

Behavioral Biases and Investment[★]

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Abstract. We investigate the way investors react to prior gains/losses. We directly examine investor reactions to different definitions of gains and losses (i.e., overall wealth, paper gains and losses, and realized capital gains and losses) and investigate how gains and losses in one category of wealth (e.g., real estate) affect holdings in other categories (e.g., financial assets). We show that investors change their holdings of risky assets as a function of both financial and real estate gains. Prior gains increase risk-taking, while prior losses reduce it. To interpret our results, we consider and compare three alternative hypotheses of investor behavior: prospect theory, house money effect and standard utility theory with decreasing risk aversion. Our evidence fails to support loss aversion, pointing in the direction of the house money effect or standard utility theory. Investors consider wealth in its entirety, and risk-taking in financial markets is affected by gains/losses in overall wealth, financial wealth, and real estate wealth.

1. Introduction

Behavioral motivation has been acknowledged as a main driving force behind portfolio choice. Perhaps the most relevant manifestation of this bias is the way investors react to prior gains and losses. While it seems clear that investor behavior is affected by prior outcomes and by the changes in wealth as opposed to the mere level of it, the “direction” of this reaction is uncertain. The main behavioral finance theory, i.e., loss aversion, posits that prior losses increase risk-taking. This runs counter to alternative behavioral explanations such as the house money effect and standard utility theory with decreasing risk aversion, which assume that prior losses decrease risk-taking.

The very definition of gain/loss is also unclear. The portfolio decision of an investor may be a function of prior gains/losses on his or her overall assets (financial and non-financial) or just on a subset of them (financial assets or specific portfolios). In the latter case, investors would suffer from narrow framing. Efforts

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to empirically address these issues have been hindered by the lack of data, which has made it impossible to test the different behavioral theories against each other. We bridge this gap by using a new and unique dataset. More specifically, we are able to effectively control for most components of the investor's decision due to the richness of the data, which contain virtually all the information on the holdings, overall wealth broken down into all of its components, as well as income and demographic characteristics of a highly representative sample of the Swedish population.

We focus on one salient moment of investor behavior, namely risk-taking, and study the relationship between risk-taking and prior gains and losses. In particular, we describe the evolution of equity holdings over time, as a function of changes in wealth and past gains/losses in equity and in real estate holdings, taking investor heterogeneity into account (including non-traded wealth and income shocks) as far as possible (and much more than others have ever been able to do). We directly examine investor reactions to different definitions of gains and losses (i.e., overall wealth, paper gains and losses, and realized capital gains and losses). We also investigate how gains and losses in one category of wealth (e.g., real estate) affect holdings in other categories (e.g., financial assets). We show that investors change their holdings of risky assets as a function of both financial and real estate gains. Prior gains increase risk-taking, while prior losses reduce it.

To interpret our results, we consider and compare three alternative hypotheses of investor behavior: prospect theory, house money effect and standard utility theory with decreasing risk aversion. Our evidence fails to support loss aversion, pointing in the direction of standard utility theory with decreasing risk aversion.

An important contribution of our study is that we are able to effectively control for most of the other determinants affecting the investor's decision that may have confounding effects on the tests. In particular, the use of a panoply of control variables (measures of income and wealth, contemporaneous gain/loss variables, borrowing constraints, demographic variables, momentum variables, and geographical and macroeconomic variables) allows us to move closer to a designed experiment, while exploiting the advantages of field data. To date, the main obstacle has been the lack of good quality data on the overall wealth of a representative sample of investors in the market.

Biases are bound to arise in the analysis of stock portfolios when other sources of income (e.g., real estate, labor, entrepreneurial income) are ignored. For example, if a change in wealth of the investor is due to income shocks or real estate capital gains, a test of investor behavior based only on changes in portfolio holdings and stock market gains/losses would not be able to distinguish loss aversion from standard wealth effects. Moreover, the lack of data on real estate wealth may be very worrisome. Changes in wealth due to real estate capital gains/losses may affect investor behavior regardless of financial capital gains/losses. Genesove and Mayer (2001) shed some light on this topic by analyzing loss aversion and seller behavior

in the housing market.¹ This could affect any behavioral study focusing only on financial holdings.

Data constraints have induced the literature to focus only on a subset of investor wealth and to limit itself to a particular subset of investors. For example, Barber and Odean (2000, 2001, 2002) and Odean (1998, 1999) study the stock-trading behavior of a subset of investors who have an account with a major discount broker. Grinblatt and Keloharju (2000, 2001a, 2001b) are the first to use a dataset containing information on the investors' entire stock holdings. However, they focus on issues such as geographical preferences and momentum trading without considering the overall dimension of the portfolio (wealth, real estate, non-financial income). Recently, Brown et al. (2002), using Australian data, show that loss aversion is a short-term phenomenon, while the house money effect applies mostly to long-run behavior. Still, their analysis is only based on stock holdings and does not account for the entire wealth of the investor. To our knowledge, we are the first to provide a complete picture of portfolio behavior.

The remainder of the paper is organized as follows. In Section 2, we describe the data and the way we construct the main variables. In Section 3, we introduce the main econometric issues and present the empirical restrictions we will test. In Sections 4 and 5, we present and discuss our empirical findings, which are followed by a brief conclusion.

2. Data Description and Variable Construction

The data we use come from different sources and contain information on both sides of the market, i.e., on both the investor and the company. For each investor, we have detailed information on stock holdings (at the stock level), mutual funds, bank accounts, real estate and other forms of wealth.

We also have the income profiles of all the investors, provided by the tax authorities, in addition to their demographic and family characteristics. This information has been matched at the individual level, so that we have investment and income information for each investor. For each stock, we have detailed information on the company as well as stock market data (price, volume and volatility). We also use aggregated data on Swedish macroeconomic conditions and real estate market indices. Let us look at the sources in more detail.

2.1. INDIVIDUAL STOCKHOLDINGS

We use the data on individual stockholders collected by the Swedish Security Register Center (*Värdepapperscentralen AB* or *VPC*). The data contain both stock held directly and in street name, including holdings of US-listed ADRs. In addition, *SIS Ägarservice AB* collects information on ultimate owners of shares held via

¹ However, while they are the first to use real estate data to test behavioral theories, they do not consider other aspects of the investor's wealth.

trusts, foreign holding companies and the like (for details, see Sundin and Sundqvist, 2002). Our data cover the period 1995–1999. Overall, the records provide information on the owners of 98% of the market capitalization of publicly traded Swedish companies. We have information on at least 81.6% of market capitalization of each company; for the median company, we have information on 97.9% of the equity. The data provided by SIS Ägarservice AB were linked by Statistics Sweden with the LINDA dataset described below.

2.2. LINDA

LINDA (Longitudinal INdividual DATaset for Sweden) is a register-based longitudinal dataset, and a joint endeavor between the Department of Economics at Uppsala University, The National Social Insurance Board (RFV), Statistics Sweden, and the finance and industry ministries. It consists of a large panel of individuals, and their household members, which is representative of the population from 1960 to 1999. For each year, information on all family members of the sampled individuals is added to the dataset. In addition to the panel that is representative of the population in general, the sampling procedure ensures that the data are representative for each year. Moreover, the same family is traced over time. This provides a real time series dimension, usually missing in surveys, based on different cohorts polled over time.

