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The Effect of a Risk Tail Event on Investor Risk Tolerance[1]

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Abstract: Classical finance theory assumes that investor decisions can be modelled based on rational expectations. Under this assumption, investors form their risk tolerance beliefs with the knowledge of all current and future events, and their corresponding riskiness. Therefore, it is expected that investor risk tolerance will not decrease following the occurrence of a risk tail event, such as the COVID-19 Pandemic. This paper uses data from the risk profiling questionnaire of a wealth management firm in the Netherlands to explore the relationship between risk tolerance and macroeconomic conditions. The regressions are based on a balanced panel of 47 clients who responded to the questionnaire twice, once before and once during COVID-19. This paper demonstrates an overall decrease in investor risk tolerance indicated by the lower response categories chosen on the questionnaire. The inclusion of investor characteristics and market indicators in the regression analysis suggests that this decrease in risk tolerance may be explained by the fluctuation in macroeconomic conditions.

Keywords: Rational Expectations; Risk Tolerance; Risk Tail Event.
JEL Classification: (D81, G11, G40)

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1. Introduction

Dutch investment advisors and asset managers are required to determine a risk profile for every client – a procedure which is set out by the Netherlands Authority for the Financial Markets (AFM). According to the AFM, a risk profile is a composite measure of risk tolerance and is taken into account from two perspectives; risk capacity and risk appetite. Risk capacity measures how much financial risk the investor is *able* to carry, while their risk appetite is based on how much financial risk they are *willing* to carry. The AFM recognizes that these two risk measures may not be consistent with each other and requires wealth management firms in the Netherlands to first assess them separately before they are used in combination to create an overall risk profile with which both advisor and client are satisfied (The Netherlands Authority for the Financial Markets, 2011).

The most common method used to measure risk tolerance is a questionnaire which follows the guidelines published by the CFA Society VBA Netherlands. These guidelines were first published in 2010 according to the regulatory framework defined in the Markets in Financial Instruments Directive (MiFID). This directive is aimed at harmonizing regulation for investment services across the European Union and includes basic outlines for how *all* European investment advisors should approach risk profiling. Article 25 of the MiFID II states that:

"the investment firm shall obtain the necessary information regarding the client's or potential client's knowledge and experience in the investment field relevant to the specific type of product or service, that person's financial situation including his ability to bear losses, and his investment objectives including his risk tolerance…"

The purpose of this paper is to examine the effect of a risk tail event on investor risk tolerance. This includes investigating the theories which exist surrounding the measurement of risk tolerance, and whether the models produced by these theories are reliable when faced with a risk tail even. Using the breakdown of risk tolerance into risk capacity and risk appetite, it is expected that while risk capacity may be affected briefly by a decline in the market, risk appetite should remain unaffected if investors behave according to rational expectations.

To explore this theory, 213 completed risk profiling questionnaires, consisting of both risk capacity and risk appetite questions, were provided by a Dutch wealth management firm. A quasi-experiment (an experiment without random selection) was then conducted to estimate the effect of the risk tail event, the COVID-19 pandemic, on investor risk tolerance. All 213 clients were asked to complete the questionnaire again and the responses created a sub-sample of 47 clients with questionnaire responses in two time periods, once before and once during the COVID-19 pandemic.

Each question has a response category (A-E), but of particular interest are the responses to the risk appetite questions, which effectively represent an ordered proxy scale of risk tolerance (1-5); where A=1 represents the lowest risk tolerance. Inferring clients risk tolerance from a scale produced from the risk appetite questions, rather than calculating an aggregated score, means the data cannot be estimated using a linear model. An ordered probit model provides a way to interpret each response category. This is seen in the analysis of the ten-category ordered response risk tolerance question in the German Socio-Economic Panel (SOEP), which bears resemblance to Q37 of the questionnaire used in this paper (Appendix F). For this paper, the model will be applied using correlated random effects – a method which will be explored further in the data analysis.

Risk-taking, or risk tolerance, plays a crucial role in financial markets. Without it, the pricing of capital assets would be based on the expected payout and duration of the asset – rather than rewarding the investor for taking risks on unexpected gains or losses. An investor can be said to be risk averse (the inverse of risk tolerance) if they prefer certainty over uncertainty in their investment decisions. However, research into the complexity of risk aversion has evolved since it was first proposed in financial theory. For example, the original concept of risk aversion did not account for differences in investor beliefs or an investor's 'past experience' (Pompian, 2012). A higher level of risk tolerance can exist irrespective of financial situation, as some investors simply have a greater appetite for risk.

