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Individual investor perceptions and behavior during the financial crisis

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ABSTRACT

Combining monthly survey data with matching trading records, we examine how individual investor perceptions change and drive trading and risk-taking behavior during the 2008–2009 financial crisis. We find that investor perceptions fluctuate significantly during the crisis, with risk tolerance and risk perceptions being less volatile than return expectations. During the worst months of the crisis, investors' return expectations and risk tolerance decrease, while their risk perceptions increase. Towards the end of the crisis, investor perceptions recover. We document substantial swings in trading and risk-taking behavior that are driven by changes in investor perceptions. Overall, individual investors continue to trade actively and do not de-risk their investment portfolios during the crisis.

1. Introduction

An extensive literature examines the causes and consequences of the 2008–2009 financial crisis for housing and securitization markets, financial institutions, corporate investment decisions, household welfare, bank lending, financial contagion, financial regulation, as well as institutional investors.[1] Less is known, however, about the impact of the crisis on individual investors' perceptions and behavior. It is important to also study the experiences of this group of investors, as their behavior can affect asset prices (Lee et al., 1991; Hirshleifer, 2001; Kumar and Lee, 2006; Kogan et al., 2006), return volatility (Foucault et al., 2011), and even the macroeconomy (Korniotis and Kumar, 2011a). Moreover, the economic significance of individual investors' stock-market participation rises because of an increasing self-responsibility for building up retirement wealth.

To examine how individual investors' perceptions as well as their behavior changes during the crisis, we use a panel-data set which combines monthly survey data with matching brokerage records. For each month between April 2008 and March 2009, we measure individual investors' perceptions in a survey on their expectations for stock-market returns, their risk tolerance, and their risk perceptions.[2] In addition, we collect information on these investors' trading and risk-taking behavior through their brokerage records. The sample period includes, on the one hand, the months when worldwide stock markets were hit hardest, that is, September and October 2008. During these months, in the US, Lehman Brothers collapsed and AIG was bailed out, and in Europe, parts of ABN AMRO and Fortis were nationalized. On the other hand, stock markets were still relatively calm at

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[1] See, for example, Demyanyk and Van Hemert (2011) (housing and securitization markets), Maddaloni and Peydró (2011) and Brunetti et al. (2011) (financial institutions), Campello et al. (2011) (corporate investment decisions), Bricker et al. (2011) (household welfare), Santos (2011) and Ivashina and Scharfstein (2010) (bank lending), Longstaff (2010), Aloui et al. (2011), and Baur (2012) (financial contagion), Jin et al. (2011) and Moshirian (2011) (financial regulation), and Ben-David et al. (2012) (institutional investors).

[2] Whenever we do not specifically refer to return expectations, risk tolerance, or risk perceptions, the term "perceptions" is used to refer to these survey variables in a general way to set them apart from the brokerage data.

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the beginning of the sample period (April 2008), while at the end of the sample period, stock markets already began to recover (March 2009). As such, the available data provide a relatively complete coverage of the crisis's impact on the stock markets.

The brokerage records at hand show that individual investors were hit hard by the financial crisis: several months of double-digit negative stock-market returns almost halved their portfolio values within the sample period. According to conventional wisdom (Steverman, 2009; Shell, 2010) as well as expectations from prior literature (Malmendier and Nagel, 2011), this dramatic shock to investor wealth, combined with this market period's uncertainty and volatility, could permanently shift investor perceptions of the stock market as well as of their personal investments. In particular, the financial crisis could be expected to make individual investors aware of the true risk of investing in stocks, decreasing their return expectations and risk tolerance, increasing their risk perceptions, and leading them to de-risk their investment portfolios.

Our results, however, challenge these predictions: although the financial crisis temporarily decreases individual investors' return expectations and risk tolerance, and increases their risk perceptions, these variables quickly recover. Furthermore, investors continue to trade and do not de-risk their investment portfolios during the crisis. Investors also do not try to reduce risk by shifting from risky investments to cash. Instead, investors use the depressed asset prices as a chance to enter the stock market.

The remainder of this paper is organized as follows. In Section 2 we present related literature and develop the hypotheses. In Section 3 we introduce the data. In Section 4 we set out the results. In Section 5 we present robustness checks and evaluate alternative explanations. In Section 6 we conclude.

2. Literature and hypotheses

In this section we develop hypotheses about the expected changes in investor perceptions and behavior during the financial crisis. Recent research shows a persistent effect of investor psychology on trading and risk-taking behavior (Barber and Odean, 2001; Bailey et al., 2011). A key finding from such studies is that individual investors have difficulty learning from their experiences, and if they learn, this is a slow process (Gervais and Odean, 2001; Seru et al., 2010). Moreover, individual investors often fail to update their behavior to match their experiences and are relatively unaware of their return performance (Glaser and Weber, 2007). Thus, it seems that at least during tranquil times, investors' experiences have little or no impact on their perceptions and behaviors.

Extreme events such as the 2008–2009 financial crisis, however, may have a strong impact on individual investors because of their salience (Kahneman and Tversky, 1972). Malmendier and Nagel (2011), for example, suggest that dramatic experiences, such as the Great Depression of the 1930s, can have a permanent impact on investors' perceptions and risk-taking behavior. Thaler and Johnson (1990) as well as Barberis (2013) find that experiencing a number of consecutive losses reduces investors' subsequent willingness to take risks. As the financial crisis combines an unexpected and negative shock to investors' wealth as well as their returns with an uncertain and volatile market environment, we hypothesize that:

H_1. The financial crisis depresses individual investors' perceptions. That is, their return expectations and risk tolerance decrease, while their risk perceptions increase

H_2. The financial crisis makes investors aware of a higher than expected investment risk. In response, individual investors reduce their portfolio risk

During the financial crisis, investors are exposed to an unusually high volume of dramatic and unexpected news (Dzielinski, 2011). Receiving (too) much information can result in information overload (Lam et al., 2011), which stimulates status-quo bias, thus potentially reducing individual investors' trading activity during the crisis (cf. Agnew and Szykman, 2005). Alternatively, however, the large amount of information investors receive during a crisis may induce frequent changes in their perceptions, as well as a larger divergence of such perceptions (disagreement amongst various investors). Glaser and Weber (2005), for example, find an increase in the standard deviation of individual investors' return and volatility forecasts directly after September 11 and the subsequent stock-market turmoil. Changes in and divergence of perceptions are both expected to lead to higher trading activity: the first effect provides more reasons to trade, the second effect makes it more likely to find a trading counterpart (cf. Harris and Raviv, 1993; Banerjee, 2011). Based on the prior discussion, we develop two mutually exclusive hypotheses:

H_{3a}. The frequent arrival of information during the financial crisis leads to information overload. As a result, individual investors reduce their trading activity

H_{3b}. The frequent arrival of information during the financial crisis changes investor perceptions and creates a larger divergence in their perceptions. As such, having more reasons as well as opportunities to trade increases individual investors' trading activity

3. Data

To test the hypotheses, we combine brokerage records of 1510 clients of the largest discount broker of the Netherlands with matching monthly questionnaire data that we collected for these investors from April 2008 through March 2009. The investors do not receive investment advice and manage their own accounts, which ensures that the observed trading patterns, as well as survey responses, reflect their own decision making and opinions. An additional advantage of discount-brokerage data is that this is the dominant channel through which both US and Dutch individuals invest (Barber and Odean, 2000; Bauer et al., 2009). As in Bauer et al. (2009), we exclude accounts of minors (age < 18 years) and those with an average end-of-month portfolio value (in the sample period) of less than €250. Furthermore, to exclude professional traders, we discard accounts in the top 1% of annual trading volume, number of transactions, or turnover distributions. Imposing these criteria leaves 1376 individual accounts for analysis.

3.1. Brokerage records

Brokerage records are available for investors who completed at least one survey during the sample period. A record consists of an identification number, a transaction date and time, a buy/sell indicator, the type of asset traded, the gross transaction value, and transaction commissions. The records also contain information on investors' daily account balances, demographics such as age and gender, and their 6-digit postal code. Based on this postal code, which is unique to each street (or even parts of a street) in the Netherlands, and data from Statistics Netherlands, we assign income and residential house value to each investor.[3] Table 1 defines all variables. Table 2 shows descriptive statistics.

[3] Home ownership rates are high in the Netherlands (67.5%, as of 2008 (Eurostat, 2011)), as well as skewed towards wealthier households (Rouwendal, 2007). Thus, it is likely that the assigned house values correspond closely to the value of the houses actually owned by the investors in the sample.

Table 1
Variable definitions.