The variables available include individual background variables (sex, age, marital status, country of birth, citizenship, year of immigration, place of residence, detailed at the parish level, education, profession, employment status), housing information (type and size of housing, owner, rental and occupation status, one-family or several-family dwelling, year of construction, housing taxation value), and tax and wealth information. In particular, the income and wealth tax registers include information on labor income, capital gains and losses, business income and losses, pension contributions, taxes paid and taxable wealth. A detailed description of the dataset is provided by Edin and Fredriksson (2000), and is available at <http://linda.nek.uu.se/>.

The tax part deserves more detailed discussion. In Sweden, in addition to the usual income tax, a wealth tax applies to wealth exceeding SEK 900,000 (about US\$90,000). Taxable wealth includes tax-assessed value of real estate, market value of publicly listed securities, balance of bank accounts and fair value of valuable possessions (including jewelry, cars, antiques, etc.). For the purpose of this paper, we compute the current market value of housing using the tax-assessed value provided by LINDA. We evaluate it at current prices by using the average ratio of market value to tax-assessed value that is provided for each year and county by the Swedish Office of Statistics.²

There is no real estimate of market value of privately held companies. However, the data contain an indicator variable for owners of privately held companies and

² It may lack precision for summer houses if they are not located in the same county as the household's permanent residence, as no information on the location of summer houses is provided.

entrepreneurs who file their business tax return along with their personal tax return. For privately held unlimited liability companies, the value of the assets is included in the tax return. For privately held limited liability companies that are not listed, the value of assets held is, in general, missing. However, the size of the group is rather small (1.74–1.91% of the sample, depending on the year) and is unlikely to have a significant effect on our estimates. Moreover, for the members of the 5,000 wealthiest families, we have been able to reconstruct their values and to correctly impute them by using information from SIS Ägarservice AB (Sundin and Sundqvist, 2002).

The combined LINDA/Shareholding dataset covers the period 1995–1999. In addition, we use data from LINDA for the period 1991–1994. The overall sample we use comprises 1,487,602 observations. In Table I, we report some descriptive statistics. In particular, Panel A contains the general demographic characteristics (number of households, members in the household, adults in the household, age of the oldest member of the household, percentage of the sample with secondary and higher education). Panel B reports the age and gender distribution of the sample, while Panel C details the wealth and income characteristics, defined in terms of wealth, real estate, labor and entrepreneurial income. We define as a shareholder anyone who owns more than SEK 2,000 worth of stock. We remove all the households with average income and volatility of income exceeding four standard deviations as well as all the households with less than 3 years of observations. We also remove the households whose oldest member is under eighteen years of age.

2.3. FIRM-LEVEL INFORMATION AND OTHER DATA

In order to derive information on individual security returns (including dividends) and to track the overall market index (SIX Index), we use the SIX Trust Database. For information on the various firm-level characteristics, we use the Market Manager Partners Database. These two databases are the equivalent of CRSP and COMPUSTAT, respectively. In addition, the Market Manager Partners Database contains information at the plant level, including the location of the plant (detailed at the municipality level). We use the set of Swedish residential real estate indices provided by Professor Peter Englund. The indices were computed at the county level and are based on the resale value of the properties.³ The Consumer Confidence Index is provided by Statistics Sweden. Geographical coordinates, which contain the latitude and longitude of Swedish postal offices (on a three-digit level), are supplied by Swedish Postal Service.

³ The methodology used in the construction of the indices is described in Englund, Quigley and Redfearn (1998).

Table I. Descriptive statistics of the sample

This table contains the descriptive statistics of the sample. Panel A reports the general demographic characteristics (number of households for each year, members in household, adults in the household, age of the oldest member of the household, percentage of the sample with secondary and higher education). Panel B reports the age and gender distribution of the sample. We report Mean, Median, Standard Deviation, Inter-Quartile Range (IQR) and Maximum value. They have been calculated over the whole sample (i.e., across-investors and time). Panel C reports the percentage of households that pay wealth tax, are labor income earners, entrepreneurial income earners and real estate holders. The column "Representation in the sample" reports the proportion of households in the sample that pay wealth tax, earn labor or entrepreneurial income or hold real estate wealth. The other columns report statistics (Mean, Median, Standard Deviation, IQR, Maximum) of, respectively, the value of wealth, labor and entrepreneurial income (gross yearly income) and real estate. All monetary values are in Swedish kronor.

Panel A: General demographic characteristics					
Variable	Mean	Median	Std. Dev.	I.Q.R.	Maximum
Number of households	292,901	291,913	647	686	293,320
# of members in household	2.67	2.00	1.51	3.00	16.00
# of adults in household	1.77	2.00	0.69	1.00	9.00
Age of oldest household member	49.28	47	17	24	107
% with secondary education	43.5%	43.5%	0.6%	0.5%	44.3%
% with higher education	31.4%	31.2%	1.4%	1.4%	33.7%

Panel B: Age and gender distribution of the sample			
Age	Males (%)	Females (%)	Households where the age of the oldest member falls within the age bracket in first column
0–19	18.2	17.2	0.5
20–29	4.8	4.9	10.7
30–39	7.1	8.2	21.7
40–49	7.4	7.4	23.6
50–59	5.9	5.3	17.9
60+	6.6	7.2	25.8
Total	49.9	50.2	100

Panel C: Wealth and income characteristics of households						
Variable	Representation in the sample	Mean	Median	Std. Dev.	I.Q.R.	Maximum
Wealth-tax payers	7.9%	359,592	102,700	2,648,521	353,400	1,023,147,857
Labor income earners	100.0%	321,489	287,722	237,526	276,190	43,445,271
Entrepreneurial income earners	9.8%	88,114	43,268	172,565	111,726	7,320,000
Real estate holders	54.6%	449,400	387,000	348,736	340,000	78,140,000

2.4. DEFINITION OF GAINS AND LOSSES

We start by defining gains/losses. Π_t^+ and Π_t^- are the gains and losses, respectively, normalized to the level of the investor's wealth. We first define three measures: the change in overall wealth ($\Pi_{Wt} = \text{Wealth}_t / \text{Wealth}_{t-1} - 1$), the realized financial capital net gains and losses ($\Pi_{Ft} = (\text{Financial Capital Gains}_t - \text{Financial Capital Losses}_t) / \text{Wealth}_{t-1}$) and the realized real estate net capital gains and losses ($\Pi_{Rt} = (\text{Real Estate Capital Gains}_t - \text{Real Estate Capital Losses}_t) / \text{Wealth}_{t-1}$). The changes are standardized to the level of wealth to make them homogeneous across investors. Next, we consider the positive (Π_t^+) and negative (Π_t^-) components of these variables. That is, Π_t^+ (Π_t^-) is a variable that takes the value Π_{Ft} (or Π_{Wt} or Π_{Rt}) when Π_{Ft} (or Π_{Wt} or Π_{Rt}) is positive (negative), and zero otherwise. For example, Π_{Wt}^+ is defined as $\text{Max}(0, \text{Wealth}_t / \text{Wealth}_{t-1} - 1)$, while Π_{Wt}^- is defined as $\text{Max}(0, 1 - \text{Wealth}_t / \text{Wealth}_{t-1})$. Benartzi and Thaler (1995) and Barberis et al. (2001) only consider the changes in the value of the investor's financial wealth. As a robustness check, and in order to study the differential impact of gains/losses related to different sources of wealth, we also consider real estate and overall wealth.