An accurate risk profile is important for determining the asset allocation of an investor's portfolio, but as expected, investors do not always make decisions based on how they *should*. This is converse to classical finance theory, which assumes that all investors have rational expectations based on the correct evaluation of market fundamentals; and specifically, that risks of future events are part of this information. However, during periods of financial market turmoil it is understandable that individuals may experience a decrease in risk tolerance, due to fluctuations in the macroeconomic conditions. The recent market shock which developed as a result of the COVID-19 pandemic is such an event which falls outside of investor expectations and lays the potential for considering behavioral biases in measuring risk tolerance. Under rational expectations it is expected that investor risk tolerance will not decrease following the occurrence of a risk tail event.

There are a growing number of studies surrounding the relationship between risk tolerance and financial crises (Sahm, 2012; Gerrans, Faff & Hartnett, 2015). Notably, a paper has yet to investigate the possible effect of the COVID-19 pandemic on investor risk appetite – an analysis which is undertaken in this thesis. The results demonstrate a distributional shift to the left in the client responses to the risk appetite questions, which reflect a lower risk tolerance. Furthermore, the regression analysis demonstrates significant positive estimates on COVID-19 in seven of the risk appetite questions. The inclusion of market indicators reduces the significance of the COVID-19 estimates to only two questions. However, any market fluctuations are most likely attributable to the COVID-19 pandemic, which suggests the effect of COVID-19 on investor risk tolerance is instead demonstrated through these indicators.

The outline of the thesis is as follows; **Section 2: Literature Review** includes the development of risk tolerance measures in economic models to more recent risk tolerance analyses and explores the field of behavioral finance. **Section 3: Data** outlines how the data is collected and interprets the changes in distribution of risk tolerance among the sub-sample of clients.

Section 4: Empirical Strategy derives the model used for the regression analysis. **Section 5: Results** presents the estimates of the of the COVID-19 pandemic using an ordered probit model with control variables. **Section 6: Discussion and Conclusion** discusses the implications of the results and reflects on the impact of this research for wealth management firms and the investment industry.

2. Literature Review

a. Classical Finance Theory

In classical finance theory all investors are rational; they correctly evaluate fundamentals and maintain the same outlook on investing. The introduction of the role of risk aversion can be traced back to a simple coin-toss experiment by Bernoulli in the 18th century (Bodie, Kane & Marcus, 2018a). Through evaluating the game, Bernoulli infers that individuals have risk-averse preferences, such that they trade-off risk and return. Bernoulli also concludes that the wealthier an individual is, the less they "appreciate" an increase in the overall payoff – a concept which is also known as diminishing marginal utility. It wasn't until 1946 that Von Neuman and Morgenstern applied the concept of risk aversion with a concave utility function to investment theory, which recognized that a wealthier individual's satisfaction increases at a diminishing rate. At its most basic level, this 'Expected Utility Theory' (EUT) assumes that investors make the same choice in terms of riskiness regardless of a situation or an event, (Grable, 2016). Markowitz's 'Modern Portfolio Theory', an extension on EUT, predicts that investors should only be willing to carry additional risk if it is associated with a higher return.

An important implication of these early models is that all investors with long-term investment goals, even those with high risk aversion, should invest a portion of their assets in stocks or high-return investments. However, Kahneman and Tversky's 'Prospect Theory' helps to explain why this is not always the case. Prospect Theory (PT) depends not on how wealthy the investor is but instead on *changes* to their wealth from a reference point. When evaluating a loss, this reference point is always adjusted to their current wealth. This evaluation is the basis for 'Loss Aversion', a concept in prospect theory whereby losses matter twice as much as gains. Furthermore, when presented with risks involving definite overall gains, investors are predicted to be less risk tolerant; conversely if the risk is associated with a definite overall loss, investors are

more risk tolerant even so far as risk-seeking (Grable, 2016). Some of the outcomes of PT, including Loss Aversion and how an event is framed, are still used in behavioral research.

b. Demographic Studies of Risk Tolerance

Outside of the rational expectations model in economics, research conducted on risk tolerance has been diverse. Roszkowski and Grable (2005) propose that a model to represent risk tolerance is possible and that, due to correlations between factors, relatively few variables would be needed in the model. Research on how these independent variables would affect risk tolerance in a model is not aligned. This is partly due to cross-sectional analysis at an individual level which can be influenced by the sample population. Grable (2016) provides statistical analysis of demographic factors associated with financial risk tolerance based on 144 published studies between the years 1960 and 2004 (Appendix A) which provides a basis for the controls to use when modeling risk tolerance.

