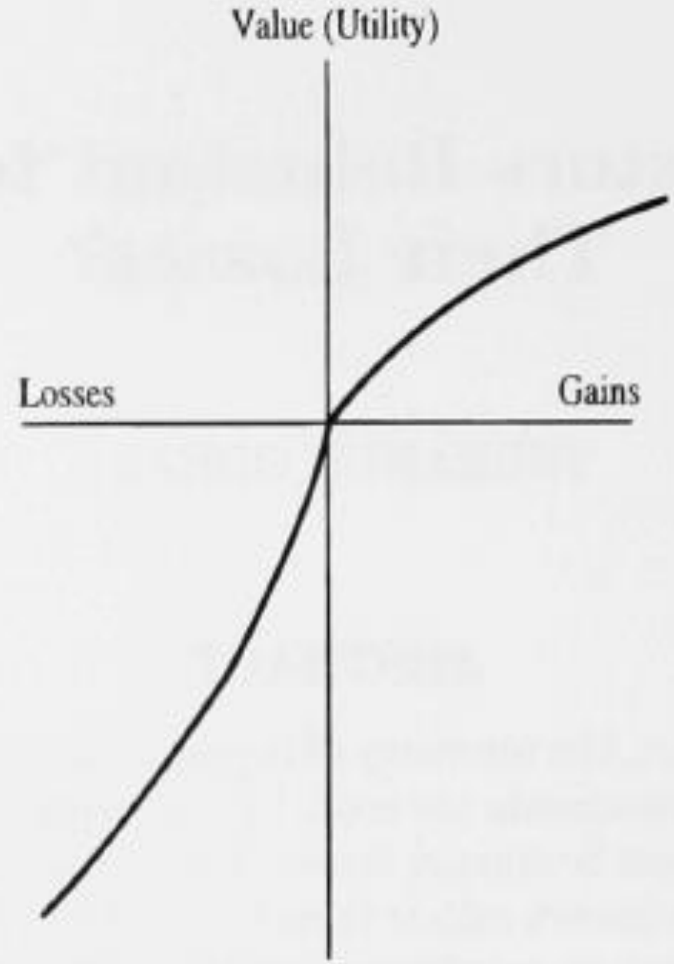

Figure 1. Prospect theory value function.

CUMULATIVE PROSPECT THEORY (Tversky and Kahneman, JRU 1992)

Problem with original formulation: violates stochastic dominance (a prospect can become less desirable if the probability for a better outcome increases at the expense of a worse outcome) and is not readily extended to prospects with a large number of outcomes.

Example stochastic dominance: assume that the individual could get \$1000 with a probability of 0.90 and \$500 with a probability of 0.05 (and 0 with the residual probability of 0.05). Now the probability of the \$1000 outcome increases by 0.01 at the expense of the \$500 outcome. This is an improvement (stochastic dominance); but if the decrease in the decision weight for the \$500 outcome is greater than the increase in the decision weight for the \$1000 outcome the value of the prospect could decrease (e.g. if the decrease in the decision weight is 0.02 for the \$500 outcome and the increase in the decision weight is 0.009 for the \$1000 outcome and the value function is linear).

Cumulative prospect theory solves this problem by transforming cumulative probabilities over ranked outcomes to decision weights (instead of transforming each probability separately). A separate probability weighting function, $w^+(p)$, is applied to gains (ranked from largest to smallest gain) and losses, $w^-(p)$, (ranked from largest to smallest loss). The probability weighting function is as before increasing in the probability and lies between 0 (p=0) and 1 (p=1).

CUMULATIVE PROSPECT THEORY

Example: three positive outcomes, $x_3>x_2>x_1>0$ (can be extended to any number of outcomes):

$$V=\pi_1 v(x_1) + \pi_2 v(x_2) + \pi_3 v(x_3)$$

$$\pi_3=w^+(p_3)$$
$$\pi_2=w^+(p_2+p_3) - w^+(p_3)$$
$$\pi_1 =w^+(p_1+p_2+p_3) - w^+(p_2+p_3)$$

Example: three negative outcomes, $0>x_{-1}>x_{-2}>x_{-3}$ (can be extended to any number of outcomes):

$$V=\pi_{-1} v(x_{-1}) + \pi_{-2} v(x_{-2}) + \pi_{-3} v(x_{-3})$$

$$\pi_{-3}=w^-(p_{-3})$$
$$\pi_{-2}=w^-(p_{-2}+p_{-3}) - w^-(p_{-3})$$
$$\pi_{-1}=w^-(p_{-1}+p_{-2}+p_{-3}) - w^-(p_{-2}+p_{-3})$$

Example: three positive and three negative outcomes, $x_3>x_2>x_1>0>x_{-1}>x_{-2}>x_{-3}$ (can be extended to any number of outcomes):

$$V=\pi_1 v(x_1) + \pi_2 v(x_2) + \pi_3 v(x_3)$$
$$+ \pi_{-1} v(x_{-1}) + \pi_{-2} v(x_{-2}) + \pi_{-3} v(x_{-3})$$

ESTIMATING THE VALUE AND PROBABILITY WEIGHTING FUNCTION (Tversky and Kahneman JRU 1992)

A data collection was carried out to obtain more information about the value and weighting functions. 25 subjects answered repeated (hypothetical) questions about certainty equivalents and indifference outcomes of prospects (gambles).