Variable	Definition
Gender	Indicator variable taking the value 0 for male investors and 1 for female investors
Age	Age of the investor in years as of April 2008
Account tenure	Account tenure of the investor in years as of April 2008
Income	Annual disposable income in 2007 (= gross income minus taxes, social security contributions, health insurance premiums paid) per person receiving income. Assigned to each investor based on their 6-digit postal code (= average net income per postal code from Statistics Netherlands). This postal code is unique for each street in the Netherlands
Portfolio value	Value of investment assets in an investor's account at the end of the month
House value	Value of house in 2008. Assigned to each investor based on their 6-digit postal code. This postal code is unique for each street in the Netherlands. Data source is the average residential house value per 6-digit postal code from Statistics Netherlands
Derivatives	Indicator variable taking the value 1 if an investor traded an option or futures contract at least once during the sample period or 0 otherwise
Traded	Indicator variable taking the value 1 if an investor traded in a particular month or 0 otherwise
Trades	Number of all executed transactions in a particular month
Volume	Sum of the absolute values of all purchases and sales in a particular month
Turnover	Average of the absolute values of all purchases and sales in a particular month divided by the average of the portfolio values at the beginning and end of a particular month
Dividend choice stock	Indicator variable taking the value 1 if the investor's preferred way to receive dividend is stock dividend or 0 in case of a preference for cash dividend
Dividend choice Cash and Stock	Indicator variable taking the value 1 if the investor's preferred way to receive dividend is stock dividend for one of her subaccounts and cash for another subaccount or 0 in case of a preference for cash dividend for all her subaccounts
Buy–sell ratio	Difference between volume buy and volume sell, divided by volume. For investors with no trades in a particular month, this ratio is set to zero (such investors mimic an investor with equal buy and sell volume)
Return	Monthly investor return given by the product of the daily relative changes in the value of her portfolio after transaction costs and portfolio in- and outflows
Portfolio volatility	Investor realized monthly portfolio volatility calculated based on the daily returns on investor portfolios
Account volatility	Investor realized monthly account volatility calculated based on the daily returns on investor account values (= portfolio value + cash)
Sharpe Ratio	Monthly return divided by portfolio volatility (in monthly terms)
Alpha	One-factor alpha (Jensen's alpha) in a particular month (in monthly terms)
Return expectation	Reflects how optimistic a respondent is about her investment portfolio and its returns in the upcoming month (see Table 3)
Risk tolerance	Reflects a respondent's general predisposition toward financial risk (see Table 3)
Risk perception	Reflects a respondent's interpretation of how risky the stock market will be in the upcoming month (see Table 3)

Notes: Because of data availability, the data retrieved from Statistics Netherlands refer to different years. That is, to 2007 for the income data, and to 2008 for the house value data.

A comparison with samples used in other studies of individual investor behavior in the United States (Barber and Odean, 2000) and the Netherlands (Bauer et al., 2009) shows that the sample is similar with regard to key characteristics such as investors' portfolio sizes, age, and gender. Comparing the average account value of the surveyed investors to the average account value of €50,000–60,000 for Dutch individual investors in general (Bauer et al., 2009) suggests that the average investor in our sample invests more than three-fourths of her total self-managed portfolio with this broker. Over 40% of survey respondents hold an account only with this particular broker. Of the respondents who also have accounts with other brokers, more than 50% indicate that the other account(s) comprise(s) less than half their total investment portfolio. Together with the reasons outlined above, the sample of investors that is available to us seems sufficiently representative to justify extrapolating our results to the broader population of self-directed individual investors. As there is no capital gains tax under the Dutch tax system, the data and results are not affected by tax-loss selling motivated trading.

3.2. Survey data

At the end of each month between April 2008 and March 2009, a panel of the broker's clients received an email with a link to an online survey. To develop the panel, we sent an email invitation to 20,000 randomly selected clients in March 2008. Six months later, a re-invitation was sent to all initially invited clients to maintain a sufficient response rate. The initial response rate of 4.28% (April 2008) is comparable to that of other large-scale surveys (cf. Dorn and Sengmueller, 2009). Including respondents who joined the panel after April 2008, 1510 clients answered at least one questionnaire, with an average of 539 clients answering each month, and a minimum of 296. Regarding willingness to respond regularly, 319 (43) clients responded at least 6 (12) consecutive times (see the monthly response numbers in Table 2, Panel B).

A possible concern with samples of investors such as used in this study is that monthly variation of non-response might not be random. For example, trading activity or investment success could be related to the likelihood to respond. Differences in the timing of survey responses might also affect the results. That is, because of intermediate changes in stock-market returns and volatility, the return expectations, risk tolerance, and risk perceptions of early vs. late respondents might differ and lead to behavioral differences. Based on robustness checks in Sections 5.1 and 5.2 we show that the sample is not subject to non-random response behavior problems and we demonstrate that the results are unaffected by the timing of responses.

The survey elicited information on investors' expectations of stock-market returns, risk tolerance, and risk perceptions for each upcoming month (see Table 3). Following recent work (Kapteyn and Teppa, 2011), we use qualitative measures for these variables, as these tend to have a higher explanatory power for individuals' behavior than more complex quantitative measures, which are often misunderstood by respondents. To ensure a valid measurement, we use tested scales which are well-established in the psychometric literature (Nunnally and Bernstein, 1994).[4] Return expectations reflect the extent to which a respondent is optimistic about her investment returns and are measured similar as in Weber et al. (forthcoming). Risk tolerance reflects a respondent's predisposition toward financial risk (like or dislike of risky situations) and is measured as in Pennings and Smidts (2000). Risk perception reflects a respondent's interpretation of the riskiness of the stock market and is measured according to Pennings and Wansink (2004). The type of

[4] A "scale" represents a set of items (i.e., survey questions) that together measure a particular variable (e.g., return expectations).

Table 2
Descriptive statistics.

Month		April-08	May-08	June-08	July-08	August-08	September-08	October-08	November-08	December-08	January-09	February-09	March-09
Panel A: all brokerage accounts													
Investors	*N*	1376	1376	1376	1376	1376	1376	1376	1376	1376	1376	1376	1376
Gender	Mean	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Age	Mean	50.56	50.56	50.56	50.56	50.56	50.56	50.56	50.56	50.56	50.56	50.56	50.56
Age	Std	13.57	13.57	13.57	13.57	13.57	13.57	13.57	13.57	13.57	13.57	13.57	13.57
Account tenure	Mean	4.07	4.07	4.07	4.07	4.07	4.07	4.07	4.07	4.07	4.07	4.07	4.07
Account tenure	Std	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77
Income €	Mean	20,242	20,242	20,242	20,242	20,242	20,242	20,242	20,242	20,242	20,242	20,242	20,242
Income €	Std	4314	4314	4314	4314	4314	4314	4314	4314	4314	4314	4314	4314
Portfolio value €	Mean	52,854	52,695	44,872	42,840	45,963	37,688	31,127	30,100	30,679	29,564	26,514	27,875
Portfolio value €	Std	156,058	156,096	134,883	127,338	135,203	117,935	101,325	104,663	105,279	99,322	91,598	92,307
House value €	Mean	278,982	278,982	278,982	278,982	278,982	278,982	278,982	278,982	278,982	278,982	278,982	278,982
House value €	Std	112,278	112,278	112,278	112,278	112,278	112,278	112,278	112,278	112,278	112,278	112,278	112,278
Fraction derivatives		0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
Fraction traded		0.46	0.47	0.48	0.47	0.41	0.51	0.63	0.42	0.37	0.41	0.40	0.42
Trades (Traders)	Mean	8.57	7.54	7.71	9.24	7.16	8.72	10.60	8.83	7.81	9.64	8.87	10.13
Trades (Traders)	Std	11.38	11.15	12.44	16.75	10.63	13.06	16.65	13.10	12.04	14.66	14.86	17.75
Volume € (Traders)	Mean	48,067	30,260	33,038	36,312	30,861	41,439	51,042	31,225	22,919	28,506	26,003	29,593
Volume € (Traders)	Std	202,150	70,839	95,236	113,827	98,506	147,420	275,317	107,946	63,888	78,723	77,374	97,800
Turnover (Traders)	Mean	0.55	0.46	0.42	0.60	0.46	0.62	0.99	0.73	0.61	0.80	0.67	0.78
Turnover (Traders)	Std	1.53	1.22	1.12	1.85	1.41	1.87	3.63	1.82	1.82	2.77	2.49	2.46
Panel B: survey respondents													
Investors	*N*	787	701	605	557	520	491	650	402	330	312	272	291
Gender	Mean	0.07	0.08	0.08	0.08	0.08	0.08	0.09	0.08	0.08	0.08	0.09	0.09
Age	Mean	50.55	51.22	51.50	51.83	52.79	52.60	51.50	52.31	52.65	52.64	53.83	53.25
Age	Std	13.51	13.55	13.43	13.57	12.90	13.05	13.29	13.25	12.88	12.86	12.62	12.67
Account tenure	Mean	3.93	3.98	4.09	3.98	4.11	4.08	4.26	4.35	4.34	4.45	4.53	4.38
Account tenure	Std	2.76	2.79	2.77	2.78	2.77	2.76	2.78	2.73	2.75	2.74	2.68	2.71
Income €	Mean	20,181	20,088	20,109	19,978	20,085	20,002	20,147	19,892	19,859	20,046	20,034	20,028
Income €	Std	4285	3956	4240	3729	3835	4153	4197	3808	3543	3897	3844	3860
Portfolio value €	Mean	54,446	54,264	45,411	45,509	49,557	39,707	29,490	33,660	30,169	30,693	27,444	27,229
Portfolio value €	Std	143,872	144,617	128,455	128,159	124,176	105,507	100,216	118,529	66,600	66,198	53,089	55,039
House value €	Mean	276,690	272,969	272,038	273,559	274,221	274,736	277,543	272,429	272,020	273,443	277,193	273,037
House value €	Std	110,125	102,015	109,290	101,943	101,006	110,771	112,864	104,787	98,530	99,506	108,672	100,576
Fraction Derivatives		0.41	0.42	0.43	0.42	0.44	0.44	0.37	0.38	0.41	0.45	0.41	0.41
Fraction traded		0.52	0.54	0.55	0.52	0.46	0.54	0.64	0.46	0.42	0.48	0.49	0.45
Trades (Traders)	Mean	9.23	7.08	7.94	8.40	6.68	8.54	10.79	8.66	7.23	10.20	10.08	9.72
Trades (Traders)	Std	12.26	10.79	11.90	12.57	9.58	13.76	18.50	12.51	10.33	16.10	16.88	13.97
Volume € (Traders)	Mean	56,262	24,814	31,821	27,447	22,637	28,375	55,642	30,555	22,986	35,797	31,304	27,663
Volume € (Traders)	Std	242,164	53,239	80,947	65,300	48,199	65,511	359,009	87,480	69,731	93,522	84,222	73,659
Turnover (Traders)	Mean	0.65	0.43	0.49	0.57	0.36	0.50	1.10	0.86	0.47	0.56	0.70	1.00
Turnover (Traders)	Std	1.82	1.13	1.41	1.61	0.91	1.08	4.68	2.23	1.51	1.07	2.08	3.91
Return expectation	Mean	4.35	4.22	3.68	3.93	4.27	3.53	3.41	3.73	3.93	4.13	3.61	4.36
Return expectation	Std	0.93	0.90	0.96	1.00	0.96	0.99	1.01	1.05	0.89	1.09	1.15	1.03
Risk tolerance	Mean	4.03	4.02	3.64	3.90	4.08	3.71	3.85	3.97	4.03	3.95	3.98	4.04
Risk tolerance	Std	1.15	1.13	1.26	1.19	1.12	1.28	1.28	1.23	1.14	1.15	1.28	1.13
Risk	Mean	4.47	4.46	5.02	4.19	3.93	4.49	4.31	4.34	4.12	4.13	4.50	4.25