In a study conducted by Sahm (2012), data from the Health and Retirement Study (HRS) 1992 – 2002 is used to test whether an investor's risk tolerance changes over time. The initial data collection includes information from 12,000 respondents aged between 45 and 70; granted the sub-sample created to increase the level of analysis was smaller, with only 8% of the individuals responding to three or more waves of the survey. Of particular interest are the surveys from the years that captured by the 'Dot Com Bubble', which was a defining event in US stock market history. Crucially, this present study takes COVID-19 as a defining event, following a similar analysis to Sahm's research.

Comparable to the response categories of the risk appetite questions used in this thesis, Sahm (2012) investigates the results of an ordered risk tolerance hypothetical gamble question in the HRS. It is important to recognize the limitations of using survey data to infer individual preferences, as well as the potential drawbacks using of ordered response categories as the

dependent variable because a simple linear model cannot be estimated. Nevertheless, the analysis can be effectively carried out using an ordered probit model. The results from Sahm (2012) find risk tolerance to be relatively stable over time but with a tendency to decrease with age and increase with better macroeconomic conditions. On the other hand, over 70% of the variance in risk tolerance in the sample is left to be explained by investor's different beliefs about risk. This is converse to the assumption of rational expectations, whereby all investors maintain the same beliefs surrounding their investments.

Gerrans, Faff and Hartnett (2015) conducted a similar study using cross-sectional data from different time periods, from a FinaMetrica survey consisting of 25 questions, to analyze changes in risk tolerance around the 2008 financial crisis. Their overall sample size includes at least two responses from each of the 4,741 investor clients at financial advisory firms surveyed during the time period January 2001 to July 2009. Again, a sub-sample is formed with all the surveys which qualify for the analysis, and the final sample used is that of 3,368 investors. While their research supports previous literature identifying demographic factors which affect risk tolerance at an individual level, they also acknowledge that stock market prices are a factor affecting tolerance scores. While Gerrans, Faff and Hartnett (2015) find that the magnitude of the difference in risk tolerance scores from before and after the crisis is small, their results are in agreement with Sahm (2012) that risk tolerance is influenced by age and major economic disruptions.

One study which is particularly relevant to the methods of analysis in this thesis is that of Dohmen et al. (2011) conducted using the German Socio-Economic Panel (SOEP) which includes a ten-category ordered response question to measure risk attitudes. The SOEP sample is from the 2004 survey which consists of more than 22,000 individuals across 11,803 households. Dohmen et al. (2011) also conduct a field experiment over two months in the summer of 2005 which generates a further sample of 450 subjects. In this experiment the individuals were required to

participate in a paid lottery experiment – offering an incentive to the concept of hypothetical gambles. This collection of data took place face-to-face at the subject's home to reduce any noise or error in an individual's responses when faced with cognitively difficult questions. Although there is a possibility of further noise created if the subject is influenced by the data collector. This is especially relevant to the data in this thesis as the data collector is an investment advisor, thus the investors might feel inclined to attach their preferences to any advice they are given when responding to the questionnaire.

Furthermore, Dohmen et al. (2011) focus on the predictive value of age, gender, height and parental background during a time period when the macroeconomic conditions were very favorable (2004/2005). While in agreement with other studies about the direction of the effect of age and gender, any behavioral biases which may have surfaced during the market crash of the 2008 financial crisis were ominously hidden behind individual's exponentially growing expectations. This potentially results in an overstatement of the magnitude of the predictive value of these observable investor characteristics.

c. Exploring Behavioral Responses to Market Fluctuations

Roszkowski and Grable (2005) warn against analyses like Dohmen et al. (2011) which assign too much diagnostic value to observable demographic factors. In a study conducted by Foerster et. al (2017), on investment information from Canadian households, similar results to Sahm (2012) are found regarding unexplained variance in individual's risk tolerance. Crucially, an investor's observable characteristics explain less than 15% of the portion of stock selection in investor's portfolio. Moreover, any variation between the risk tolerance of investors is converse to the assumption of rational expectations. This further demonstrates the importance of exploring the behavioral biases associated with market fluctuations, which can influence investment decisions.