Proposed value function:

$v(x)=x^{\alpha}$; if $x\geq 0$

$V(x)=-\lambda(-x)^{\beta}$; if $x<0$

Estimated parameters: $\alpha=0.88$; $\beta=0.88$; $\lambda=2.25$

Proposed probability weighting function:

$W^{+}(p)=p^{\gamma}/[(p^{\gamma} + (1-p)^{\gamma})^{1/\gamma)}]$

$W^{-}(p)= p^{\varsigma}/[(p^{\varsigma} + (1-p)^{\varsigma})^{1/\varsigma)}]$

Estimated parameters: $\gamma=0.61$; $\varsigma=0.69$

Table 3. Median cash equivalents (in dollars) for all nonmixed prospects

	Probability								
Outcomes	.01	.05	.10	.25	.50	.75	.90	.95	.99
(0, 50)			9		21		37		
(0, −50)			−8		−21		−39		
(0, 100)		14		25	36	52		78	
(0, −100)		−8		−23.5	−42	−63		−84	
(0, 200)	10		20		76		131		188
(0, −200)	−3		−23		−89		−155		−190
(0, 400)	12								377
(0, −400)	−14								−380
(50, 100)			59		71		83		
(−50, −100)			−59		−71		−85		
(50, 150)		64		72.5	86	102		128	
(−50, −150)		−60		−71	−92	−113		−132	
(100, 200)		118		130	141	162		178	
(−100, −200)		−112		−121	−142	−158		−179	

Note: The two outcomes of each prospect are given in the left-hand side of each row; the probability of the second (i.e., more extreme) outcome is given by the corresponding column. For example, the value of $9 in the upper left corner is the median cash equivalent of the prospect (0, .9; $50, .1).

In the Table the probability of the non-zero outcome (in some cases a gain and in some cases a loss) is varied; the residual probability is the probability of receiving zero. Risk aversion implies that the certainty equivalent should be below the expected gain for gains and above the expected loss for losses. For gains subjects appear to be risk seeking at small probabilities (the certainty equivalent is above the expected gain) and risk averse at intermediate and large probabilities (the certainty equivalent is below the expected gain). For losses subjects appear to be risk averse at small probabilities (the certainty equivalent is above the expected loss) and risk seeking at intermediate and large probabilities (the certainty equivalent is below the expected loss).

Table 4. Percentage of risk-seeking choices

	Gain		Loss	
Subject	$p \leq .1$	$p \geq .5$	$p \leq .1$	$p \geq .5$
1	100	38	30	100
2	85	33	20	75
3	100	10	0	93
4	71	0	30	58
5	83	0	20	100
6	100	5	0	100
7	100	10	30	86
8	87	0	10	100
9	16	0	80	100
10	83	0	0	93
11	100	26	0	100
12	100	16	10	100
13	87	0	10	94
14	100	21	30	100
15	66	0	30	100
16	60	5	10	100
17	100	15	20	100
18	100	22	10	93
19	60	10	60	63
20	100	5	0	81
21	100	0	0	100
22	100	0	0	92
23	100	31	0	100
24	71	0	80	100
25	100	0	10	87
Risk seeking	78[a]	10	20	87[a]
Risk neutral	12	2	0	7
Risk averse	10	88[a]	80[a]	6

[a]Values that correspond to the fourfold pattern.

Note: The percentage of risk-seeking choices is given for low ($p \leq .1$) and high ($p \geq .5$) probabilities of gain and loss for each subject (risk-neutral choices were excluded). The overall percentage of risk-seeking, risk-neutral, and risk-averse choices for each type of prospect appear at the bottom of the table.