What is the horizon over which the gains/losses are defined? In addressing this issue, we try to be consistent with the standard literature. Therefore, we follow Benartzi and Thaler (1995), Barberis et al. (2001) and Barberis and Huang (2001) and consider the unit of measure equal to one year. The rationale for this choice is that "we file taxes once a year and receive our most comprehensive mutual fund reports every year; moreover, institutional investors scrutinize their money managers' performance most carefully on an annual basis" (Benartzi and Thaler, 1995). This horizon also allows us to operate at a frequency where we can properly account for all the other sources of income and changes in wealth of the investor. Our study, therefore, complements the seminal studies that use higher frequency data (Barber and Odean, 2000, 2001, 2002 and Odean, 1998, 1999).

It is worth noting that the use of two alternative measures of gains and losses has important implications. Indeed, while the change in overall wealth is only the change in the value of the wealth in the year, the realized financial and real estate capital net gains and losses are self-reported by the investors. By using the gains/losses declared by the investors when they file with the authorities, we implicitly use as a reference point the price at which the asset has been purchased. In our view, the purchase price does indeed offer the best indication of the status quo, as each investor directly defines gains and losses in terms of the original purchase price. This approach allows us indirectly to account for financial and real estate realized and paper gains/losses, without being forced to make assumptions. Barberis et al. (2001) consider the *status quo* as the reference point, scaled up by the risk-free rate. More operationally, Odean (1998) considers the average purchase price. This approach also presents the additional advantage of allowing us to test whether investors react to the overall gains/losses or to a subset of them. We also

experimented with the direct inclusion of paper gains/losses, and the results are qualitatively similar to those reported.

A caveat applies regarding optimal tax trading. In Sweden, individual investors pay capital gain taxes upon the realization of their holdings. While we recognize that over the course of the year, the trading behavior of some investors might be affected by tax considerations (e.g., Poterba and Weisbenner, 2001), we rely on the results of Poterba (1987) suggesting that only a small percentage of investors take advantage of tax rules for offsetting losses. It is also important to note that the tax benefits of capital losses should reduce the negative response to capital losses. Moreover, one would expect the effect to be more important for wealthy and liquid investors. However, our results will indicate that the pattern is quite the opposite. Capital losses have stronger effects on wealthy investors than on non-wealthy investors.

2.5. CONTROL VARIABLES

Given the importance of properly controlling for confounding factors, we use a panoply of control variables. The availability of these control variables makes the results unique. We consider the following sets of control variables: measures of income and wealth, contemporaneous gain/loss variables, borrowing constraints, demographic variables, momentum variables, and geographical and macroeconomic variables.

The *contemporaneous gain/loss variables* are the contemporaneous capital gains/losses and the contemporaneous changes in overall wealth, as defined in the previous subsection. A change in wealth is a less precise measure of gains/losses, as it also contains the portfolio decisions of the investor. In order to account for this, we include, among the explanatory variables, the main moments (mean, variance and correlation with financial and real estate income) of the other sources of income. Provided that the saving/income ratio of the investor does not change dramatically over time, this should control for it. The *income variables* are the variance of labor and entrepreneurial income of the investor and the correlation between them and financial and real estate income. To make the results comparable with the standard literature on portfolio choice in the presence of non-financial income risk, we construct them by using the measures of the permanent non-financial income based on the approach of Carrol and Samwick (1997), and Vissing-Jørgensen (2002). We consider labor income and entrepreneurial income as non-financial income. We provide a detailed description of the procedure in the Appendix.

As an additional robustness check, we replicate our results by using the actual levels of non-financial income, their volatilities and the correlation of financial and non-financial income, defined as in Heaton and Lucas (2002a). This replaces the measures of permanent income, volatility of income and their correlation with portfolio returns that had been constructed according to the Carrol and Samwick

(1997) methodology we described earlier. Given that the results are consistent, we will report only those based on the Carrol and Samwick methodology.

The *wealth variables* are the overall level of wealth of the investor and its breakdown into its components (financial and real estate wealth). Financial wealth is made up of cash, equity holdings, mutual funds, loans, bonds and other assets. We consider two types of *borrowing constraint variables*. The first one is the ratio of investor debt to total income (labor and entrepreneurial income), and the second is the ratio of investor debt to total wealth (financial and real estate wealth). Both of them are constructed at the investor level at time t . Debt is defined as the sum of all interest-bearing debts the household has.⁴

The *momentum variables* include the return and volatility of the investor's portfolio (equity and mutual funds), and the return and volatility of the market index for the previous twelve months. These variables are included to control for the possibility that the change in wealth is merely due to momentum, that is, consecutive increases in the value of the stock market or in the value of the holdings.

The *demographic variables* include the level of education, broken down into high school and university level. These are dummies that take the value 1 if the highest level of education in the household is secondary education and university or higher education, and 0 otherwise. We also include the number of adults in the household (18 years of age and above) and the size of the household (the number of family members in the household), the age of the oldest member of the family of the investor and its value squared. This latter variable is used in line with standard results (Guiso and Jappelli, 2002; Vissing-Jørgensen, 2002) finding a non-linear relationship between age and the degree of stock market participation. We also include a dummy that takes the value 1 if the investor lives in the capital, and 0 otherwise, and the investor's immigration status. The latter takes the value 0 if all the members of the household are native Swedes, and 1 if at least one member of the household is an immigrant.⁵ Furthermore, we construct a variable to proxy for the professional ability of the investor. Ability represents the professional expertise and tries to gauge the quality of the investor. This is based on the difference between the investor's income and the average income of others in the same profession. The assumption is that the higher the income, relative to the average income of other investors in the same profession, the higher the investor's ability should be.

Finally, the *geographical and macroeconomic variables* are an Index of Consumer Confidence, and a set of dummies that account for the regional location of

⁴ In Sweden, part of the interest paid on the debt is tax-deductible and wealth tax only applies to wealth net of debt. As a result, the tax office collects data from, for example, banks, credit card companies, and consumer credit finance companies.

⁵ We also tried two alternative specifications. In the first one, we used the sum of the immigration statuses of the members of the household. That is, if two members of the household are immigrants, the variable takes the value of 2. In a second specification, we used the inverse of the number of years since the oldest immigrant in the household arrived in Sweden. These two alternative specifications produce results that are qualitatively analogous to those reported. These results are available upon request from the authors.

the investor as well as the industry in which the investor works. We consider eight geographical areas and ten industries.⁶

2.6. SAMPLE AND DESCRIPTIVE STATISTICS

Let us now describe the samples we use. We investigate how the reaction to prior gains/losses varies for different levels of wealth and degree of liquidity of the investor's portfolio. Both wealth and liquidity are good proxies for the degree of informativeness of the investor. We therefore consider four different samples: the overall sample and two sub-samples constructed on the basis of either the wealth or the liquidity of the investor's overall portfolio. In particular, we define as *high-wealth investors* all the investors who, in the previous year, paid wealth tax; all the others are defined as *low-wealth investors*. High-wealth investors represent approximately 8% of the overall sample. We then divide the high-wealth investors into two categories: illiquid and liquid. To do this, we rank all the high-wealth investors in terms of the ratio of illiquid assets (i.e., real estate) over total wealth. *Illiquid investors* are those who, in the previous year, belonged to the top quintile, while *liquid investors* are those who, in the previous year, belonged to the bottom quintile.