In particular, understanding the behavioral link between stock market returns and risk tolerance might help explain why investors "exhibit herding behavior by purchasing risky investments during upturns, and selling securities during market downturns" (Grable, Lytton & O'Neill, 2004). This behavior is characterized by: Regret Avoidance, whereby the investor anticipates feeling regret if securities they hold continue to decrease in value unless they sell them, and may sell when they shouldn't; and Projection Bias, whereby investors project current events into the future, and may buy when they shouldn't. Grable, Lytton and O'Neill (2004) demonstrate the presence of Projection Bias behavior in that when there is an increase in the closing price of the NASDAQ, the S&P500 or the Dow Jones, the risk tolerance scores in the subsequent week increase as well.

There are other biases in addition to Regret Avoidance and Projection Bias which could explain how investor's form their beliefs, including Availability Bias, Loss Framing, Loss Aversion and Overconfidence. Availability Bias characterizes a similar judgemental heuristic whereby an investor attributes the occurrence of an event to previous or available examples (Kubilay & Bayrakdaroglu, 2016). This implies that decades of results from risk tail events may be needed for investors to appreciate the risks and rewards attributed to them (Bodie Kane & Marcus, 2018). More often than not, behavioral responses or behavioral biases are the influence of an individual's past experiences or personal beliefs.

Pompian (2012) points out that behavioral biases can be categorized as either cognitive or emotional. Cognitive biases, or how people think, include information processing errors such as Anchoring or Framing. These types of biases can be managed if an advisor is aware of them and educates the investor. Loss Framing is particularly relevant in a situation where a client's answer to the hypothetical loss on paper indicates a certain risk profile where risk aversion is underestimated and only manifests when the next financial crisis hits. Emotional biases are driven by how people feel, and an advisor may have to accept that it is more difficult to change the way

a client feels (Pompian, 2012). Loss Aversion and Overconfidence are examples of how emotions can overpower during times of stress. Interestingly, both the least risk tolerant and the most risk tolerant investors are driven by emotional bias.

3. Data

a. Data Collection and Description

The data in this thesis is collected with the assistance of a private wealth management firm in the Netherlands. They have created their own risk tolerance questionnaire in line with the guidelines from the AFM – as is the norm with investment advisors or asset management firms. It is mandatory, as part of the wealth management firm's onboarding, for each new client to complete a risk tolerance questionnaire with their account manager. The initial sample size for this thesis consists of 213 completed questionnaires from January 2017 to February 2020 which represents over 50% of the firm's total clients. Clients who joined the firm before December 2016 completed a different version of the questionnaire, so they are not included. A second collection of data was made in May 2020 when the same 213 clients were asked to submit another response to the questionnaire as part of a quasi-experiment. This took place a couple of months on from the 'intelligent lockdown' in the Netherlands as a result of the COVID-19 pandemic.

Consistent with the collection of data from the initial sample, the clients completed the questionnaire in the presence of their account manager. In agreement with Dohmen et al. (2011) this both decreases the probability of questionnaire response error but also increases potential noise from the influence of the advisor. Due to the restrictive nature of the lockdown there was difficulty in collecting data from the clients resulting in a response rate of just under 25% (47 clients).

Table 3.1 shows a summary of the demographic characteristics from each collection of data. The percentages give an indication that although small in number, the responding investors are representative of the initial sample pool. The average age in both samples is close to 60, the gender profile in both cases is around 75-25 male dominated and the distribution across the remaining categorical variables is comparable. However, due to the low response rate there is an unbalanced panel. This can be a problem when using a random effects estimator, as the same

weights are applied to those with only one questionnaire response; this will be further addressed in the data analysis.

Table 3.1a, in Appendix B, demonstrates the demographics of the balanced panel of 47 clients in both time periods. More clients are financially independent and retired than when responses to the first questionnaire were recorded. Correspondingly, the distribution of income has shifted to the lower categories and wealth includes more responses in the higher categories. Furthermore, Table 3.1b (Appendix C) contains a similar table of a comparison of the demographics of the 166 clients who did not respond a second time to the 47 clients who did; it demonstrates a very similar distribution across the variables to Table 3.1 below. This indicates that the sub-sample of 47 clients is at least representative of the initial sample of 213 clients.