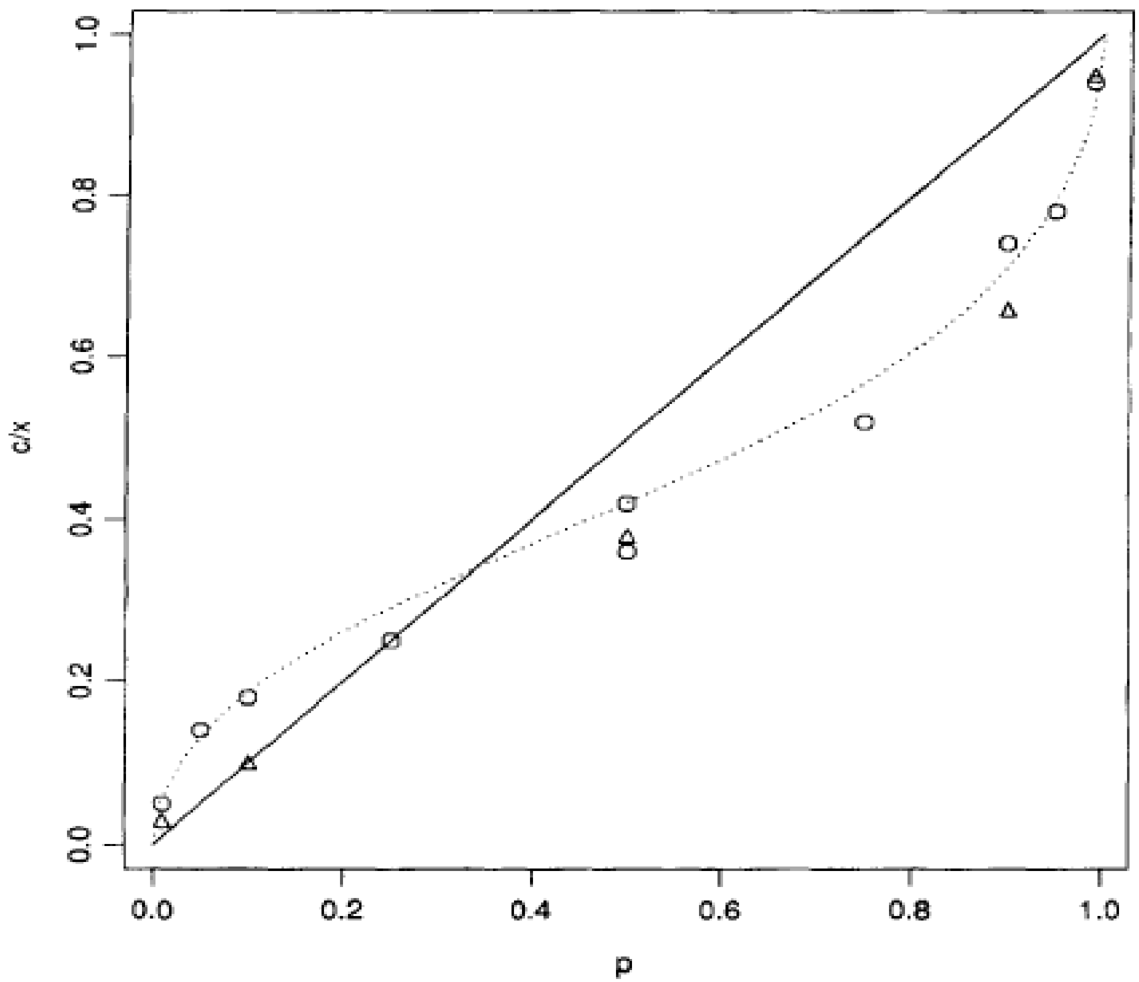

Figure 1. Median c/x for all positive prospects of the form $(x, p; 0, 1-p)$. Triangles and circles, respectively, correspond to values of x that lie above or below 200.

c/x is the certainty equivalent divided by the potential gain; for a risk neutral individual c/x will be equal to the probability of the gain (and the graph will equal the 45-degree line). For a risk averse individual c/x will be below the probability (and the graph will be below the 45-degree line). For a risk seeking individual c/x will be above the probability (and the graph will be above the 45-degree line). The curve suggests probability weighting; overweighting of small probabilities and underweighting of large probabilities.

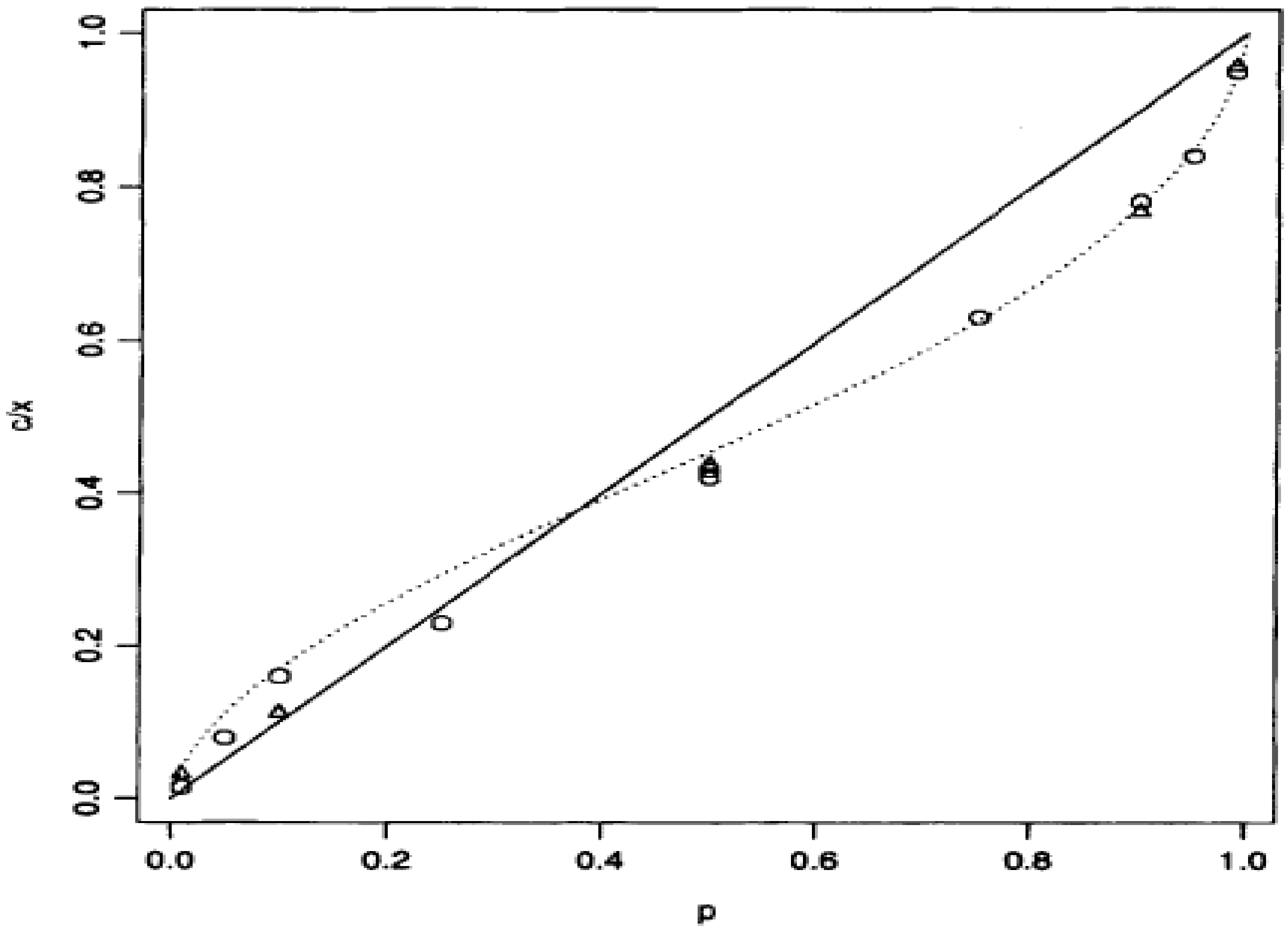

Figure 2. Median c/x for all negative prospects of the form $(x, p; 0, 1 - p)$. Triangles and circles, respectively, correspond to values of x that lie below or above -200.

c/x is the certainty equivalent divided by the potential loss; for a risk neutral individual c/x will be equal to the probability of the loss (and the graph will equal the 45-degree line). For a risk averse individual c/x will be above the probability (and the graph will be above the 45-degree line). For a risk seeking individual c/x will be below the probability (and the graph will be below the 45-degree line). The curve suggests probability weighting; overweighting of small probabilities and underweighting of large probabilities.