Descriptive statistics on the different proxies for gains and losses are reported in Table II. We consider the three proxies for gains and losses as defined above. Panel A reports the mean and median values for the different classes, as well as their standard deviation and inter-quartile range (I.Q.R.). We consider raw gains and risk-adjusted gains, i.e., net of risk. For Π_{Wt} and Π_{Ft} (as defined in the previous section) risk is constructed as the standard deviation of the time series of the corresponding measures of gains. For the Real Estate measure Π_{Rt} we use the standard deviation of Π_{Wt} . We also used another measure (not reported) based on volatility of real estate indices in the county where the household lives. The results are similar to the ones reported. The risk-adjusted measure is defined as the ratio of percentage profits minus three-month interest rate T-Bill to standard deviation of the percentage profits. Table II (Panels B and C) reports the tests of differences between classes of investors. We compare the high-wealth investors with the low-wealth investors and the liquid investors with the illiquid ones. Given the characteristics of the distribution of the investors, we consider three different tests: *t*-tests, the Wilcoxon test and the Kolmogorov-Smirnov test. Where the classes are defined in terms of wealth (Panel B), all the tests consistently show that the high-wealth investors have higher gains than the low-wealth investors. Also, where the classification is based on the degree of liquidity of the overall portfolio (Panel C), the liquid investors seem to have higher gains than the illiquid investors.⁷

⁶ Geographical area definitions are based on the NUTS2 classification for Sweden. An additional dummy for public sector workers is added to the industrial classification of households.

⁷ If we use the tests based on the median (i.e., Wilcoxon and Kolmogorov-Smirnov), the more liquid investors always make more profits than the less liquid investors do. If we consider the *t*-test,

Table II. Descriptive statistics of gain measures

This table reports the descriptive statistics for three measures of gains: wealth-based, securities gains/losses-based, and real estate capital gains and losses-based. The first measure is defined as $\Pi_{Wt} = (Wealth_t/Wealth_{t-1} - 1)$ and capital gains/losses are defined as $\Pi_{F,Rt} = (CAPITAL\ GAINS_t - CAPITAL\ LOSSES_t)/Wealth_{t-1}$, where capital gains are those for securities (real estate) correspondingly. We report statistics for both raw measures and risk-adjusted measures. The adjustment for risk is defined in the text. Panel B reports the results of the t -tests, the Wilcoxon test and the Kolmogorov-Smirnov test of equality for high-wealth vs. low-wealth households. Panel C reports the results of the t -tests, the Wilcoxon test and the Kolmogorov-Smirnov test of equality for liquid vs. illiquid high-wealth households.

Panel A: Descriptive statistics								
Variable	Low-wealth				Wealthy			
	Mean	Median	Std. Dev.	I.Q.R.	Mean	Median	Std. Dev.	I.Q.R.
Raw Gains								
Π_{Ft}	0.007	0.000	0.033	0.000	0.008	0.000	0.029	0.000
Π_{Rt}	0.018	0.000	0.083	0.003	0.026	0.002	0.067	0.024
Π_{Wt}	0.094	0.050	0.415	0.162	0.123	0.087	0.259	0.204
Risk-adjusted gains								
Π_{Ft}	0.037	0.000	0.236	0.002	0.069	0.000	0.335	0.002
Π_{Rt}	0.161	0.000	0.921	0.014	0.350	0.016	0.981	0.258
Π_{Wt}	0.792	0.214	4.228	0.750	1.556	0.519	3.840	2.188
Panel B: Tests of differences between high- and low-wealth households								
Variable	<i>t</i> -test		Wilcoxon test		Kolmogorov-Smirnov test			
	<i>t</i> -value	Prob > <i>t</i>	Z	Prob > Z	<i>KSa</i>	Prob > <i>Ksa</i>		
Raw Gainszz								
Π_{Ft}	4.25	< 0.0001	4.78	< 0.0001	5.47	< 0.0001		
Π_{Rt}	16.16	< 0.0001	75.66	< 0.0001	43.51	< 0.0001		
Π_{Wt}	13.65	< 0.0001	41.59	< 0.0001	21.58	< 0.0001		
Risk-adjusted Gains								
Π_{Ft}	15.96	< 0.0001	4.13	< 0.0001	9.27	< 0.0001		
Π_{Rt}	29.99	< 0.0001	84.25	< 0.0001	43.67	< 0.0001		
Π_{Wt}	29.36	< 0.0001	59.60	< 0.0001	33.70	< 0.0001		
Panel C: Tests of differences between liquid and illiquid households								
Variable	<i>t</i> -test		Wilcoxon test		Kolmogorov-Smirnov test			
	<i>t</i> -value	Prob > <i>t</i>	Z	Prob > Z	<i>KSa</i>	Prob > <i>Ksa</i>		
Raw Gains								
Π_{Ft}	8.91	< 0.0001	7.97	< 0.0001	4.09	< 0.0001		
Π_{Rt}	−6.02	< 0.0001	14.11	< 0.0001	8.24	< 0.0001		
Π_{Wt}	−1.55	0.1205	1.96	0.0501	3.76	< 0.0001		
Risk-adjusted Gains								
Π_{Ft}	3.98	< 0.0001	5.06	< 0.0001	4.09	< 0.0001		
Π_{Rt}	−6.93	< 0.0001	14.94	< 0.0001	8.23	< 0.0001		
Π_{Wt}	−0.81	0.4160	4.85	< 0.0001	4.15	< 0.0001		

3. Econometric Issues

3.1. SELECTION BIAS

The biggest econometric issue is generated by the sample selection problem. Indeed, out of the entire population, we can only observe investors who have money invested in the stock market. As we do not observe the investment decisions of investors who do not participate in financial markets, and since participation is endogenous, the standard estimates are biased. To address this issue, we follow the standard theoretical (Calvet et al., 2002) and empirical literature (Vissing-Jørgensen, 2002). We use the Heckman (1979) two-stage procedure and separately estimate what induces the investor to enter the stock market and what influences his or her choice of assets. In particular, the econometric model can be expressed formally as:

$$RT_{it}^* = \alpha_1 + \beta_1 X_{1,i,t} + \varepsilon_{1,i,t} \quad (1)$$

$$P_{it}^* = \alpha_0 + \beta_0 X_{0,i,t} + \varepsilon_{0,i,t} \quad (2)$$

$$RT_{i,t} + RT_{i,t}^*, P_{i,t} = 1 \quad \text{if } P_{i,t}^* > 0$$

$$RT_{i,t} \text{ not observed}, P_{i,t} = 0 \quad \text{if } P_{i,t}^* \leq 0$$

where (1) is the equation of interest (where RT_{it} refers to the amount of risk taken by the i th investor at time t) and (2) is the selection equation that represents whether the individual enters the sample (i.e., whether the individual enters the stock market). $P_{i,t}$ is a dummy that takes the value 1 if the investor participates in financial markets, and zero otherwise, and $X_{0,i,t}$ and $X_{1,i,t}$ are explanatory variables. In particular, $X_{0,i,t}$ is a vector of variables that affect the probability of entry. We include all the control variables defined in the previous section. Equations (1) and (2) represent the fact that we do not observe the individuals who decide not to enter the stock market, and that this selection is itself endogenous with respect to the explanatory variables. That is, the variable $P_{i,t}$ (the dummy of selection for the individual) depends on the latent variable, $P_{i,t}^*$, itself a function of individual characteristics. The probability of investors entering the financial markets is modeled as a normal c.d.f. The model assumes the following correlation structure:

$$\begin{pmatrix} \varepsilon_{1i} \\ \varepsilon_{0i} \end{pmatrix} \approx NID \left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_1^2 & \sigma_{10} \\ \sigma_{10} & \sigma_0^2 \end{pmatrix} \right).$$

In cases where self-selection is indeed a problem, the standard OLS estimates of Equation (1) are biased. We therefore use the approach developed by Heckman

however, it appears that there is no significant difference for the gains defined in terms of overall wealth, while the less liquid investors make more real estate capital gains.