Table 3.1: Demographics of Initial Sample and of Sub-Sample of Clients with Repeat Responses.

Variable	**Category**	**Panel Data Descriptive Statistics**			
		N=213	(%)	N=47	(%)
Age:	Minimum:	20		35	
	Maximum:	96		76	
	Mean:	58.6		60.4	
	Standard Deviation:	12.2		10.2	
Gender:	Male:	157	(73.7)	36	(76.6)
	Female:	56	(26.3)	11	(23.4)
Education Level:	Primary:	2	(0.9)		
	Secondary:	59	(27.7)	11	(23.4)
	HBO:	89	(41.8)	21	(44.7)
	WO:	63	(29.6)	15	(31.9)
Employment:	Employed:	70	(32.9)	13	(27.7)
	Self-Employed:	69	(32.4)	10	(21.3)
	Financially Independent:	10	(4.7)	5	(10.6)
	Retired:	64	(30)	19	(40.4)
Gross income: (per year, €)	< 25,000:	30	(14.1)	6	(12.8)
	25,000 – 75,000:	98	(46)	28	(59.5)
	75,000 – 125,000:	50	(23.5)	7	(14.9)
	125,000 – 250,000+:	35	(16)	6	(12.8)
Wealth: total assets excl. those invested (€):	0 - 150,000:	67	(31.5)	13	(27.7)
	150,000 - 500,000:	67	(31.5)	16	(34)
	500,000 - 1,000,000:	44	(20.7)	11	(23.4)
	1,000,000 +:	35	(16.4)	7	(14.9)

The risk tolerance questionnaire consists of 37 questions in total (Appendix F). Consistent with the recommendations of the AFM[2], the questionnaire is separated into two parts. The first 25 questions focus on the investors 'Risk Capacity' with the responses indicating certain demographic factors as well as their financial situation. The remaining twelve questions are phrased in a way to measure their 'Risk Appetite'. Each question has response categories from A to D, and in some cases A to E.

b. Questionnaire Responses

The primary reason for conducting this thesis, the occurrence of COVID-19, also proved to be the biggest obstacle in collecting responses. The response rate of 47 clients creates an extremely unbalanced panel, which would have impacted the analysis of the effect of COVID-19. Table 3.2 presents the sub-sample of 47 clients with questionnaire responses in two time periods, once before and once during the COVID-19 pandemic. A similar table containing a comparison of the distribution of responses of the 47 clients to the complete pool of investors, N=213, is in Appendix D (Table 3.2a).

The column labelled T=1 indicates their response from before February 2020 and T=2 contains their more recent response, between May – June 2020. The distribution of the responses in T=2 is more skewed towards the lower categories; clients were generally accepting less variation in their assets, feeling more uncomfortable from decreases in their assets and expecting less annual return from investments.

2 The AFM requires Dutch wealth management firms to first assess risk capacity and risk appetite separately before they are used in combination to create an overall risk profile with which both advisor and client are satisfied (The Netherlands Authority for the Financial Markets, 2011).

Table 3.2: Results from Risk Appetite Questions.