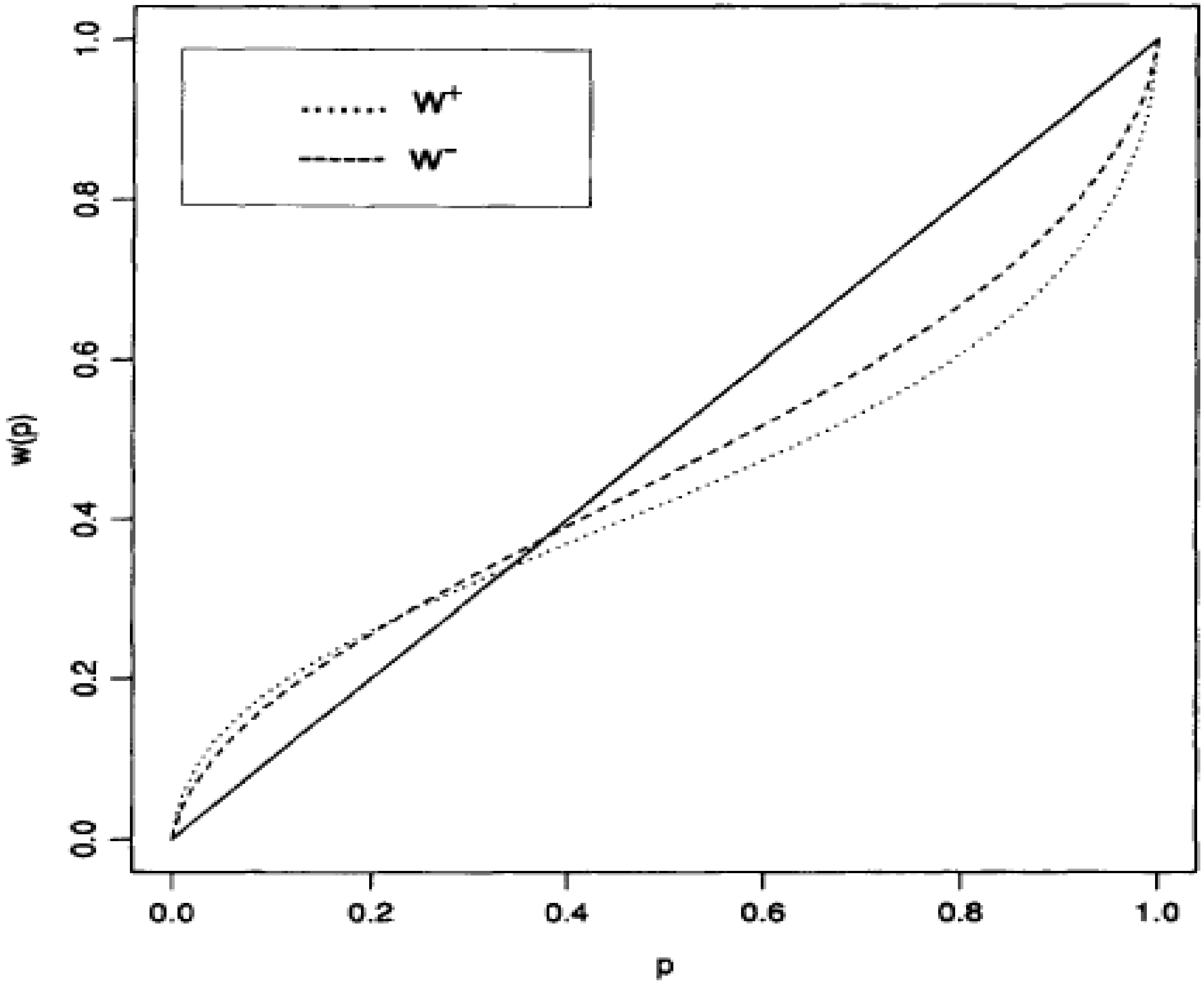

Figure 3. Weighting functions for gains (w^+) and for losses (w^-) based on median estimates of γ and δ in equation (12).

Table 6. A test of loss aversion

Problem	a	b	c	x	θ
1	0	0	−25	61	2.44
2	0	0	−50	101	2.02
3	0	0	−100	202	2.02
4	0	0	−150	280	1.87
5	−20	50	−50	112	2.07
6	−50	150	−125	301	2.01
7	50	120	20	149	0.97
8	100	300	25	401	1.35

Note: In each problem, subjects determined the value of x that makes the prospect (\$$a$, ½; \$b, ½) as attractive as (\$$c$, ½; \$$x$, ½). The median values of x are presented for all problems along with the fixed values a,b,c. The statistic $\theta = (x-b)/(c-a)$ is the ratio of the "slopes" at a higher and a lower region of the value function.

In the first four problems there is a 50/50 gamble between c and x, and the subject states at what x he/she is indifferent between taking the gamble or receiving a zero payoff. The gain typically has to be about twice as large as the loss at indifference.

In problems 5-8 the subjects choses between two 50/50 gambles (a 50/50 chance of a or b versus a 50/50 chance of c or x). The subject states at what x he/she is indifferent between the two gambles. In problems 5-6 where the worst outcome in each gamble is a loss; an increase in the loss has to be compensated by about a twice as large increase in the gain. In problem 7 (8), problem 5 (6) is transformed to the gain domain by adding 70 (150) to the outcomes a, b, and c. A reduction in the lower outcome now only has to be compensated by an increase in the better outcome of the same magnitude. Indicates a reference point effect (loss aversion).

Loss Aversion and The Stock Market (Odean Journal of Finance 1998)

Setting: To test if investors on the stock market are affected by loss aversion.

Data: Data from a nationwide discount brokerage house. From all accounts active in 1987 (those with at least one transaction) 10,000 customer accounts are randomly selected. Data on all trades made between January 1987 and December 1993 for these 10,000 customer accounts.