(*continued on next page*)

Table 2 (*continued*)

Month		April-08	May-08	June-08	July-08	August-08	September-08	October-08	November-08	December-08	January-09	February-09	March-09
perception													
Risk perception	Std	1.66	1.64	1.96	1.14	1.11	1.15	1.31	1.28	1.21	1.21	1.35	1.20

Notes: This table presents monthly summary statistics for the brokerage account data. Panel A refers to all investors for whom brokerage records are available. This sample includes investors who participated at least once during the entire sample period in the survey and who were not excluded by the sample-selection restrictions as defined in Section 3. The monthly summary statistics presented in Panel B refer to the subset of investors who responded to the survey in each respective month. Variables are defined in Table 1.

Table 3
Survey questions.

Survey variable	Answer categories
Return expectation (1 = low/pessimistic, 7 = high/optimistic)	
Next month, I expect my investments to do less well than desired.	1 (totally agree)–7 (totally disagree)
For the next month, I have a positive feeling about my financial future[a]	1 (totally agree)–7 (totally disagree)
Next month, my investments will have a worse performance than those of most other investors	1 (totally agree)–7 (totally disagree)
Next month, it is unlikely that my investment behavior will lead to positive returns	1 (totally agree)–7 (totally disagree)
For the next month, the future of my investment portfolio looks good[a]	1 (totally agree)–7 (totally disagree)
Risk tolerance (1 = low risk tolerance, 7 = high risk tolerance)	
Next month, I prefer certainty over uncertainty when investing	1 (totally agree)–7 (totally disagree)
Next month, I avoid risks when investing	1 (totally agree)–7 (totally disagree)
Next month, I do not like to take financial risks	1 (totally agree)–7 (totally disagree)
Next month, I do not like to "play it safe" when investing[a]	1 (totally agree)–7 (totally disagree)
Risk perception (1 = low perceived risk, 7 = high perceived risk)	
I consider investing to be very risky next month[a]	1 (totally agree)–7 (totally disagree)
I consider investing to be safe next month.	1 (totally agree)–7 (totally disagree)
I consider investing to be dangerous next month[a]	1 (totally agree)–7 (totally disagree)
I consider investing to have little risk next month	1 (totally agree)–7 (totally disagree)

Notes: This table presents the questions as used in this study's monthly surveys. A 7-point Likert scale is used to record investors' response to each question. Each survey variable (i.e., return expectation, risk tolerance, risk perception) is calculated as the equally weighted average of the respective survey questions.
[a] Denotes a reverse-scored question.

measures we use have been previously tested and shown to accurately capture expectations and risk preferences related to economic behaviors (Kapteyn and Teppa, 2011).

To ensure that the measurement of investors' return expectations, risk tolerance, and risk perception is reliable, we use multiple items (i.e., survey questions) per variable, include these items in the questionnaire in a random order (Netemeyer et al., 2003), and employ a mixture of regular and reverse-scored items (Nunnally and Bernstein, 1994). To formally examine the reliability of each variable we calculate their Cronbach's alphas (Cronbach, 1951). Cronbach's alpha indicates the degree of interrelatedness between a set of items (i.e., survey questions) that together measure a particular variable (e.g., return expectations) and is expressed as a number between 0 and 1.[5] For a variable to be called reliable, Cronbach's alpha should be above 0.7 (Hair et al., 1998). Our measurement of return expectations, risk tolerance, and risk perception is reliable, as Cronbach's alpha varies between 0.71 and 0.89 for these variables. One-factor solutions of exploratory factor analyses confirm the variables' convergent validity. Additional factor analyses show that cross-loadings between items of the different survey variables are either low or insignificant, confirming the variables' discriminant validity (Nunnally and Bernstein, 1994). We compute the survey variables by equally weighting and averaging their respective item scores. Such variables perform at least as well as those employing "optimally" weighted scores using factor analysis, but have the advantage of expressing a readily interpretable absolute modal meaning (Dillon and McDonald, 2001, p. 62).

[5] Cronbach's alpha is calculated as: $\alpha = \frac{k}{k-1}\left(\frac{\sum_{i=1}^{k}\sum_{\substack{j=1\\ i\neq j}}^{k} Cov(x_i x_j)}{\sum_{\substack{j=1\\ i\neq j}}^{k} Cov(x_i x_j) + \sum_{i=1}^{k} Var(x_i)}\right) = \frac{k}{k-1}\left(\frac{\sum_{i=1}^{k}\sum_{\substack{j=1\\ i\neq j}}^{k} \sigma_{ij}}{\sum_{i=1}^{k}\sum_{\substack{j=1\\ i\neq j}}^{k} \sigma_{ij} + \sum_{i=1}^{k}\sigma_i^2}\right)$, where α is Cronbach's alpha, x_i is measurement for item i, and k is the number of items (Netemeyer et al., 2003, p. 49).

4. Tests of hypotheses

4.1. Investor perceptions during the crisis

In this section we examine whether the crisis has a depressing effect on investor perceptions (H_1). In Figs. 1 and 2 we show the evolution of investors' return expectations, risk tolerance, and risk perceptions during the crisis, as well as the Dutch stock market's index returns (AEX). In Table 4 (Panel A) we provide univariate tests that show the statistical significance of these changes.

Investors' return expectations (Fig. 1) decrease significantly when investors experience a month with bad returns (compare Table 4, Panel A). Return expectations reach their lowest level during the height of the crisis (September–October 2008). In months with improving market returns, however, return expectations recover significantly. Finally, towards the end of the sample period (March 2009), their level cannot be statistically distinguished anymore from their level at the beginning of the sample period (April 2008) (Table 4, Panel A). The recovery of return expectations suggests that individual investors did not experience an enduring shock to their return expectations as a result of the crisis, but instead regularly adapt their expectations to changes in return experiences. Fig. 1 highlights that return expectations (measured at the end of each month) move in line with past market returns. The adaptive evolution of return expectations during the crisis is similar to the adaptation process found in calmer market periods

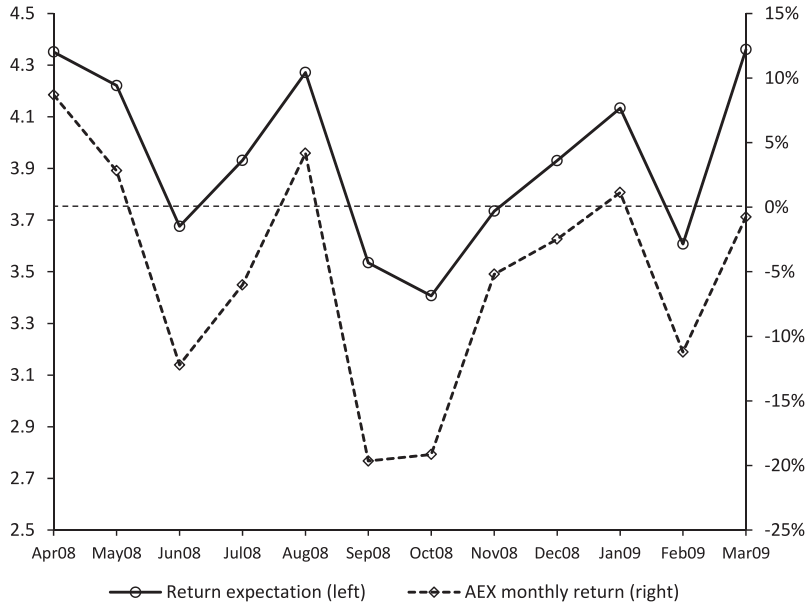

Fig. 1. Return expectations. *Notes*: Return expectations are measured on a 7-point Likert scale (see Table 3); shown is the sample mean. A small value indicates low return expectations, whereas a large value indicates high return expectations. AEX return is the total return of the Dutch stock market index.