(1979) based first on estimating Equation (2) using a standard probit model, and then estimating Equation (1) by running the OLS

$$RT_{it} = \alpha_1 + \beta_1 Z_{1,i,t} + \theta_1 \lambda_i + \eta_{1,i,t} \quad (3)$$

where

$$\lambda_i = \frac{\phi(x'_{2i}\beta_2)}{\Phi(x'_{2i}\beta_2)}$$

is the Heckman Lambda. This term is estimated using results from the first stage. To estimate this model, we need to consider a larger dataset based on the total sample universe: i.e., both the households that own financial assets and those that do not. They comprise a total of 1,487,602 households, tracked over time (1995–1999). Equation (2) is an auxiliary regression necessary for the proper estimation of the second stage, but as it is beyond the scope of this paper, the results will not be discussed here.

4. The specification

To assess the relative merits of the different theories, we focus on risk-taking and investor characteristics. We consider Equation (1) and expand it to define the main variables of interest. We consider a simplified reduced form that relates risk-taking to prior gains and losses *conditional on market participation*:

$$RT_{i,t} = \alpha_1 + \beta_i \Pi_{i,t-1}^+ + \gamma_1 \Pi_{i,t-1}^- + \mu_1 RT_{i,t-1} + \delta_1 C_{i,t} + \theta_1 \lambda_i + \eta_{1,i,t}, \quad (4)$$

where, for each i th investor, RT_{it} is the amount of risk-taking, defined as the percentage change in the value of the holdings of risky assets (stocks, mutual funds) with respect to the holdings at the beginning of the period. $\Pi_{i,t-1}^+$ and $\Pi_{i,t-1}^-$ are prior gains and losses, respectively, as defined above.⁸ The variable that proxies for risk-taking (RT_i) is the percentage change of the investment in risky assets in the period $([t, t - 1])$ by the i th investor.

C_{it} is a vector of control variables. It contains the other factors that various theories have claimed affect the portfolio choice of the i th investor (e.g., labor income risk, level of wealth, and demographic characteristics). The vector of control variables is similar to the one used in the first stage (i.e., Equation (1)). However, some of the variables used in the first stage are not included in the second stage. This is done to provide the identification restriction of the Heckman specification.⁹

⁸ We consider gains and losses separately so as to investigate the relative importance of each of them.

⁹ These variables include the set of time and industry dummies as well as the correlations between the market portfolio and investors' sources of non-financial income (i.e., labor income, entrepreneurial income, and real estate).

In our robustness checks, we consider alternative identifying restrictions, and the results are consistent with the ones reported. The lagged dependent variable is added for robustness, and is in line with the existing empirical literature on portfolio choice (Vissing-Jørgensen, 2002). We also include control variables that account for the standard portfolio choice in the presence of risky non-financial income (i.e., correlation of financial and non-financial income, volatility and conditional value of non-financial income). Moreover, we include variables that proxy for the degree of informativeness and sophistication of the investor. These variables allow us to control for the investor's view, and to focus directly on the impact of the biases.

One possible objection to this approach is that gains/losses merely proxy for either serial correlation or momentum in the stock market or in the returns of the stocks held in the portfolio. Alternatively, they may proxy for the investor's trend-chasing behavior. To address this issue, we increase the number of control variables by including the momentum variables previously defined. We also experimented with a specification based on "unexpected" gains/losses, that is, the unpredictable components in the regression of gains/losses on past gains/losses, market and momentum variables. The results (not reported) are consistent with the reported ones.

We consider a dynamic specification in order to account for possible feedback effects from past values of the dependent variable. Given that the hedging variables, as well as the parameter, λ_{it} , have been generated on the basis of a previous estimation, we need to properly account for the bias induced by the "generated regressors". This problem is exacerbated by the existence of the lagged dependent variable. The endogeneity issues further complicate the task of finding proper instrumental variables, as only strictly exogenous variables or predetermined ones can be used. We therefore follow the standard literature (Arellano, 1990; Arellano and Bond, 1991 and Kiviet, 1995) and the previous applications to finance (Vissing-Jørgensen, 2002), and use an instrumental variable estimation with instruments based on a combination of strictly exogenous variables (i.e., demographic variables) and the lagged values of the potential endogenous variables.

Specification 4 is estimated by using two-stage least squares with a consistent variance-covariance matrix. We use data disaggregated to both the individual investor level and the household level. As the results do not differ from those based on households, we will only report the latter. The significance of the estimate of θ_1 provides a test of the null of no sample selection bias. In all the specifications, we find a high degree of significance of λ_{it} , which suggests that self-selection is indeed important in the sample.

5. Empirical Findings

The results are reported in Table III. Panel A contains the result for the full-fledged specification, while Panels B and C contain the robustness checks based on alternative specifications (without contemporaneous profits, without demographic

variables). We report the results of the specification with the Heckman correction. We will discuss the results of the fully-fledged specification (Panel A) and leave the others as robustness checks.

Three main findings are particularly worthy of discussion. First, the results strongly reject the loss aversion hypothesis, as investors react to prior positive (negative) changes in wealth by increasing (reducing) risk-taking. This holds for different classes of investors and for changes in overall wealth, as well as for financial and real estate capital gains. In particular, for the entire sample, a 1% increase in the overall wealth in the prior year increases risk-taking in the stock market by 0.26%, while a 1% reduction of wealth decreases risk-taking by 0.05%. The same holds for both gains and losses. On average, a realized gain in the prior year equal to 1% of the investor's (overall) wealth increases risk-taking in the stock market by 0.17%, while a realized loss in the prior year equal to 1% of the investor's (overall) wealth reduces risk-taking in the stock market by 0.79%.

Second, the investors who react more strongly are the high-wealth investors and the liquid ones, that is, those we define as informed. This holds regardless of the specification. In particular, high-wealth investors react more than low-wealth investors, both in the case of prior gains and prior losses (the coefficients are, respectively, 4.17 vs. 2.18 in the case of prior gains, and 5.06 vs. -0.33 in the case of prior losses) and in the case of prior changes in wealth (the coefficients are, respectively, 0.33 vs. 0.19 in the case of prior positive changes in wealth and -0.15 vs. -0.12 in the case of prior negative changes in wealth).

Analogously, liquid investors react more than illiquid investors, both in the case of prior gains and prior losses (2.82 vs. 0.97, respectively, in the case of prior gains, and -2.99 vs. -2.51, respectively, in the case of prior losses), and in the case of prior positive changes in wealth (0.34 vs. 0.27, respectively).