Analysis: Each day that a sale takes place in a portfolio of two or more stocks the number of realized gains, the number of “paper gains”, the number of realized losses, and the number of “paper losses” are estimated. A stock that is sold for a gain (selling price>purchase price) is a realized gain; a stock that is sold for a loss (selling price<purchase price) is a realized loss; a stock that is not sold when both the daily low and high price exceeds the purchase price is a “paper gain”; a stock that is not sold when both the daily low and high price falls short of the purchase price is a “paper loss”.

The proportion of gains realized (PGR) is estimated as the number of realized gains divided by the number of realized and paper gains. The proportion of losses realized (PLR) is estimated as the number of realized losses divided by the number of realized and paper losses.

Table I

PGR and PLR for the Entire Data Set

This table compares the aggregate Proportion of Gains Realized (PGR) to the aggregate Proportion of Losses Realized (PLR), where PGR is the number of realized gains divided by the number of realized gains plus the number of paper (unrealized) gains, and PLR is the number of realized losses divided by the number of realized losses plus the number of paper (unrealized) losses. Realized gains, paper gains, losses, and paper losses are aggregated over time (1987–1993) and across all accounts in the data set. PGR and PLR are reported for the entire year, for December only, and for January through November. For the entire year there are 13,883 realized gains, 79,658 paper gains, 11,930 realized losses, and 110,348 paper losses. For December there are 866 realized gains, 7,131 paper gains, 1,555 realized losses, and 10,604 paper losses. The *t*-statistics test the null hypotheses that the differences in proportions are equal to zero assuming that all realized gains, paper gains, realized losses, and paper losses result from independent decisions.

	Entire Year	December	Jan.–Nov.
PLR	0.098	0.128	0.094
PGR	0.148	0.108	0.152
Difference in proportions	−0.050	0.020	−0.058
t-statistic	−35	4.3	−38

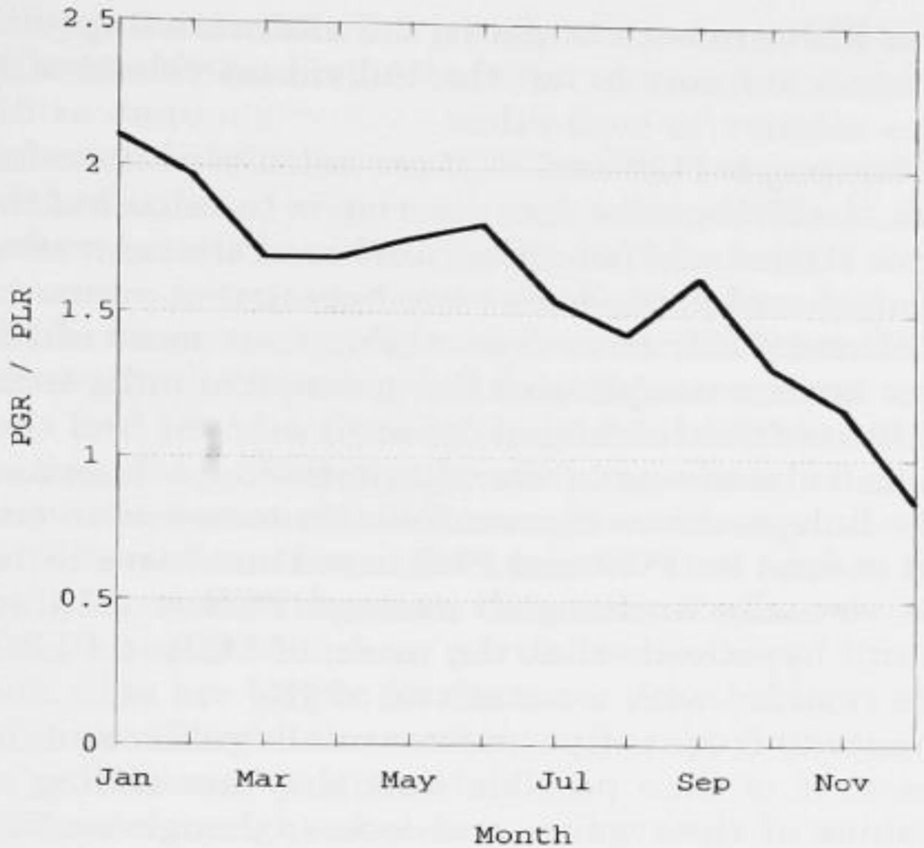

Figure 2. Ratio of the Proportion of Gains Realized (PGR) to the Proportion of Losses Realized (PLR) for each month. PGR is the number of realized gains divided by the number of realized gains plus the number of paper (unrealized) gains, and PLR is the number of realized losses divided by the number of realized losses plus the number of paper (unrealized) losses. Realized gains, paper gains, losses, and paper losses are aggregated over time (1987–1993) and across all accounts in the data set.

Table II

PGR and PLR Partitioned by Period and Trading Activity

This table compares the aggregate Proportion of Gains Realized (PGR) to the aggregate Proportion of Losses Realized (PLR), where PGR is the number of realized gains divided by the number of realized gains plus the number of paper (unrealized) gains, and PLR is the number of realized losses divided by the number of realized losses plus the number of paper (unrealized) losses. The data are partitioned into the periods 1987–1990 and 1990–1993 and into the 10 percent of the accounts that trade most frequently and the 90 percent that trade least frequently. For 1987–1990 there are 7,280 realized gains, 28,998 paper gains, 7,253 realized losses, and 50,540 paper losses. For 1990–1993 there are 6,603 realized gains, 50,660 paper gains, 4,677 realized losses, and 59,808 paper losses. For frequent traders there are 10,186 realized gains, 75,182 paper gains, 8,886 realized losses, and 103,096 paper. For infrequent traders there are 3,697 realized gains, 4,476 paper gains, 3,042 realized losses, and 7,251 paper losses. The t-statistics test the null hypotheses that the differences in proportions are equal to zero assuming that all realized gains, paper gains, realized losses, and paper losses result from independent decisions.