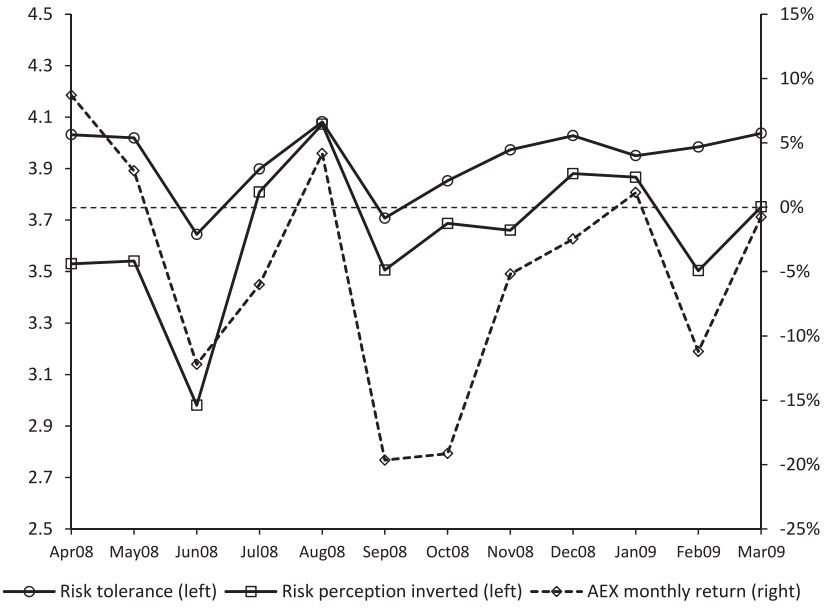

Fig. 2. Risk tolerance and risk perception. *Notes:* Risk tolerance and risk perception about investment prospects are measured on a 7-point Likert scale (see Table 3); shown is the sample mean. For illustrative purposes, risk perception is shown on an inverted scale. A small value indicates low risk tolerance or high perceived risk, whereas a large value indicates high risk tolerance or low perceived risk. AEX return is the total return of the Dutch stock market index.

(Hurd et al., 2011). Moreover, this finding is in line with De Bondt and Thaler's (1985) suggestion that investors overweigh the recent past when forming return expectations.

We find similar effects for risk tolerance and risk perception (Fig. 2), though these measures display less fluctuation over the sample period than return expectations. Both measures become depressed especially in June (i.e., the first month with bad returns during the sample period) and September 2008. In these months, the drop in the level of risk tolerance and increase in the level of risk perception is significant compared to their levels in the previous months (compare Table 4, Panel A). Both measures, however, already reach their lowest (risk tolerance) and highest (risk perception) levels in June 2008 when compared to the average levels of these measures during the complete sample period (Table 4, Panel B). Like investors' return expectations, both risk tolerance and risk perception recover towards the end of the sample period. In fact, investors' level of risk perception is significantly lower at the end of the sample period as compared to the beginning of the sample period (compare Table 4, Panel A). Again, it does not seem that the dramatic experiences of the financial crisis permanently decreased (increased) individual investors' risk tolerance (risk perception). Compared to other studies that measure individual investor perceptions during the crisis (Bateman et al., 2011; Weber et al., forthcoming), this study's longitudinal research design and frequent measurement offer additional insights. Both Bateman et al. (2011) and Weber et al. (forthcoming) measure investor per-

Table 4
Univariate tests.

	March-09 vs. April-08	May-08 vs. April-08	June-08 vs. May-08	July-08 vs. June-08	August-08 vs. July-08	September-08 vs. August-08	October-08 vs. September-08	November-08 vs. October-08	December-08 vs. November-08	January-09 vs. December-08	February-09 vs. January-09	March-09 vs. February-09
Panel A: differences in means between month pairs												
Return expectation	0.01	−0.13***	−0.55***	0.26***	0.34***	−0.74***	−0.13**	0.33***	0.20***	0.20***	−0.53***	0.75***
Risk tolerance	0.01	−0.01	−0.37***	0.25***	0.18***	−0.37***	0.15*	0.12	0.06	−0.08	0.03	0.05
Risk perception	−0.22**	−0.01	0.56***	−0.83***	−0.26***	0.57***	−0.18**	0.03	−0.22**	0.01	0.36***	−0.25**
Portfolio volatility	0.16***	−0.01	0.05***	0.05***	−0.05***	0.14***	0.21***	−0.18***	−0.09***	0.01	−0.05***	0.07***
Account volatility	0.09***	−0.01**	0.02***	0.02***	−0.02***	0.09***	0.12***	−0.10***	−0.06***	0.01**	−0.03***	0.04***
Buy–sell ratio (Traders)	0.16***	−0.03	0.10***	0.17***	−0.11***	0.11***	0.06*	−0.13***	−0.13***	0.06	0.03	0.03
Turnover (Traders)	0.35	−0.22**	0.06	0.08	−0.21*	0.14	0.60**	−0.23	−0.39*	0.09	0.14	0.30
Fraction traded	−0.07**	0.02	0.01	−0.03	−0.06**	0.08**	0.10***	−0.18***	−0.03	0.05	0.01	−0.04
Volume € (Traders)	−28,599	−31,448**	7007	−4374	−4811	5738	27,268	−25,088	−7568	12,811	−4493	−3641
	April-08	May-08	June-08	July-08	August-08	September-08	October-08	November-08	December-08	January-09	February-09	March-09
Panel B: differences in means between months and total sample period												
Return expectation	0.43***	0.30***	−0.24***	0.01	0.35***	−0.38***	−0.51***	−0.18***	0.01	0.21***	−0.31***	0.44***
Risk tolerance	0.11**	0.10**	−0.27***	−0.02	0.16***	−0.21***	−0.06	0.06	0.11	0.03	0.07	0.12*
Risk perception	0.08	0.07	0.63***	−0.20***	−0.46***	0.10	−0.08	−0.05	−0.27***	−0.26***	0.10	−0.14*
Portfolio volatility	−0.12***	−0.13***	−0.09***	−0.03***	−0.08***	0.05***	0.27***	0.09***	0.00	0.01	−0.04***	0.04***
Account volatility	−0.07***	−0.08***	−0.06***	−0.03***	−0.06***	0.03***	0.15***	0.06***	0.00	0.01**	−0.02***	0.02***
Buy–sell ratio (Traders)	−0.13***	−0.17***	−0.07**	0.11***	−0.01	0.10***	0.16***	0.03	−0.10***	−0.03	0.00	0.03
Turnover (Traders)	0.00	−0.22*	−0.16	−0.08	−0.29**	−0.15	0.45***	0.21	−0.18	−0.09	0.05	0.35*
Fraction traded	0.00	0.02	0.03	0.00	−0.06**	0.02	0.12***	−0.06**	−0.09***	−0.04	−0.03	−0.07**
Volume € (Traders)	20,750**	−10,698	−3691	−8065	−12,876	−7138	20,130*	−4958	−12,526	285	−4208	−7849
	April-08	May-08	June-08	July-08	August-08	September-08	October-08	November-08	December-08	January-09	February-09	March-09
Panel C: differences in means between investor sample and market (AEX)												
Portfolio vs. AEX realized volatility	0.08***	0.09***	0.12***	0.14***	0.11***	0.17***	0.26***	0.11***	0.11***	0.16***	0.10***	0.15***
Account vs. AEX realized volatility	0.03***	0.03***	0.04***	0.03***	0.02***	0.04***	0.03***	-0.04***	0.00	0.05***	0.00	0.03***
Portfolio vs. AEX implied volatility	0.09***	0.08***	0.11***	0.16***	0.13***	0.19***	0.36***	0.20***	0.13***	0.14***	0.10***	0.18***
Account vs. AEX implied volatility	0.03***	0.02***	0.03***	0.05***	0.04***	0.06***	0.13***	0.06***	0.02***	0.03***	0.00	0.05***
	April-08	May-08	June-08	July-08	August-08	September-08	October-08	November-08	December-08	January-09	February-09	March-09
Panel D: differences between means and zero												
Buy–sell ratio (Traders)	0.06**	0.03	0.13***	0.30***	0.18***	0.29***	0.35***	0.22***	0.09***	0.16***	0.19***	0.22***
	March-09 vs. April-08	May-08 vs. April-08	June-08 vs. May-08	July-08 vs. June-08	August-08 vs. July-08	September-08 vs. August-08	October-08 vs. September-08	November-08 vs. October-08	December-08 vs. November-08	January-09 vs. December-08	February-09 vs. January-09	March-09 vs. February-09
Panel E: differences in standard deviations between month pairs												
Return expectation	0.10	−0.03	0.06	0.03	−0.03	0.02	0.03	0.04	−0.16**	0.20	0.06**	−0.12**
Risk tolerance	−0.02	−0.03	0.13***	−0.07	−0.07	0.16***	0.00	−0.05	−0.09	0.01	0.12	−0.15
Risk perception	−0.46***	−0.02	0.33***	−0.82***	−0.03	0.04	0.16**	−0.02	−0.08	0.00	0.14	−0.15**

Notes: This table presents univariate tests for significant differences in means and standard deviations. Panels A and E show the differences in means (A) and standard deviations (E) between adjacent month pairs and the last and first month of the sample period, respectively. Panel B shows differences between monthly means and the mean of the total sample period. Panel C shows differences between monthly means of investor realized return standard deviations and of the realized and implied standard deviation of the market index AEX. AEX realized volatility is calculated for each month based on the daily total returns of the AEX index. The implied AEX volatility is given by the VAEX volatility index. Panel D shows the difference between the mean of the monthly buy–sell ratios and zero. Variables are defined in Table 1.