Question (Risk Appetite)	**Category**	**Balanced Panel, N=47; Obs.=94** T=1	(%)	T=2	(%)
Q26. What is the max. variation is acceptable for your assets?	0-10%:	5	(10.6)	10	(21.3)
	10-25%:	12	(25.5)	15	(31.9)
	15-20%:	20	(42.6)	16	(34)
	20+%:	10	(21.4)	6	(12.8)
Q27. What is the annual return you expect from the investments?	0-3%:	2	(4.3)	4	(8.5)
	3-5%:	19	(40.4)	27	(57.4)
	5-7%:	20	(42.5)	13	(27.7)
	7%+:	6	(12.8)	3	(6.4)
Q28. Compared to other people, how much risk do you like to take?	I'm much more risk averse:	1	(2.1)	5	(10.6)
	I'm a little more risk averse:	8	(17)	8	(17)
	I'm average in my risk-taking:	19	(40.5)	21	(44.7)
	I take a little more risk:	15	(31.9)	10	(21.3)
	I take much more risk:	4	(8.5)	3	(6.4)
Q29. How do you feel about the future of our financial system?	Very pessimistic:	0		1	(2.1)
	Pessimistic:	0		7	(14.9)
	Neutral:	25	(53.2)	20	(42.6)
	Optimistic:	21	(44.7)	19	(40.4)
	Very Optimistic:	1	(2.1)	0	
Q30. How do feel about financially being less profitable?	Uncomfortable:	2	(4.3)	4	(8.5)
	Somewhat uncomfortable:	20	(42.5)	22	(46.8)
	Pretty easy:	19	(40.4)	17	(36.2)
	Fine:	6	(12.8)	4	(8.5)
Q31. What word do you associate with risk?	Danger:	0		1	(2.1)
	Uncertainty:	19	(40.4)	23	(48.9)
	Chance:	27	(57.5)	21	(44.7)
	Excitement:	1	(2.1)	2	(4.3)
Q32. What probability of loss would you accept in 5 years' time?	Maximum 5%:	5	(10.6)	8	(17)
	Maximum 10%:	21	(44.7)	24	(51.1)
	Maximum 16%:	11	(23.4)	9	(19.1)
	Could be 16%+:	10	(21.3)	6	(12.8)
Q33. What motivates you more in financial decisions?	Always possible losses:	1	(2.1)	2	(4.3)
	Usually possible losses:	7	(14.9)	13	(27.6)
	Usually possible profits:	35	(74.5)	20	(63.8)
	Always possible profits:	4	(8.5)	2	(4.3)
Q34. What do you look for in a new job?	Good fixed salary:			10	(21.3)
	Reasonable fixed salary, some bonus:	19	(40.4)	19	(40.4)
	Modest fixed salary, good bonus:	27	(57.5)	16	(34)
	Little fixed salary, mainly bonus:	1	(2.1)	2	(4.3)
Q35. Have previous crises influenced your investor behavior?	Yes, I invest less:	2	(4.3)	9	(19.1)
	Yes, but I invest the same:	12	(25.5)	8	(17)
	No, risk is a part of investing:	29	(61.7)	23	(49)
	No, crises are opportunities:	4	(8.5)	7	(14.9)

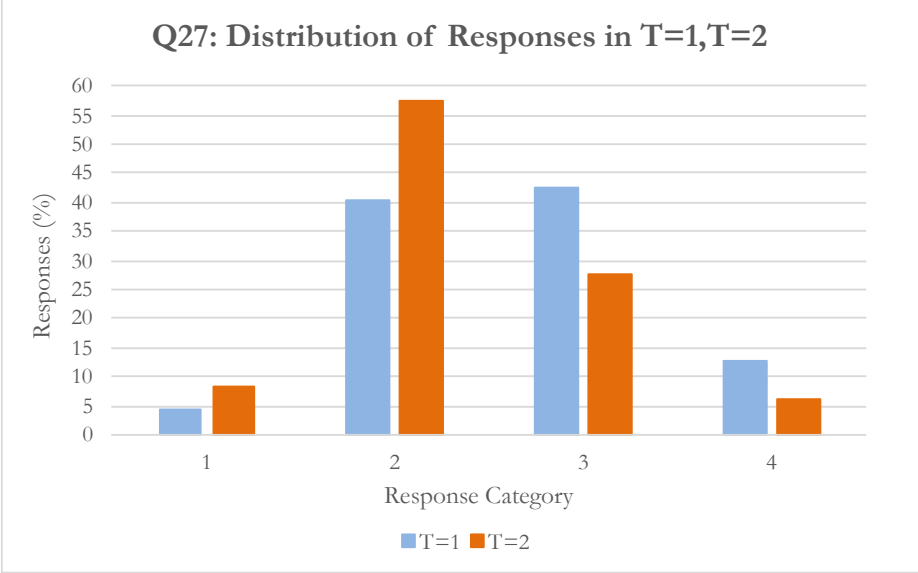
Table 3.2 (cont.): Results from Risk Appetite Questions.