	1987–1990	1991–1993	Frequent Traders	Infrequent Traders
Entire year PLR	0.126	0.072	0.079	0.296
Entire year PGR	0.201	0.115	0.119	0.452
Difference in proportions	−0.075	−0.043	−0.040	−0.156
t-statistic	−30	−25	−29	−22
December PLR	0.143	0.110	0.095	0.379
December PGR	0.129	0.097	0.084	0.309
Difference in proportions	0.014	0.013	0.010	0.070
t-statistic	1.9	2.3	2.3	3.5
Jan.–Nov. PLR	0.123	0.069	0.078	0.282
Jan.–Nov. PGR	0.207	0.117	0.123	0.469
Difference in proportions	−0.084	−0.048	−0.045	−0.187
t-statistic	−32	−27	−31	−25

Table IV

PGR and PLR When the Entire Position in a Stock Is Sold

This table compares the aggregate Proportion of Gains Realized (PGR) to the aggregate Proportion of Losses Realized (PLR), where PGR is the number of realized gains divided by the number of realized gains plus the number of paper (unrealized) gains, and PLR is the number of realized losses divided by the number of realized losses plus the number of paper (unrealized) losses. In this table losses and gains are counted only if a portfolio's total position in a stock was sold that day. Paper (unrealized) gains and losses are counted only if the portfolio's total position in another stock held in the portfolio was sold that day. Realized gains, paper gains, losses, and paper losses are aggregated over time (1987–1993) and across all accounts in the dataset. PGR and PLR are reported for the entire year and for December only. For the entire year there are 10,967 realized gains, 36,033 paper gains, 9,476 realized losses, and 51,502 paper losses. For December there are 666 realized gains, 3,440 paper gains, 1,171 realized losses, and 4,759 paper losses. The t-statistics test the null hypotheses that the differences in proportions are equal to zero assuming that all realized gains, paper gains, realized losses, and paper losses result from independent decisions.

	Entire Year	December
PLR	0.155	0.197
PGR	0.233	0.162
Difference in proportions	−0.078	0.035
t-statistic	−32	4.6

Table VI

Ex Post Returns

This table compares average returns in excess of the CRSP value-weighted index to stocks that are sold for a profit (winning stocks sold) and to stocks that could be, but are not, sold for a loss (paper losses). Returns are measured over the 84, 252, and 504 trading days subsequent to the sale of a realized winner and subsequent to days on which sales of other stocks take place in the portfolio of a paper loser. *p*-values refer to the frequency with which differences in excess returns over the same periods in the empirical (bootstrapped) distributions exceed the difference in excess returns observed in the data.

	Performance over Next 84 Trading Days	Performance over Next 252 Trading Days	Performance over Next 504 Trading Days
Average excess return on winning stocks sold	0.0047	0.0235	0.0645
Average excess return on paper losses	−0.0056	−0.0106	0.0287
Difference in excess returns	0.0103	0.0341	0.0358
(*p*-values)	(0.002)	(0.001)	(0.014)

The Endowment Effect and Market Experience (List Econometrica 2002)

Setting: To test if the endowment effect depends on market experience. The behavior is compared of dealers and non-dealers on a sportscard market (recruited on the floor of a sportscard show).

Experimental design: the following four experimental treatments are carried out on both dealers and non-dealers:

1. The subject is given a Swiss chocolate bar (priced at $6.00) in exchange for filling out a survey. After filling out the survey the subject is given an opportunity to exchange the chocolate bar for a coffee mug (priced at $5.95).
2. The subject is given a coffee mug in exchange for filling out a survey. After filling out the survey the subject is given an opportunity to exchange the coffee mug for a Swiss chocolate bar.
3. The subject fills out a survey. After filling out the survey the subject is asked to choose either the coffee mug or the chocolate bar.
4. The subject is given the Swiss chocolate bar and the coffee mug in exchange for filling out a survey. After filling out the survey the subject has to choose whether to keep the coffee mug or the chocolate bar.

For non-dealers the four above treatments are also carried out with a voting procedure (a majority vote determines the outcome for all subjects in the session; e.g. whether to replace the chocolate bar with a coffee mug.)

TABLE I

SELECTED CHARACTERISTICS OF PARTICIPANTS

	Dealers Mean (Std. Dev.)	Nondealers Mean (Std. Dev.)	Nondealers Mean (Std. Dev.)
Trading intensity	11.81	4.94	6.88
	(10.9)	(6.58)	(6.39)
Yrs. of market experience	9.88	7.15	7.21
	(9.79)	(9.83)	(8.03)
Income	4.15	4.10	4.18
	(1.75)	(1.69)	(1.81)
Age	36.55	34.54	37.04
	(13.1)	(14.41)	(14.1)
Gender (% male)	.94	.85	.82
	(.24)	(.35)	(.39)
Education	3.54	3.44	3.54
	(1.40)	(1.33)	(1.54)
Sample Sizes:			
Private			
Treatment E_{candybar}	30	31	—
Treatment E_{both}	32	30	—
Treatment E_{neither}	35	33	—
Treatment E_{mug}	32	30	—
Public			
Treatment E_{candybar}	—	—	33
Treatment E_{both}	—	—	28
Treatment E_{neither}	—	—	29
Treatment E_{mug}	—	—	35

Notes: 1. Trading intensity represents the number of trades made in a typical month. 2. Yrs. of market experience denotes years that the subject has been active in the market. 3. Income denotes categorical variable (1–8): (1) Less than $10,000, (2) $10,000 to $19,999, (3) $20,000 to $29,999, (4) $30,000 to $39,999, (5) $40,000 to $49,999, (6) $50,000 to $74,999, (7) $75,000 to $99,999, (8) $100,000 or over. 4. Age denotes actual age in years. 5. Gender denotes categorical variable: 0 if female, 1 if male. 6. Education denotes categorical variable (1–6): (1) Eighth grade or less, (2) High School, (3) 2-Year College, (4) Other Post-High School, (5) 4-Year College, (6) Graduate School Education. 7. "Private" and "Public" sample sizes denote the number of subjects in Experiments 1A and 1B, respectively.