* Statistical significance at the 10% level, respectively based on *t*-tests or Levene's tests (standard deviations in Panel E).

** Statistical significance at the 5% level, respectively based on *t*-tests or Levene's tests (standard deviations in Panel E).

*** Statistical significance at the 1% level, respectively based on *t*-tests or Levene's tests (standard deviations in Panel E).

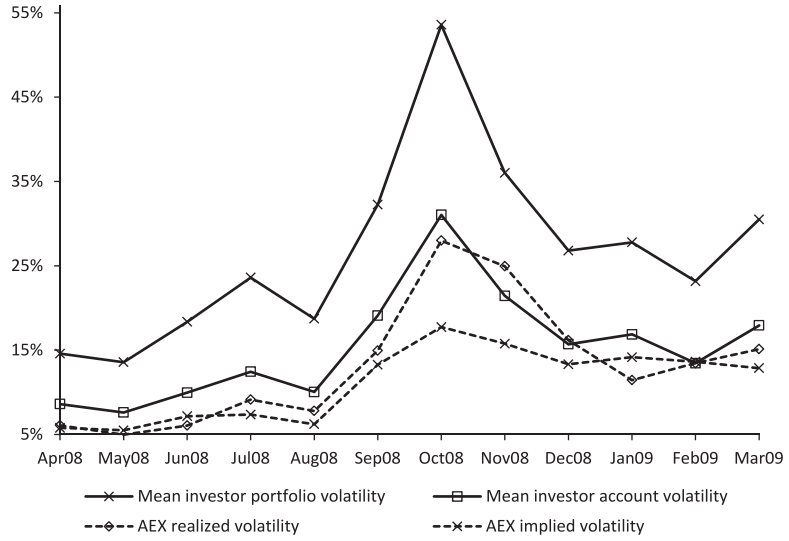

Fig. 3. Investors' monthly return volatility. *Notes*: AEX realized volatility is calculated for each month based on the daily total returns of the AEX index. The implied AEX volatility is given by the VAEX volatility index. Statistics refer to the respondent sample. All volatilities are depicted in monthly terms. Variables are defined in Table 1.

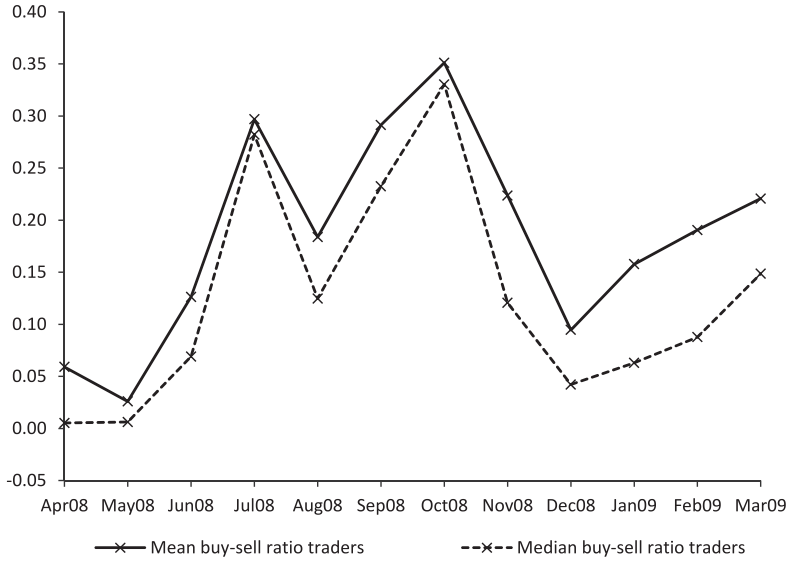

Fig. 4. Investors' buy–sell ratio (Traders). *Notes:* AEX return is the total return of the Dutch stock market index. Statistics refer to the respondent sample. Variables are defined in Table 1.

ceptions during the crisis less frequently and do not detect changes in risk tolerance and risk perceptions. Although this study's findings confirm the results of these other studies that risk tolerance and risk perception are relatively stable over longer time intervals, we find that during the crisis period, they significantly fluctuate and temporarily become depressed.

Overall, we find only limited support for hypothesis H_1. During the financial crisis, investor perceptions become depressed when the stock market does badly. That is, return expectations and risk tolerance decrease, while at the same time, risk perceptions increase. However, the depressing effect of the crisis on investors' return expectations, risk tolerance, and risk perceptions is temporarily as these variables recover with improving market returns. In fact, a comparison of investor perceptions from the beginning of the sample period to the end of the sample period shows that individual investors perceive less risk after the crisis than before the crisis, while there are no significant changes in their return expectations and risk tolerance (Table 4, Panel A).

4.2. Investor risk taking during the crisis

In this section we examine whether the financial crisis leads individual investors to reduce their portfolio risk (H_2). To measure portfolio risk, we use the volatility (standard deviation) of investors' daily portfolio returns. In Fig. 3 we show the monthly volatility of investor returns and the realized as well as implied volatility of the market index (AEX). Investors' monthly return volatility tracks both measures of market volatility, while being significantly higher, on average (Table 4, Panel C). Especially in October 2008, investors' return volatility spikes (compare Table 4, Panels A and B). Thus, during the height of the crisis, investors are not de-risking their portfolios. The sharp increase in market risk in this particular period may have come as a surprise to investors. After October 2008, however, when market volatility decreases, individual investors' return volatility remains at a significantly higher level than that of the market (Table 4, Panel C). Towards the end of the crisis, return volatility is even higher

than at the beginning of the crisis (Table 4, Panel A). Considering that individual investors are generally not well diversified and hold only a limited number of different securities in their portfolios (cf. Goetzmann and Kumar, 2008), it might be difficult to reduce risk by changing portfolio compositions. For 30% of the investors in our sample we have detailed portfolio information, showing that, on average (median), they hold 13.1 (11.6) different securities. Thus, by selling a particular risky security, idiosyncratic portfolio risk may actually go up. Furthermore, considering general equilibrium effects, it might be difficult for individual investors to reduce portfolio risk at a time when their trading counterparts (i.e., institutional investors) also try to reduce risk (cf. Ben-David et al., 2012). Tests using additional information on the cash position in investors' accounts, however, confirm the previous results (Fig. 3 and Table 4, Panels A and B). Account volatility (i.e., the sum of the investment portfolio and cash) is generally lower than portfolio volatility and also spikes at the height of the crisis. Account volatility is also significantly higher towards the end of the crisis than at its beginning. Thus, at a time when it might be difficult to reduce risk within their investment portfolio, individual investors also do not reduce risk by shifting from risky investments to cash.

Instead, individual investors use the depressed asset prices as a chance to enter the market. In Fig. 4 we show individual investors' monthly buy–sell ratio. Especially during September–October 2008, the buy–sell ratio significantly increases compared to previous months (Table 4, Panel A) as well as compared to the overall sample average (Table 4, Panel B). Generally, the buy–sell ratio is significantly greater than zero, indicating net buying, on average (Table 4, Panel D). This behavior of investors during the crisis mimics the findings of Kaniel et al. (2008) for normal stock-market periods and those of Griffin et al. (2011) for the March 2000 technology stock reversal. That is, individual investors, on average, increase their buying volume after price decreases (and vice-versa). In so doing, individual investors provide liquidity during the falling market periods of the crisis while institutional investors withdraw liquidity (cf. Ben-David et al., 2012).

To gain more insight into the factors that drive individual investors' risk-taking behavior, we regress their portfolio standard deviation and buy–sell ratio on their perceptions. We run panel regressions in which investor perceptions are included as explanatory variables in their 1-month lagged levels and changes (revisions) from that month to infer how perceptions at the start of a month, and changes in perceptions during a month, influence behavior. This approach differentiates the general effect of levels of investor perceptions (e.g., always having high risk tolerance and high trading activity) from specific effects of revisions in perceptions and resulting behavior. That is, we examine whether the monthly fluctuations in investor perceptions are an important ingredient for understanding investor behavior, or whether only the levels of perceptions matter. We control for other investor characteristics that prior literature suggests as drivers of investor behavior, such as gender, age, account tenure, income, portfolio value, house value, derivative usage, and dividend choice (Barber and Odean, 2001; Dhar and Zhu, 2006; Bauer et al., 2009; Seru et al., 2010; Korniotis and Kumar, 2011b). We control for the possible impact of past aggregate market returns by including time fixed effects (Section 5.3. provides robustness checks regarding investor-specific returns).[6] In Table 5 we present the results.