Question (Risk Appetite)	**Category**	**Balanced Panel, N=47; Obs.=94** T=1	(%)	T=2	(%)
Q36. What decrease of your managed assets will make you feel uncomfortable?	Any decrease:	2	(4.3)	4	(8.5)
	10%:	14	(29.8)	18	(38.3)
	25%:	18	(38.3)	18	(38.3)
	40%:	12	(25.5)	6	(12.8)
	50%+:	1	(2.1)	1	(2.1)
Q37. Self-evaluated Risk Tolerance: (0 – 100) **	0 – 20:	1	(2.1)	5	(10.6)
	20 – 40:	6	(12.8)	7	(14.9)
	40 – 60:	21	(44.7)	20	(42.6)
	60 – 80:	17	(36.2)	12	(25.5)
	80 – 100:	2	(4.2)	3	(6.4)

**Investors told tolerance is normally distributed.

Using the data from Table 3.2 (the balanced panel of N=47) bar-charts were constructed to further compare the distribution in each time period. A bar-chart for each of the twelve risk appetite questions can be found in Appendix E. The bar-chart which models Q27, 'What is the annual return you expect from the investments?' is demonstrated in Figure 3.1. This very clearly indicates the distributional shift towards the lower categories.

Figure 3.1: 'What is the annual return you expect from the investments?'



Furthermore, Figure 3.2 demonstrates an increase in 17% of the clients feeling pessimistic about the future of the "financial system/ world economy" (Q29), whereas both pessimistic categories

had no responses before COVID-19. There are however some irregularities in the distributional trend shifting to the lower end of the categories. Figure 3.3 is an example of this, whereby the number of clients who claim to not be influenced by financial crises, and instead see them as opportunities, has doubled (Q35).

Figure 3.2: 'How do you feel about the future of our financial system?'

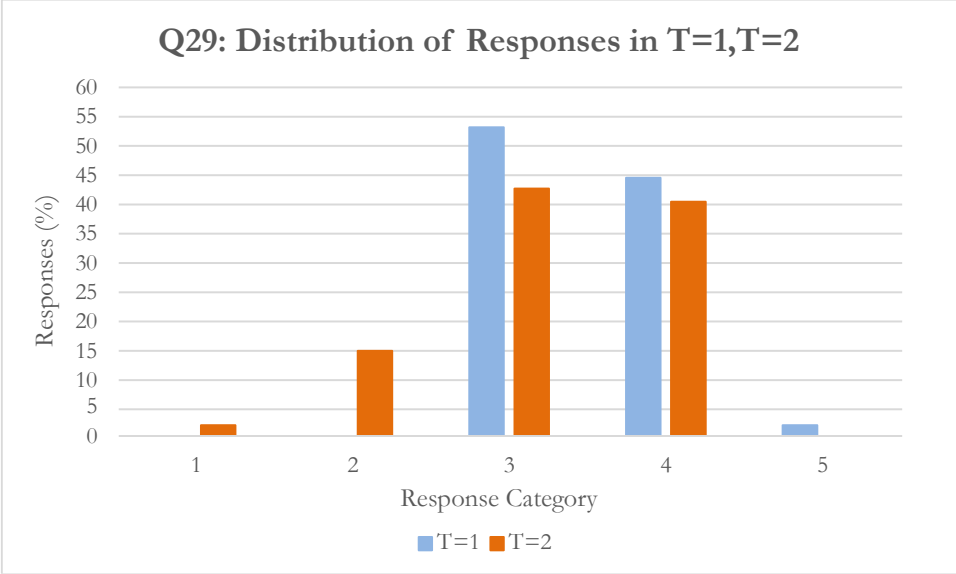
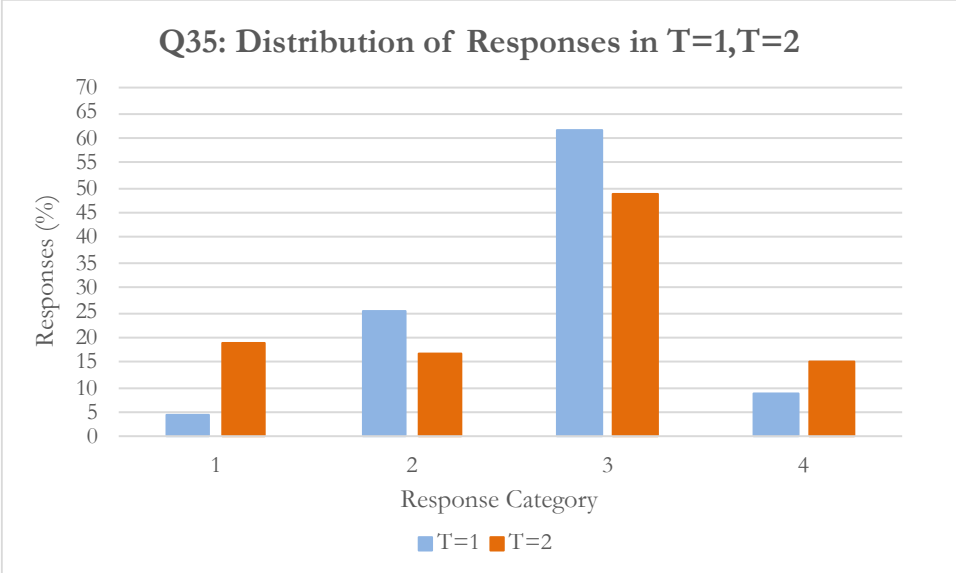