TABLE II

Summary of Experimental Raw Data

	Number of Subjects Choosing Candy Bar	Number of Subjects Choosing Mug	Pearson χ^2
Panel A. Nondealers (Private)			
Treatment E_{candybar}	25 (81%)	6 (19%)	19.21 (3 df)
Treatment E_{both}	18 (60%)	12 (40%)	
Treatment E_{neither}	15 (45%)	18 (55%)	
Treatment E_{mug}	7 (23%)	23 (77%)	
Panel B. Nondealers (Public)			
Treatment E_{candybar}	29 (88%)	4 (12%)	34.79 (3 df)
Treatment E_{both}	16 (57%)	12 (43%)	
Treatment E_{neither}	17 (59%)	12 (41%)	
Treatment E_{mug}	6 (17%)	29 (83%)	
Panel C. Dealers (Private)			
Treatment E_{candybar}	14 (47%)	16 (53%)	.54 (3 df)
Treatment E_{both}	14 (44%)	18 (56%)	
Treatment E_{neither}	18 (51%)	17 (49%)	
Treatment E_{mug}	14 (44%)	18 (56%)	

	Preferred Exchange	p-Value for Fisher's Exact Test
Panel D. Trading Rates		
Pooled nondealers ($n = 129$)	.18 (.38)	$< .01$
Inexperienced consumers (< 6 trades monthly; $n = 74$)	.08 (.27)	$< .01$
Experienced consumers (≥ 6 trades monthly; $n = 55$)	.31 (.47)	$< .01$
Intense consumers (≥ 12 trades monthly; $n = 16$)	.56 (.51)	.64
Pooled dealers ($n = 62$)	.48 (.50)	.80

Notes: 1. The Pearson chi-square tests in Panels A–C are distributed with 3 degrees of freedom and each have a null hypothesis of Hicksian preferences. 2. Data in Panel D are pooled from Treatments E_{candybar} and E_{mug}. For nondealers, data from "public" and "private" are pooled. Standard deviations are in parentheses. 3. Experienced consumers are those consumers who trade 6 or more times per month (6 is roughly the mean level of monthly trades). Intense consumers trade 12 or more times per month (12 is roughly the mean plus one standard deviation). 4. Fisher's exact test in Panel D has a null hypothesis of no endowment effect.

Myopic Loss Aversion and the Equity Premium Puzzle (Benartzi & Thaler QJE 1995)

Equity-premium puzzle: Difficult to explain the substantial difference in return on stocks versus the risk-free return (bonds) based on the standard model and reasonable levels of risk aversion (real annual return 7% versus 1% mentioned in the article). A number of explanations proposed in the literature; myopic loss aversion one of them (the below is no test of myopic loss aversion, but merely illustrates that the model is consistent with the equity premium puzzle).

Myopic loss aversion: Loss aversion for losses relative to a reference point; and a short evaluation period based on mental accounting (the shorter the evaluation period the more likely is a loss and the more important will loss aversion be).

In the paper they carry out simulations based on historical rates of return to estimate for which evaluation period an investor would be indifferent between holding stocks and bonds. The historical rates of return consistent with myopic loss aversion and with an evaluation period of about 1 year (i.e. investors evaluate their portfolios annually). Utility function based on prospect theory with parameters from the Tversky and Kahneman 1992 JRU article (a loss aversion parameter of 2.25). Although they also assume risk aversion for gains, risk taking for losses and probability weighting from prospect theory; the results is mainly driven by loss aversion and not these other aspects of prospect theory.