Table 5 shows that studying the dynamics of investors' perceptions leads to a better understanding of their risk-taking behavior during the crisis. Both the levels of and revisions in risk tolerance, as well as the levels of risk perception, are associated with risk taking. That is, higher past levels of and upward revisions in risk tolerance lead investors to choose portfolios with higher standard deviations. Furthermore, risk perceptions are positively associated with portfolio risk, suggesting that individual investors are aware of the risk of their investment portfolios. The regression coefficients are economically significant, as we examine monthly standard deviations. For example, a one-point increase in the past level of risk perception is associated with an increase in the annualized standard deviation of almost 4% points.

Table 5
Risk-taking behavior.

Dependent variable	Std (Return)		Buy–sell ratio	
	Coef.	Std. err.	Coef.	Std. err.
Return expectation prev. month	0.006	0.009	−0.008	0.022
Δ return expectation	0.002	0.007	−0.030	0.021
Risk tolerance prev. month	0.030	0.009***	0.060	0.017***
Δ risk tolerance	0.014	0.005***	0.067	0.016***
Risk perception prev. month	0.017	0.006***	−0.029	0.015*
Δ risk perception	0.007	0.004	−0.013	0.013
Gender	−0.022	0.022	0.019	0.057
Age	0.001	0.001	0.000	0.001
Account tenure	0.006	0.003*	−0.009	0.006
ln(Income)	0.097	0.057*	−0.215	0.171
ln(Portfolio value) prev. month	−0.049	0.007***	−0.055	0.010***
ln(House value)	−0.028	0.034	0.181	0.078**
Derivatives	0.115	0.019***	−0.175	0.043***
Dividend choice stock	0.021	0.023	0.007	0.045
Dividend choice Cash and stock	0.026	0.018	0.003	0.040
Constant	0.077	0.389	0.525	1.145
Time fixed effects	Yes		Yes	
N Observations		3885		1914
N Investors		1041		968
R^2		0.262		0.091

Notes: This table presents the results from regressions of risk-taking behavior on investor perceptions and a set of control variables. Dependent variables are the investor-specific standard deviation of daily portfolio returns in a particular month and the buy–sell ratio. The columns show results of linear panel models for the full sample (standard deviation of return) and for the truncated sample of investors who have at least one trade in a particular month (buy–sell ratio). The number of individual investors included in the first regression (1041) is smaller than the sample available for analysis (1376), because not all investors responded to the survey for two consecutive months. Standard errors are clustered on the investor level. Variables are defined in Table 1.

* Statistical significance at the 10% level.
** Statistical significance at the 5% level.
*** Statistical significance at the 1% level.

The coefficients of the control variables are consistent with prior literature. Investors who are more experienced (longer account tenure) and sophisticated (i.e., trade derivatives) take more risk, while investors with larger portfolios take less risk (cf. Barber and Odean, 2001; Bailey et al., 2008; Grinblatt and Keloharju, 2009; Seru et al., 2010).

With respect to the buy–sell ratio, we find that investors with higher levels of and upward revisions in risk tolerance, lower levels of risk perception, less experience (shorter account tenure), more wealth (higher average house value), and lower levels of derivatives usage have a higher buy–sell ratio (second column in Table 5). That is, more risk-tolerant investors increase their market exposure, while investors who perceive higher risk lower their market exposure.

Overall, the results lead us to reject hypothesis H_2. The financial crisis does not induce individual investors to de-risk their portfolios. This behavior is rooted in the time-variation of investor perceptions: risk tolerance quickly returns to pre-crisis levels while risk perception levels are even lower at the end of the sample period than at the beginning of the sample period. As these measures are key drivers of portfolio risk and buy–sell ratios, investors do not de-risk.

[6] We cluster standard errors on the investor level. Alternatively, we use Driscoll and Kraay (1998) standard errors. Results in the latter specification are very similar in terms of coefficient significance (detailed results available upon request), that is, the time fixed effect is picking up potential cross-sectional correlation.

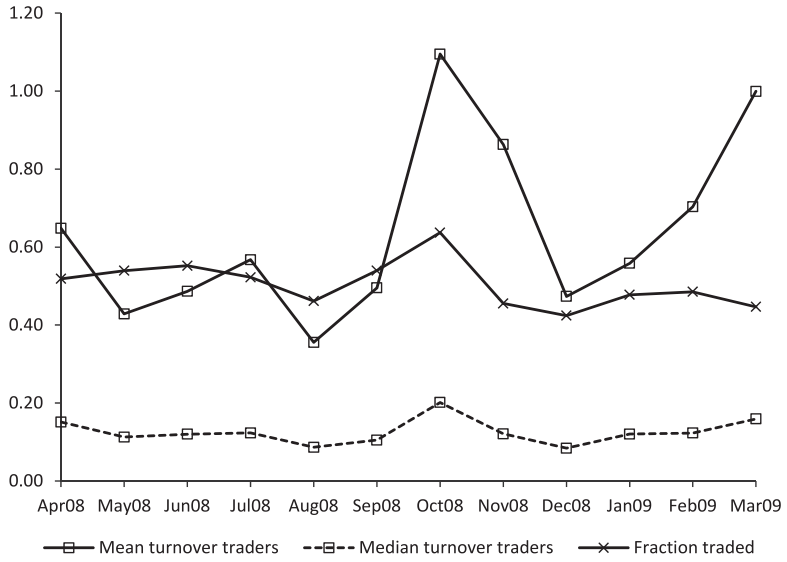

Fig. 5. Trading activity – fraction of investors that traded and turnover. *Notes*: Statistics refer to the respondent sample. Variables are defined in Table 1.

4.3. Investor trading activity during the crisis

In this section we examine whether experiencing the final crisis leads individual investors to decrease (H_{3a}) or increase (H_{3b}) their trading activity. In Fig. 5 we plot the fraction of investors that trades each month and their turnover. The likelihood of trading and turnover significantly increase during the height of the crisis, in particular in October 2008 (see Table 4, Panels A and B). The increase in turnover is not a mechanical effect of falling portfolio values, as trading volume also (marginally significantly) rises (compare Fig. 6 and Table 4, Panels A and B).

The significant increase in trading activity during the height of the crisis makes it unlikely that information overload (being associated with lower trading activity) plays a major role for individual investors during the financial crisis. Increasing trading activity alone, however, is insufficient to rule out potential information-overload effects. As a more formal test, we regress investors' trading activity on their perceptions and variables that previous research showed to be linked to susceptibility to information overload. In particular, Agnew and Szykman (2005) find that financially literate and experienced investors, that is, those with longer account tenure, higher income, and larger portfolio values, suffer less from information overload. These investors typically have less difficulty interpreting the frequent and sometimes conflicting information that arrives during a crisis. Therefore, we expect them to have a lower tendency to be overwhelmed by crisis events that could lead them to refrain from trading. If information overload is present, trading activity (i.e., likelihood to trade and turnover) should be positively related to variables that proxy for financial literacy and experience, such as account tenure, income, and portfolio value. To examine this notion, we estimate two regression models explaining investors' likelihood of trading and turnover. As in Section 4.2, we control for a variety of investor characteristics that prior literature identifies as drivers of behavior and include

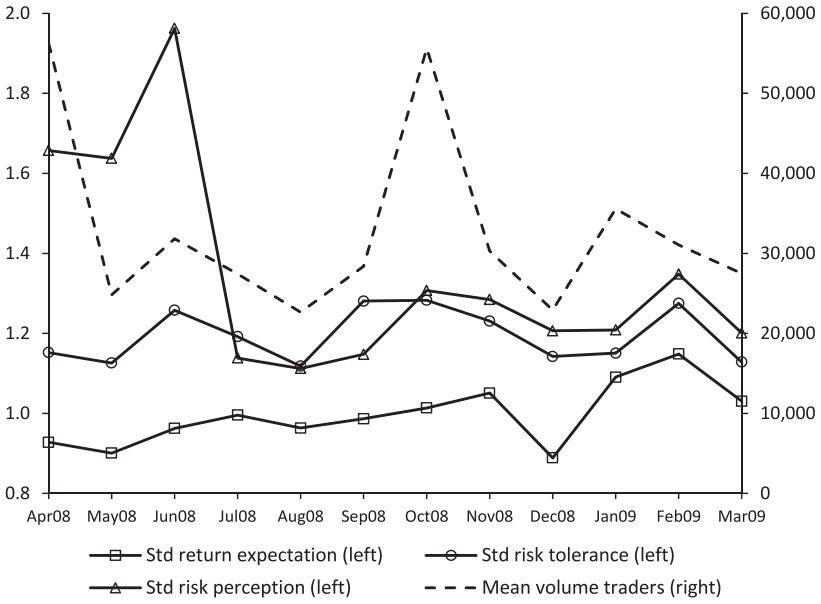

Fig. 6. Divergence of perceptions and trading volume. *Notes*: Shown are the monthly cross-sectional standard deviations of return expectation, risk tolerance, and risk perception, as well as the mean of the monthly volume (buy + sell) per investor. Statistics refer to the respondent sample. Variables are defined in Table 1.

time fixed effects to control for the effect of past aggregate market returns (Section 5.3 provides robustness checks regarding investor-specific returns). In Table 6 we show the regression results.