The third observation is the asymmetry in the reaction to positive and negative changes. In particular, liquid investors react more strongly to prior losses than to prior gains, and more strongly to prior negative changes in wealth than to prior positive changes in wealth. Low-wealth investors, on the other hand, react more strongly to prior gains than to prior losses, and more strongly to prior positive changes in wealth than to prior negative changes in wealth. The fact that liquid investors react more strongly to losses than to gains can be explained by the fact that they have a higher proportion of their wealth invested in financial assets. This makes losses very painful and the reaction stronger.

The fact that the reaction of the low-wealth investors is disproportionately stronger for gains than for losses suggests the possible presence of borrowing constraints. In fact, in the case of low-wealth investors, our measures of borrowing constraints (i.e., debt-to-wealth ratio and debt-to-total income ratio) display a significant negative correlation with the investment in risky assets. In the case of the high-wealth investors, however, borrowing constraints seem to affect only the illiquid investors, presumably the ones more exposed to mortgages, given their higher investment in real estate. The liquid investors are not affected by borrowing

Table III. Risk-taking and prior gains/losses

This table reports estimates of the determinants of risk-taking. We report the results for the overall sample, the samples of the low- and high-wealth investors, and the samples of liquid and illiquid investors. The dependent variable is the percentage change in holdings of risky assets (stocks, mutual funds) with respect to the holdings at the beginning of the period. We consider three measures of gains/losses based on overall wealth, gains/losses from financial securities and gains/losses from real estate. $\Pi_{F,t}^+$ is defined as $\text{Max}(0, -\Pi_{F,t})$, $\Pi_{F,t}^-$ is defined as $\text{Max}(0, \Pi_{F,t})$, $\Pi_{W,t}^+$ is defined as $\text{Max}(0, -\Pi_{W,t})$, $\Pi_{W,t}^-$ is defined as $\text{Max}(0, \Pi_{W,t})$ and $\Pi_{Re,t}^+$ is defined as $\text{Max}(0, -\Pi_{Re,t})$, $\Pi_{Re,t}^-$ is defined as $\text{Max}(0, \Pi_{Re,t})$. We consider six groups of control variables: *Contemporaneous Gains/Losses*, *Income Variables*, *Borrowing Constraints Variables*, *Demographic Variables*, *Geographic Variables*, *Momentum Variables*, and *Macroeconomic Variables*. The *Contemporaneous Gain/Loss* variables are the contemporaneous capital gains/losses and changes in overall wealth (i.e., $\Pi_{F,t}^+$, $\Pi_{F,t}^-$, $\Pi_{W,t}^+$, $\Pi_{W,t}^-$, $\Pi_{Re,t}^+$, $\Pi_{Re,t}^-$). Capital gains/losses include the capital gains/losses from the financial market, as well as the capital gains and losses from real estate. They are standardized by the overall level of wealth at the beginning of the period. The *Income Variables* include the mean and variance of both labor and entrepreneurial income and the correlation between them and financial and real estate income estimated using the methodology of Carroll and Samwick (1997) and Vissing-Jorgensen (2001). The *wealth variables* include the overall level of wealth of the investor and its breakdown into its components (financial and real estate wealth). The *Borrowing Constraint Variables* are the *Debt/Wealth Ratio* and the *Debt/Income Ratio*. The former proxies for the leverage of the household, and the latter for the interest payment coverage. The *Demographic Variables* include: *Secondary Education* and *Higher Education*. These are dummies that take the value 1 if the highest level of education in the household is secondary education and university or higher education, and 0 otherwise. *Ability* proxies for the individual abilities of the members of the household. The *Number of Adults* in the household and *Size of Household* are, respectively, the number of adults (18 year old and older) and the number of family members in the household. *Age* and *Age2* are, respectively, the age and square of the age of oldest member of the household. *Immigrant Status* is a dummy that takes the value 1 if at least one household member immigrated to Sweden and 0 otherwise. The *geographical variables* are a *Stockholm Dummy*, that is, a dummy that takes the value 1 if the household lives in Stockholm, and 0 otherwise, a set of eleven industry dummies and eight regional dummies. The *Macroeconomic Variables* includes an index of *Consumer Confidence* that represents the year-by-year change in the Swedish consumer confidence index (provided by Statistics Sweden). The *Momentum Variables* include the *Return* and the *Volatility of the Portfolio* of the investor in the previous 12 months and the *Return on the Market* in the previous 12 months. For the specification based on the overall sample, we include a dummy that takes the value 1 if the investor is high-wealth and 0 otherwise. Their coefficients are not reported. We also include λ , ("Heckman lambda"), i.e., the variables that control for the selection bias, and the lagged dependent variable. Panel A reports the result for "full" specification. Panel B reports the specification without contemporaneous profits. Panel C reports the specification without demographic variables. We report the results for estimates performed on the sample of participants with Heckman correction. Estimates were performed using 2SLS with robust variance-covariance matrix. The *t*-statistics are reported in parentheses.

Panel A											
Variables	Total sample		Low-wealth		High-wealth		Liquid		Illiquid		
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	
Intercept	0.120	(2.62)	-0.478	(-7.02)	-0.547	(-2.15)	0.331	(1.44)	0.058	(0.11)	
$\Pi_{W,t-1}^+$	0.261	(3.16)	0.187	(11.44)	0.330	(6.47)	0.343	(7.62)	0.266	(2.37)	
$\Pi_{W,t-1}^-$	-0.051	(-2.16)	-0.123	(-3.67)	-0.152	(-2.26)	-0.532	(-2.91)	-0.003	(-0.01)	
$\Pi_{F,t-1}^+$	0.174	(2.76)	2.179	(24.49)	4.169	(10.00)	2.817	(7.95)	0.972	(0.86)	
$\Pi_{F,t-1}^-$	-0.791	(-1.99)	-0.332	(-2.58)	-5.065	(-2.64)	-2.992	(-2.25)	-2.508	(-1.49)	
$\Pi_{Re,t-1}^+$	0.312	(7.48)	0.490	(7.36)	0.905	(5.36)	0.823	(5.15)	1.216	(4.12)	
$\Pi_{Re,t-1}^-$	-0.179	(-2.63)	-1.704	(-11.50)	-11.008	(-8.27)	-5.434	(-4.18)	0.543	(0.22)	
Control variables											
Contemp. Gains/Losses Variabl.	yes		yes		yes		yes		yes		
Income and Wealth Variables	yes		yes		yes		yes		yes		
Borrowing Constraint Variables	yes		yes		yes		yes		yes		
Demographic Variables	yes		yes		yes		yes		yes		
Geographic Variables	yes		yes		yes		yes		yes		
Momentum Variables	yes		yes		yes		yes		yes		
Macro-economic Variables	yes		yes		yes		yes		yes		
λ	-0.129	(-17.71)	-0.138	(-3.30)	-0.183	(-4.38)	0.055	(3.29)	-0.349	(-5.32)	
Adjusted R^2	0.05		0.05		0.04		0.04		0.04		
Number of Observations	110,399		76,899		35,000		19,314		7,093		

Table III. Risk-taking and prior gains/losses (continued)