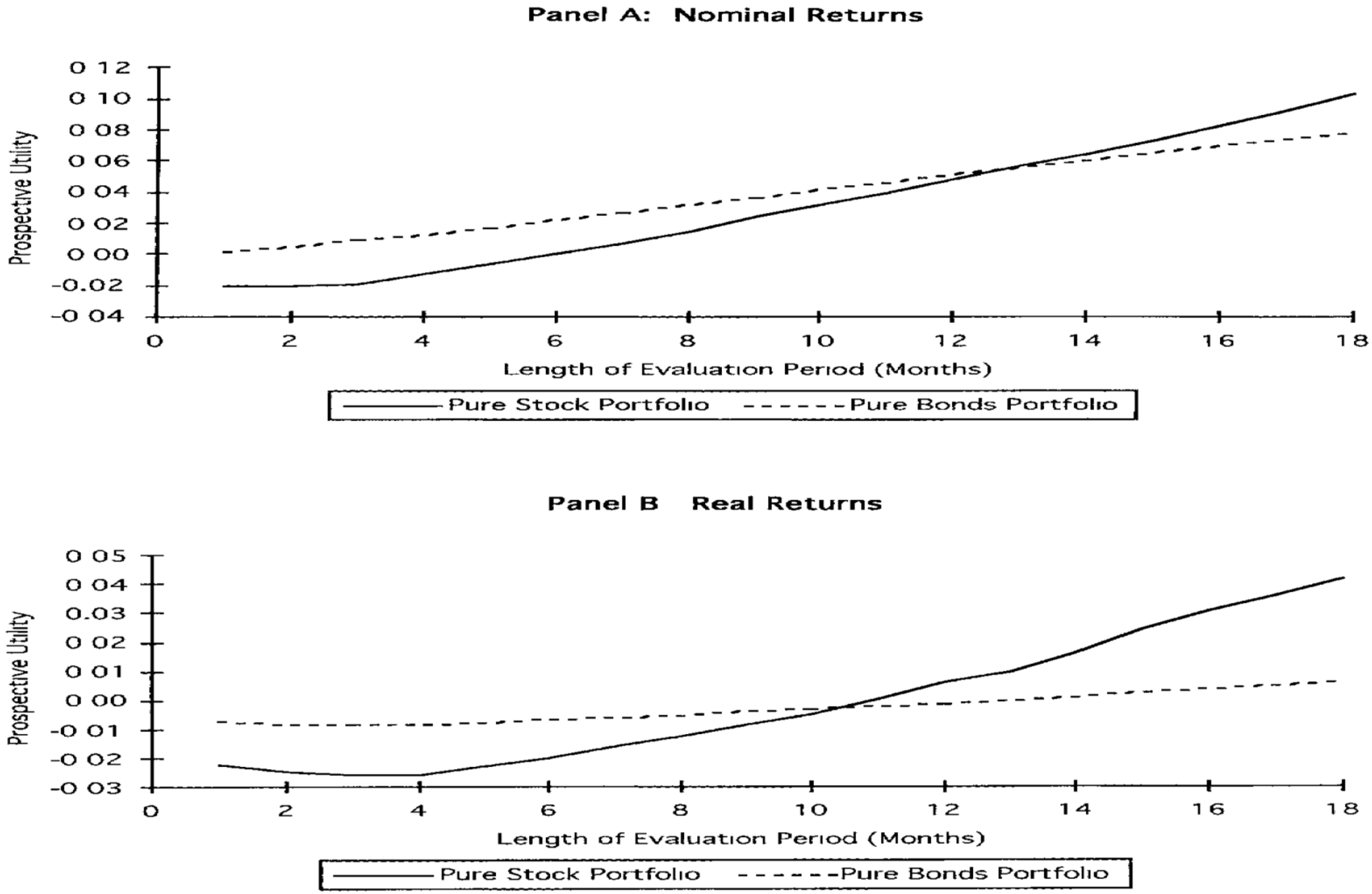

FIGURE I
Prospective Utility as Function of the Evaluation Period

An investor indifferent between stocks and bonds with an evalution period of about 13 months based on nominal returns and about 11 months based on real returns (the probability of a loss greater with real returns leading to a somewhat lower evaluation period at indifference).

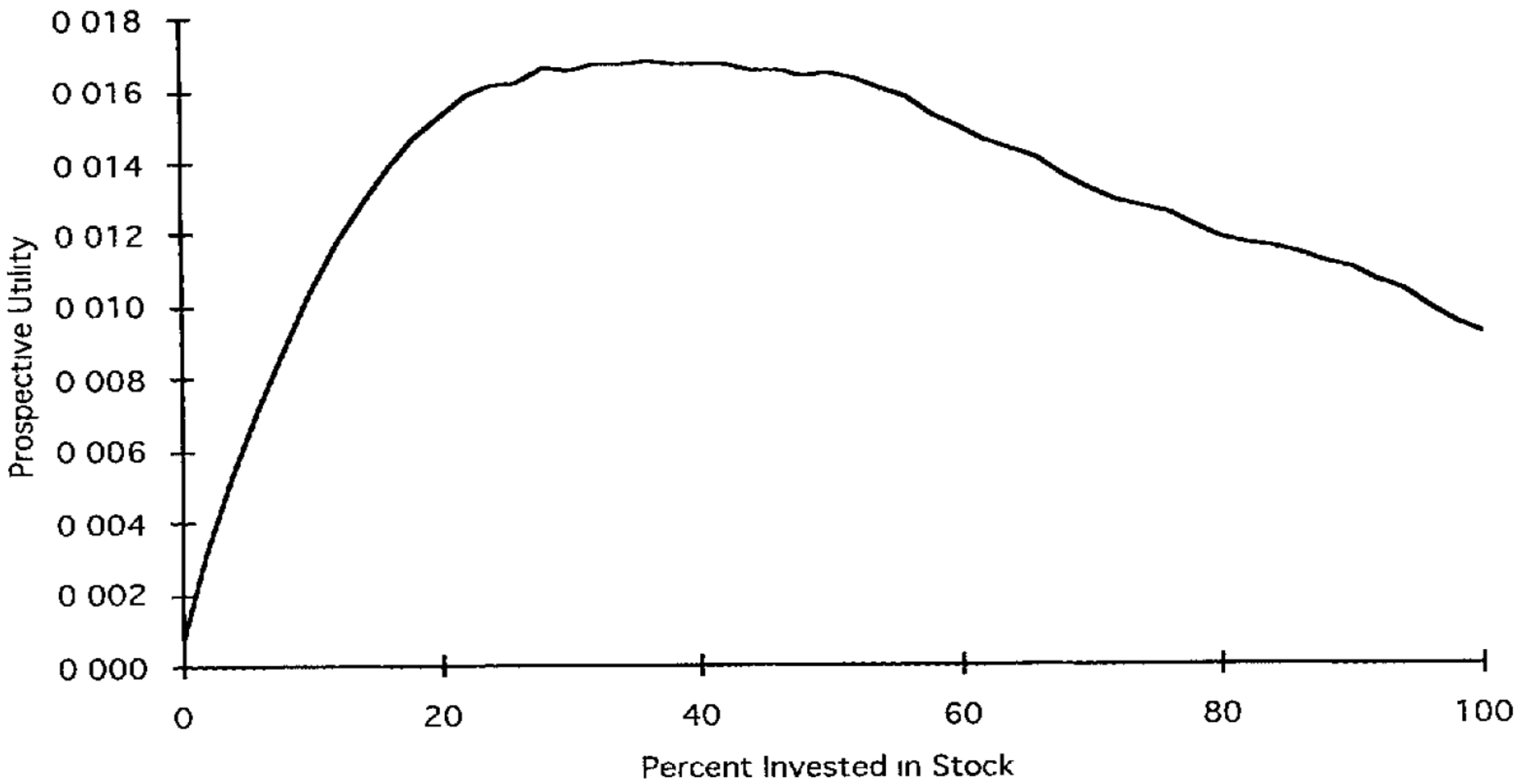

FIGURE II
Prospective Utility as Function of Asset Allocation (One-Year Evaluation Period)

Optimal asset portfolio allocation with myopic loss aversion with a one-year evaluation period (and based on nominal returns). Portfolios with about 35%-55% stocks maximize ”prospective utility” (roughly consistent with data).