Income is significantly and positively related to the likelihood to trade (consistent with an information overload effect), but is not significantly related to turnover. Account tenure is negatively associated with the likelihood to trade (not consistent with an information overload effect), but is positively related with turnover (consistent with an information overload effect). We find opposite results for the portfolio value coefficients. The results of Table 6 are consistent with the intuition provided by Fig. 5: the coefficient signs are sometimes in line but are also often not in line with the theoretical predictions of information overload effects. It thus seems unlikely that information overload plays a major role for investor behavior during the crisis.

As we do not find evidence in support of hypothesis H_{3a}, we next test hypothesis H_{3b}. That is, we examine whether more reasons (changes in perceptions) and opportunities to trade (divergence of perceptions) can explain the increase in trading activity, as observed in Fig. 5. Both in the likelihood of trading and the turnover regressions, most perception coefficients are significant (Table 6). Exceptions are the coefficients for changes in risk perception (likelihood to trade), and level and changes in risk tolerance (turnover). Overall, levels and changes in perceptions drive trading activity. Figs. 1 and 2 and Table 4 show that perceptions fluctuate significantly during the crisis. Together with the regression results, this suggests that having more reasons to trade leads investors to increase their trading activity. To measure divergence of perceptions (i.e., disagreement between different investors), we use the monthly cross-sectional standard deviation of the perception measures (Doukas et al., 2006; Zhang, 2006; Güntay and Hackbarth, 2010; Banerjee, 2011). In Fig. 6 we plot the divergence of investor perceptions during the crisis. Divergence of perceptions tends to move similarly as trading volume in most months. That is, in months in which volume increases (June, September, August, however, not January), divergence of perceptions also increases significantly (Table 4, Panel F). Overall, we thus find support for H_{3b} but reject H_{3a}: the increased trading activity during the height of the crisis is related to changes in perceptions as well as higher divergence of perceptions. In other words, the crisis provides individual investors with more reasons as well as more opportunities to trade.

Table 6
Trading activity.

Dependent variable	Traded		Turnover	
	Marg. eff.	Std. err.	Coef.	Std. err.
Return expectation prev. month	0.094	0.019***	0.035	0.021*
Δ return expectation	0.054	0.016***	0.031	0.017*
Risk tolerance prev. month	0.076	0.015***	0.015	0.015
Δ risk tolerance	0.069	0.013***	−0.008	0.013
Risk perception prev. month	0.028	0.013**	0.032	0.012***
Δ risk perception	0.016	0.0.010	0.026	0.009***
Gender	0.046	0.070	−0.067	0.044
Age	0.001	0.002	0.003	0.001*
Account tenure	−0.014	0.007**	0.011	0.006*
ln(Income)	0.313	0.181*	0.248	0.165
ln(Portfolio value) prev. month	0.068	0.010***	−0.065	0.012***
ln(House value)	−0.197	0.090**	−0.210	0.095**
Derivatives	0.475	0.037***	0.002	0.040
Dividend choice stock	0.010	0.052	0.152	0.051***
Dividend choice cash and stock	−0.046	0.045	0.073	0.034**
Constant			0.632	0.917
Time fixed effects		Yes		Yes
N observations		3885		1914
N investors		1041		698
R^2				0.108

Notes: This table presents the results from regressions of two indicators of investor trading activity on investor perceptions and a set of control variables. Dependent variables are market participation (Traded) and turnover. The first column shows the results of a random-effects panel probit estimation for the dependent variable Traded, which indicates whether an investor traded in a particular month (1) or not (0). Reported are marginal effects at means (0) of independent continuous (discrete dummy) variables. The number of individual investors included in the regression (1041) is smaller than the sample available for analysis (1376), because not all investors responded to the survey for two consecutive months. The second column shows results of a linear panel model for the truncated sample of investors who have at least one trade in a particular month. Standard errors are clustered on the investor level for the linear panel model. Variables are defined in Table 1.

* Statistical significance at the 10% level.
** Statistical significance at the 5% level.
*** Statistical significance at the 1% level.

5. Robustness checks and tests of alternative explanations

5.1. Sample selection bias

A general concern with studies using surveys is that response behavior could be non-random. To examine this issue, we first compare the investors that respond to the survey to the broker's overall investor population, followed by an analysis of the monthly variation of non-response.

As described in Section 3, brokerage records are available only for investors who respond at least once to the survey. A limited amount of background information is available for all of the broker's clients for December 2005. This information includes their age, gender, portfolio value, and number of trades. After imposing the same sample-selection restrictions for the broker's complete client base as for the 2008–2009 survey respondents (see Section 3), we have 2005 background information for 35,122 investors in total, of which 742 are also respondents to the 2008–2009 survey. A comparison of the 742 survey respondents with all of the broker's clients based on the 2005 data shows that 2008–2009 survey respondents are, on average, more likely to be male (95% vs. 91%, $p = 0.000$) and older (3.25 years, $p = 0.000$), have larger portfolios (€10.956, $p = 0.000$), and are more likely to trade (55% vs. 39%, $p = 0.000$). We find no significant differences regarding their number of trades (given that they trade).

In the following, we compare the characteristics of all investors who respond to the 2008–2009 survey with those of the non-responding investors for each month using the 2008–2009 broker-age-account data. Additionally, to examine whether non-response is related to investor behavior or performance, we analyze investors' trading and risk-taking variables, returns, Sharpe Ratios and alphas. Comparing respondent with non-respondent means shows that in some months there are significant differences, especially with respect to age, account tenure, and trading activity (detailed results available upon request). In these months, respondents, compared to non-respondents, are older, have longer account tenure, and are more likely to trade, whereas their overall transaction volume is smaller. That is, based on the 2008–2009 data, similar tendencies with respect to response behavior emerge as with the 2005 data. This indicates that investors that respond to the survey only a few times mimic investors that do not respond at all. Except for August 2008 (alpha) and December 2008 (Sharpe Ratio) we find no significant differences between respondents and non-respondents regarding risk taking or performance. Thus, response behavior is unlikely to be driven by these investor characteristics. When we examine the months with significant differences between respondents and non-respondents regarding overall market performance, no patterns emerge that indicate that response behavior would be driven by overall market developments.

To statistically account for the identified differences between respondents and non-respondents, as well as the monthly varia-

Table 7
Investor performance.

Dependent variable	Return		Sharpe Ratio		Alpha	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Gender	0.001	0.007	−0.025	0.029	−0.005	0.010
Age	0.000	0.000	0.000	0.001	0.000	0.000
Account tenure	0.002	0.001**	0.005	0.003	0.002	0.001
ln(Income)	0.002	0.022	0.056	0.083	−0.042	0.032
ln(Portfolio value) prev. month	0.000	0.002	−0.009	0.005	0.005	0.002**
ln(House value)	0.011	0.012	0.013	0.041	0.019	0.017
Derivatives	−0.011	0.006*	0.006	0.022	−0.009	0.007
Dividend Choice stock	−0.004	0.007	0.003	0.022	−0.007	0.008
Dividend Choice cash and stock	−0.006	0.005	0.006	0.019	−0.004	0.007
Std(Return)	−0.309	0.022***				
Buy–sell ratio	−0.019	0.005***	−0.079	0.018***	−0.017	0.006***
Traded	−0.005	0.005	0.023	0.019	−0.005	0.007
Turnover	−0.015	0.003***	−0.014	0.005***	−0.023	0.006***
Constant	−0.191	0.150	−1.202	0.523**	0.174	0.190
Time fixed effects	Yes		Yes		Yes	
N observations	3885		3885		3885	
N investors	1041		1041		1041	
R^2	0.492		0.585		0.056	

Notes: This table presents the results from regressions of investment performance on investor behavior and a set of control variables. Dependent variables are the investor's return, Sharpe Ratio, and alpha. The columns show results of linear panel models. The number of individual investors included in the regression (1041) is smaller than the sample available for analysis (1376), because not all investors responded to the survey for two consecutive months. Standard errors are clustered on the investor level. Variables are defined in Table 1.

* Statistical significance at the 10% level.
** Statistical significance at the 5% level.
*** Statistical significance at the 1% level.

tion in significant differences, as a robustness check we apply an inverse-probability-weighted estimator (Robins and Rotnitzky, 1995; Wooldridge, 2002). For each of the 12 months, we estimate a logit model where the dependent variable indicates either response (1) or non-response (0). As explanatory variables, we include the set of variables as discussed above. Next, we calculate the predicted probabilities of survey response. Finally, we estimate all regression models of Section 4 again using the inverse of the predicted probabilities as sample weights. The results of the regressions that include this estimator are similar to those obtained from the original specifications in terms of coefficient magnitudes, significance, and signs (detailed results available upon request). That is, in general our results are not impacted by non-random response behavior. Exceptions are the turnover regression where we identify that, compared to male investors, female investors have lower turnover ($\beta = -0.075$, $p = 0.085$), and the portfolio risk regression, where we find that female investors hold less risky portfolios ($\beta = -0.036$, $p = 0.048$). Both results are consistent with the findings of Barber and Odean (2001).