Panel B											
Variables	Total Sample		Low-wealth		High-wealth		Liquid		Illiquid		
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	
Intercept	0.260	(25.97)	0.189	(11.74)	0.710	(22.98)	0.546	(16.65)	0.612	(10.14)	
$\Pi_{W,t-1}^+$	0.056	(2.33)	0.402	(11.06)	0.404	(9.07)	0.344	(7.95)	0.283	(2.63)	
$\Pi_{W,t-1}^-$	-0.006	(-2.55)	-0.128	(-10.22)	-0.179	(-2.51)	-0.506	(-2.85)	-0.145	(-0.55)	
$\Pi_{F,t-1}^+$	0.428	(32.47)	1.629	(75.50)	3.024	(5.19)	1.950	(3.15)	0.881	(7.95)	
$\Pi_{F,t-1}^-$	-0.186	(-8.31)	-0.806	(-22.79)	-2.314	(-20.22)	-1.822	(-16.07)	7.761	(26.96)	
$\Pi_{Re,t-1}^+$	0.175	(2.78)	2.418	(24.92)	3.960	(10.79)	2.670	(7.75)	1.151	(1.05)	
$\Pi_{Re,t-1}^-$	-0.822	(-2.00)	5.287	(1.45)	-2.651	(-1.97)	-2.789	(-2.20)	-16.886	(-1.16)	
Control variables											
Contemp. gains/Losses variabl.											
Income variables	yes		yes		yes		yes		yes		
Borr. constraint variables	yes		yes		yes		yes		yes		
Demographic variables	no		no		no		no		no		
Geographic variables	yes		yes		yes		yes		yes		
Momentum variables	yes		yes		yes		yes		yes		
Macro-economic variables	yes		yes		yes		yes		yes		
λ	-0.133	(-19.46)	-0.085	(-7.81)	-0.164	(-4.66)	0.014	(3.36)	-0.357	(-5.76)	
Adjusted R^2	0.05		0.05		0.04		0.04		0.04		
Number of observations	110,399		76,899		35,000		19,314		7,093		

Table III. Risk-taking and prior gains/losses (continued)

Panel C											
Variables	Total Sample		Low-wealth		High-wealth		Liquid		Illiquid		
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	
Intercept	0.312	(6.84)	-0.107	(-2.30)	-0.110	(-0.71)	0.106	(0.61)	-0.203	(-0.50)	
$\Pi_{W,t-1}^+$	0.214	(9.19)	0.183	(8.23)	0.418	(13.48)	0.371	(10.94)	0.497	(5.86)	
$\Pi_{W,t-1}^-$	-0.031	(-2.91)	-0.045	(-4.03)	-0.152	(-2.88)	-0.493	(-3.59)	-0.298	(-1.44)	
$\Pi_{F,t-1}^+$	0.225	(3.61)	0.160	(2.67)	0.566	(2.24)	0.710	(2.66)	0.428	(0.50)	
$\Pi_{F,t-1}^-$	-0.544	(-2.64)	-0.415	(-2.10)	-2.695	(-2.85)	-2.557	(-1.41)	-2.292	(-2.00)	
$\Pi_{Re,t-1}^+$	0.333	(8.05)	0.312	(6.93)	0.376	(3.68)	0.350	(2.92)	0.402	(1.82)	
$\Pi_{Re,t-1}^-$	-0.051	(-0.46)	-0.011	(-0.11)	0.723	(0.90)	0.920	(0.95)	-0.424	(-0.24)	
Control variables											
Contemp. gains/Losses variabl.	no		no		no		no		no		
Income variables	yes		yes		yes		yes		yes		
Borr. constraint variables	yes		yes		yes		yes		yes		
Demographic variables	yes		yes		yes		yes		yes		
Geographic variables	yes		yes		yes		yes		yes		
Momentum variables	yes		yes		yes		yes		yes		
Macro-economic variables	yes		yes		yes		yes		yes		
λ	-0.169	(-23.37)	-0.103	(-14.18)	-0.161	(-6.46)	-0.138	(-4.42)	-0.272	(-5.62)	
Adjusted R^2	0.04		0.04		0.04		0.04		0.04		
Number of Observations	110,399		76,899		35,000		19,314		7,093		

constraints. Interestingly, the illiquid investors do not seem to be affected by either financial gains or financial losses. Most of their wealth is invested in real estate, and this may explain this weaker reaction. In the case of the liquid investors, however, the reaction to financial gains and losses is stronger and almost identical (i.e., the coefficients are 2.81 in the case of gains, and 2.99 in the case of losses).

Finally, if we consider the separate effect of the different sources of wealth, we see that both financial gains/losses and real estate gains/losses affect overall risk-taking in the stock market. On average, a realized real estate gain in the prior year, equal to 1% of the investor's (overall) wealth, increases risk-taking in the stock market by 0.31%, while a realized real estate loss in the prior year, equal to 1% of the investor's (overall) wealth, reduces risk-taking in the stock market by 0.18%. At a disaggregated level, this holds for both high-wealth and low-wealth investors.¹⁰ For all classes, the reaction to gains is not as strong as the reaction to losses, with the exception of the illiquid investors. In particular, the reaction to prior real estate gains ranges between 1.7% and 11.5%, while the reaction to prior real estate losses ranges between 0.49% and 0.90%. The results hold after controlling for other wealth and income effects as well as momentum. In other words, they are not due to momentum trading behavior or to spurious correlation with portfolio or stock market appreciation.

6. Discussion

How do we interpret these results? Behavioral theory argues that prior gains and prior losses affect behavior differently. The standard behavioral workhorse is the loss aversion theory. This theory hypothesizes that prior losses increase risk-taking, while prior gains reduce it. This induces investors to gamble and “to seek risk when faced with possible losses, and to avoid risk when a certain gain is possible” (Tversky and Kahneman, 1979; Benartzi and Thaler, 1995). Loss aversion is based on the psychological principle that a decline in utility arising out of the realization of losses relative to gains encourages investors to sell winning stocks rather than losing stocks. Empirical evidence of this, in the form of the disposition effect, has been found by Odean (1998), and Barber and Odean (2000), who have shown that investors tend to hold on to the losers and sell the winners.

The alternatives to this theory are either the house money effect or standard utility theory. The house money effect suggests that prior gains, by providing investors with a “cushion” that makes future losses less painful, in fact increase risk-taking. In particular, Thaler and Johnson (1990) show that “while a prior gain can increase subjects’ willingness to accept gambles, . . . , prior losses sensitize people to subsequent losses of similar magnitude”. Barberis et al. (2001) use this behavioral finding to explain the size of the equity premium and patterns in stock volatility. They argue that “previous capital gains reduce investors’ sensitivity to

¹⁰ This effect on risk-taking in financial markets is consistent with the real estate wealth effect (Shiller et al., 2001).

risk, . . . , while previous losses, by making any new loss more painful, increase risk aversion.”

Standard utility theory, in the case of utility characterized by constant relative risk aversion, predicts no changes in exposure to equity (keeping total wealth constant) as a function of real estate capital gains/losses (assuming that real estate is an asset class separate from equity). Decreasing risk aversion, on the other hand, posits that previous losses, by reducing wealth, increase risk aversion, while previous gains, by increasing wealth, reduce risk aversion.¹¹

Consequently, both the house money effect and standard utility theory, in the presence of decreasing risk aversion, represent our alternative to loss aversion. Loss aversion postulates a positive (negative) correlation between risk-taking and prior losses (gains). The house money effect (or standard utility theory), on the other hand, postulates a negative (positive) correlation between risk-taking and prior losses (gains). That is, we expect investors to react to prior losses (gains) by taking more (less) risk in the case of loss aversion and by taking less (more) risk in the case of the house money effect.

The data clearly reject loss aversion. This appears to run contrary to previous findings documenting the disposition effect (i.e., prospect theory) on transaction data (Odean, 1998 and Barber and Odean, 1999). However, these results are based on a much higher frequency of observation. Indeed, as Jackson (2002) shows for Australian data, the disposition effect fades after approximately 200 days. This suggests that loss aversion is perhaps a better predictor of short-term behavior, while the house money effect (or standard utility theory) applies mostly to long-term behavior.

The data support the house money effect to the extent that changes in financial wealth predict subsequent increases in investment in equity and mutual funds. However, the house money effect does not anticipate the effects that are documented across asset classes: a decrease in real estate wealth, for instance, leads to a decrease in investment in equity and mutual funds.

Standard expected utility theory, with constant relative risk aversion, predicts the observed patterns across asset classes. However, constant relative risk aversion does not predict a change in exposure to equity (keeping total wealth constant) as a function of real estate capital gains/losses.¹² In contrast, decreasing constant relative risk aversion is most consistent with our results, predicting that increases in financial wealth lead to higher equity and mutual fund exposure.

¹¹ Empirically, there is little evidence in favor of decreasing relative risk aversion. The evidence indicates increasing or constant risk aversion. For example, Guiso et al. (2002) find increasing risk aversion using survey data on hypothetical gambles. So do studies using farm data.

¹² The only way to square these results with constant relative risk aversion is when the expected returns are persistent. That is, equity returns continue to be favorable (less favorable) after a period of financial gains (losses), and equity returns become favorable (less favorable) after real estate gains (losses). Unfortunately, this has not been the case in Sweden.

It is important to stress that the data indirectly reveal substantial heterogeneity in the investment experiences of Swedish investors. This heterogeneity is, in general, absent in standard models of intertemporal asset pricing based on complete markets (Judd et al., 2003). Our findings provide a first set of results generated in a unified framework in which alternatives are simultaneously entertained. By using field data. Indeed, while experimental literature has provided ample evidence of the conditions under which loss aversion and the house money effect take place (Shefrin and Statman, 1985; Tversky and Kahneman, 1979; Weber and Camerer, 1998), these alternative theories have never been jointly tested by using the field data. Given that the implications of these theories are often very highly correlated, separate partial tests may fail to provide proper identification that avoids spurious correlation. Our findings provide a first step in this direction.

7. Conclusion

We focus on the determinants of portfolio choice by directly examining investor reactions to different definitions of gains and losses (i.e., overall wealth, paper gains and losses, and realized capital gains and losses) and investigating how gains and losses in a category of wealth (e.g., real estate) affect changes in holdings in other categories (e.g., financial assets). We provide evidence to show that previous gains increase investor risk-taking, while previous losses reduce it. In view of our findings, we argue that investors do not react to prior gains/losses as postulated by loss aversion, but that their behavior is more in line with standard utility theory with decreasing risk aversion. Also, investors consider wealth in its entirety and risk-taking in financial markets is affected by gains/losses in overall wealth, financial wealth and real estate wealth.

Appendix: Construction of Income-related Variables

In this section, we briefly describe the methodology we follow to construct proxies for permanent non-financial income, its volatility and its correlation to financial and real estate income. We follow the approach of Carroll and Samwick (1997) and Vissing-Jørgensen (2002). We consider labor income and entrepreneurial income as non-financial income. In particular, we define the relevant moments of long-term investors' non-financial income:

$$E(\omega_{it} \mid \omega_{it-1}, X_{it-1}), \text{Var}(\omega_{it} \mid \omega_{it-1}, X_{it-1}) \text{ and } \rho_{it},$$

where ω_{it} is the non-financial income of investor i at time t , X_{it-1} are the variables that can be used to predict income next period, and ρ_{it} is the conditional correlation between shocks to log non-financial income and the log stock return. We assume that non-financial income follows:

$$\ln \omega_{it} = p_{it} + \varepsilon_{it},$$

where

$$p_{it} = g_{it} + p_{it-1} + \eta_{it}, \varepsilon_{it} \sim N(0, \sigma_{\varepsilon_t}^2), \eta_{it} \sim N(0, \sigma_{\eta_t}^2),$$

and

$$\text{cov}(\varepsilon_{it}, \varepsilon_{is}) = 0, \text{cov}(\eta_{it}, \eta_{is}) = 0, \text{cov}(\varepsilon_{it}, \eta_{is}) = 0 \text{ for each } t, s.$$

The variable p_{it} represents the permanent income component of non-financial income. It has a drift term (g_{it}) that is known and based on the information available at $t - 1$. This allows us to write:

$$\ln \omega_{it} - \ln \omega_{it-1} = p_{it} - p_{it-1} + \varepsilon_{it} - \varepsilon_{it-1} = g_{it} + \varepsilon_{it} - \varepsilon_{it-1} + \eta_{it},$$

or

$$\ln \omega_{it} - \ln \omega_{it-1} = g_{it} + \eta_{it} + \varepsilon_{it} - \varepsilon_{it-1}.$$

This implies:

$$E(\omega_{it} \mid \omega_{it-1}, X_{it-1}) = \ln \omega_{it-1} + g_{it} = \omega_{i,t-1} G_{it} \exp\{J_{it}/2\}$$

$$\text{Var}(\omega_{it} \mid \omega_{it-1}, X_{it-1}) = (\omega_{i,t-1} G_{it})^2 \exp(J_{it}) \{\exp(J_{it}) - 1\},$$

where

$$G_{it} = \exp(g_{it}), J_{it} = \sigma_{\eta_t}^2 + 2\sigma_{\varepsilon_t}^2 s$$

and $X_{i,t-1}$ is the set of variables used to predict g_{it} . In order to estimate $E(\omega_{it} \mid \omega_{it-1}, X_{it-1})$ and $\text{Var}(\omega_{it} \mid \omega_{it-1}, X_{it-1})$, we use data for the period 1990–2000, with a 5-year rolling window, based on the previous 5 years of data. Following Carroll and Samwick (1997) and Vissing-Jørgensen (2002) methodology, we regress $\ln \omega_{it} - \ln \omega_{it-1}$ on the set of explanatory variables $X_{i,t-1}$ and use the predicted values of such a regression as an estimate of g_{it} , and the residuals as an estimate of $\eta_{it} + \varepsilon_{it} - \varepsilon_{it-1}$. The correlation between financial and non-financial income (ρ_{it}) is constructed as the conditional correlation between shocks to log non-financial income ($\eta_{it} + \varepsilon_{it} - \varepsilon_{it-1}$) and the log gross stock returns (i.e., $\ln(1 + R_t)$). We use rolling five-year windows to estimate the parameters.

The set of variables contained in $X_{i,t-1}$ are: demographic variables (secondary education, higher education, age, age squared, marital status, size of the household, number of adults belonging to the household), changes in the demographic variables, industry dummies for the company the investor works for (e.g., oil industry), dummies for the investor's occupation/profession (e.g., doctor), and immigrant status. Following Vissing-Jørgensen (2002a), given the potential inaccuracy of

estimates based on few observations, we calculate the correlation over the entire sample.

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