5.2. Response timing bias

Besides sample selection considerations, response timing might impact the results. Large differences in the point in time at which investors respond to the survey might affect the results due to the rapidly changing market conditions during the crisis. Therefore, we first check the monthly distributions of survey response time. Generally, investors complete the survey shortly after they receive the monthly invitation email: 31% of responses occur on the same day that the clients get the survey email. Within another day, we receive 53% of the total number of responses, after 5 days we receive 85%, and after 10 days we receive 95% of total survey responses. The clustering of responses within the first few days after sending each survey email makes it unlikely that there is a response-time pattern in the data that could introduce a possible bias. Nevertheless, to check more carefully for this possibility, we estimate all regression models of Section 4 again. Yet, we now exclude investors with long response durations (more than 5 days, or alternatively, more than 10 days from the day of sending the survey email). The results of these regressions are similar to those we obtain from the original specifications in terms of coefficient magnitudes, significance, and signs (detailed results available upon request). One exception is the portfolio risk regression, where removing investors with a response duration of either more than 5 or 10 days, leads the coefficient for the change in risk tolerance to be significant only at the 5% level (this coefficient is significant at 1% before excluding late responders).

5.3. Investor perceptions vs. past returns as drivers of behavior

Figs. 1 and 2 suggest that the month-to-month changes (revisions) in investors' perceptions follow changes in the Dutch stock market index (AEX). In particular, revisions in return expectation and risk tolerance seem to be positively, and revisions in risk perception negatively, associated with changes in market returns. Hence, one could hypothesize that perceptions have a significant effect in the regression analyses only because they reflect past returns (cf. Statman et al., 2006; Barber et al., 2007; Nicolosi et al., 2009).

To examine this alternative explanation, we examine the within-investor correlations of the levels of and revisions in perceptions with the levels of and changes in the market and individual investor returns, respectively. Since we measure perceptions at the end of each month, while returns realize over the course of each month, we examine the contemporaneous correlations to detect an impact of past returns on current perceptions. The results show that although the levels and changes in perceptions are correlated with both the levels and changes in the market and individual investor returns, all correlations are relatively low and far from unity (detailed results available upon request). This gives first evidence that investors' perceptions provide additional information over and beyond the information included in their past returns.

In addition, we break down the changes in investor perceptions on a monthly basis and distinguish between investors with positive and negative past returns, as well as changes in past returns. The results show that, in most months, average return expectations

and risk tolerance move in the same direction, while risk perceptions move in the opposite direction of both market returns and individual investor returns (detailed results available upon request). There is, however, considerable heterogeneity between the directions of investors' changes in perceptions. The maximum percentage of investors that changes perceptions in line with the average change of the overall sample of investors is 77% (= negative change in return expectations in June 2008). In most months, this percentage is lower than 60%. Furthermore, when looking closer at individual investor returns, which may be the source of heterogeneity of the direction of changes in investor perceptions, it becomes clear that it is not only individuals' past return experience that drives changes in their perceptions. The results show that the fraction of investors that change their perceptions in line with the change in the overall market return is larger among investors with an individual return experience that matches the sign (direction) of the market return (change). Thus, investor perceptions are partially influenced by past individual returns. The effect of past individual returns is small, however, because the difference between the fractions of investors with positive and negative individual return experience that change perceptions in line with the market is less than 10% points (detailed results available upon request).

Finally, we analyze the impact of investor past return experience vs. investor perceptions on their trading and risk-taking behavior. Since the possible impact of the past market return (AEX) on investor behavior is already accounted for by the time fixed effects that are included in the regression models of Section 4, we only further examine the possible impact of individual investor return experience. For this, we again estimate the regression models including investors' past returns, change in past returns, or both, as control variables. The results show that the levels of investors' past returns have no significant effect in any of the regression models. Changes in investors' past returns do impact behavior, but including them does not eliminate the explanatory power of investor perceptions (detailed results available upon request). Consistent with Statman et al.'s (2006) findings, changes in investors' past returns have a significant effect in the turnover regression ($\beta = 0.013$, $p = 0.004$), which also includes past returns as a control variable, and in the buy–sell ratio regression models that include only the investors' change in past returns, as well as both the past returns and change in past returns ($\beta = 0.011$, $p = 0.000$ in both models). The significance, signs, and approximate magnitudes of the investor perception coefficients do not change in any of the regression models. The only exception is that in the risk-taking (standard deviation of portfolio return) regression models that include the change in past returns, or both the past returns and the change in past returns, the coefficient for the change in risk perception becomes significant and positive ($\beta = 0.009$, $p = 0.072$ in both models). Overall, the analyses of this section show that investor perceptions not only pick up information from past returns, but they also provide explanatory power for investor behavior well beyond the previously documented effect of past returns and changes in past returns.

5.4. Relevance of investor risk-taking and trading behavior during the crisis

Results of Section 4 show that investor perceptions and fluctuations therein are important drivers of investor behavior. The aspects of trading and risk-trading behavior that we study have been shown to relate to investor performance during normal market periods. Thus, economically, they matter. In this section we assess whether, also during the financial crisis, the behavioral variables that we study relate to investor performance, and thus have relevance in this particular period. To do so, we regress three measures of investor performance on investor behavior and a set of controls. As performance measures, we study investors' monthly portfolio return, their monthly Sharpe-Ratio, and their monthly one-factor (Jensen's) alpha.[7] The aspects of investor behavior that we include are based on Section 4: we examine the impact of the standard deviation of investors' portfolio return, as well as that of their buy–sell ratio, likelihood to trade, and turnover. Note that, since we already account for investment risk in the dependent variable in the Sharpe-Ratio and alpha regression, only in the portfolio-return regression we do include the standard deviation of returns as an independent variable. The results of Table 7 show that the behavioral variables that we consider in this paper are important drivers of investor performance during the financial crisis. As overall market returns were mostly negative during the sample period, both portfolio risk (standard deviation) and the buy–sell ratio are negatively associated with performance. In addition, trading activity (turnover), is negatively related to performance, consistent with results that related work finds in normal market periods (Barber and Odean, 2000). Overall, these regression results provide evidence that the investor behaviors that we study during the financial crisis are economically relevant.

6. Conclusion

We combine monthly survey data with matching brokerage records and show how individual investor perceptions change and drive trading and risk-taking behavior during the 2008–2009 financial crisis. Investor perceptions exhibit significant fluctuation over the course of the crisis, with risk tolerance and risk perceptions being less volatile than return expectations. In the worst months of the crisis, investors' return expectations and risk tolerance decrease, while their risk perceptions increase. Towards the end of the crisis, return expectations, risk tolerance, and risk perceptions recover. We find substantial swings in trading and risk-taking behavior during the crisis that are driven by changes in investor perceptions. Contrary to popular beliefs and expectations from prior literature, however, individual investors continue to trade and do not de-risk their investment portfolios during the crisis. Individual investors also do not try to reduce risk by shifting from risky investments to cash. Instead, individual investors use the depressed asset prices as a chance to enter the stock market.

Our study provides two insights for asset pricing. First, consistent with the recent work of Guiso et al. (2011), we show that investor's risk tolerance is time-varying (see Fig. 2 and Table 4, Panels A and B) and significantly related to risk-taking behavior (see the risk-taking regression). Investor's portfolio risk, however, seems to move in parallel with market risk (see Fig. 3), as if changes in risk tolerance had no impact. Hence, it may be investor inertia, that is, the large fraction of investors not trading during the sample period (see Fig. 5), as well as rebalancing behavior after price changes (see Fig. 4 and the buy–sell ratio regression), that ultimately drives portfolio risk. Thus, although present, time-varying risk tolerance and its impact on risk-taking behavior can be masked and overcompensated by the impact of investor inertia found by Brunnermeier and Nagel (2008) as well as Bilias et al. (2010). Second, although the sample period does not cover the time before the financial crisis, our findings on the evolution of investor perceptions do shed light on the psychological factors contributing to the asset-price bubble preceding the crisis. Barberis

[7] We cannot estimate multi-factor alphas because of limitations on the portfolio-holdings data. Daily market-value data on the portfolio level is available for all investors. Detailed portfolio component data, however, is only available for a subset of 30% of the investors. But even in that case, only the name of the security, the indication of the asset class, and the historical purchase prices are available for each portfolio component.

(2013), for example, argues that the representativeness heuristic is largely responsible for the overly optimistic pre-crisis expectation formation. We show that individual investor perceptions indeed exhibit adaptive behavior with respect to very recent stock-market performance (see Figs. 1 and 2). We thus provide empirical support for Barberis's (2013) theoretical viewpoint regarding the psychological factors that contribute to the creation of financial bubbles in general and to the financial crisis of 2008–2009 in specific.

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