Figure 3.3: 'Have previous financial crises influenced your investor behavior?'



4. Empirical Strategy

a. Hypothesis Development

The framework is based on previous analyses of the significant relationship between financial crises and risk tolerance (Sahm, 2012; Gerrans, Faff & Hartnett, 2015). However, this is converse to what is predicted under the rational expectations model in economics. In order to explore the possibility of these behavioral biases surrounding a risk tail event, the null hypothesis (H0) of this thesis is that investors hold rational expectations, true to classical finance theory. If this is the case, a decrease in risk tolerance is not expected. This is formalized below as H0.

H0: Under rational expectations it is expected that investor risk tolerance will not decrease following the occurrence of a risk tail event.

To conduct the analysis of H0, the dependent variable, risk tolerance, is modelled in Equation 4.1 as a function of explanatory variables which include observable investor characteristics and market indicators. Risk tolerance is measured by the ordered response categories of the risk appetite questions in the questionnaire. The explanatory variable of interest is COVID-19, a dummy variable indicating whether the questionnaire was completed before or after the COVID-19 shock and estimating the effect on risk tolerance. If the estimated coefficient of COVID-19 is significant and negative, this indicates that H0 can be rejected.

Equation 4.1: Factors which Affect Investor Risk Tolerance:

$$Risk\ Tolerance_{it}^{*} = \beta_1 COVID19_t + \beta_2 Age_{it} + \beta_3 Age^2{}_{it} + \beta_4 Female_i + \beta_5 Employment_{it} + \beta_6 Wealth_{it} + \beta_7 Income_{it} + \beta_8 VIX_{it} + \beta_9 Equity\ {}^{Put}/_{Call_{it}} + c_i + \epsilon_{it} \qquad t = 1,2$$

Controls based on significant demographic factors in previous literature of cross-sectional analysis of investor risk tolerance have been included; age, gender and employment status. Whereby a young, self-employed male would have higher risk tolerance. A polynomial variable of age (age^2)

has also been included to also control for a possible relationship between risk tolerance and the rate of the effect of age. Other controls such as income and wealth are predicted, based on previous studies to be positively correlated with risk tolerance, in that higher levels of these variables increase an individual's risk tolerance because any potential losses are cushioned (Dohmen et al., 2011). However, any effect of wealth will be analyzed with caution because of the potential reverse causality; a greater willingness to take risks may lead to a higher level of wealth.

Furthermore, acknowledging that some studies place too much value on demographic factors, the market shock of COVID-19 might be explained by market factors so two proxies for the market are included. The volatility index and a put/call ratio which accounts for market risk and market direction respectively. The total put/call ratio has a tendency to be skewed towards buying, so instead an equity-only put/call ratio is used. Table 4.1 explains how these variables are measured in the model.

Table 4.1: Variables in the Model

Variable	**Explanation**	**Source**
Risk Tolerance*	Ordered response categories	Questionnaire (q26-37)
COVID19	Dummy variable for questionnaires from either existing (0) or retest (1).	Response 1 or 2 of the questionnaire
Age	Age of investor.	Investor information from the firm
Age Squared	To estimate the rate of the effect of 'Age', if any.	
Female	Dummy variable for gender (male =0)	
Employment Status	Dummy variables for each response category	Questionnaire (q.4)
Income	Gross Income per year	Questionnaire (q.22)
Wealth	Total assets not including those invested	Questionnaire (q.19)
VIX (Volatility Index)	Market risk = Monthly average of the daily highs and lows of the VIX	Chicago Board Operations Exchange (CBOE)
Equity-only Put/Call Ratio	Market direction = Monthly average	Chicago Board Operations Exchange (CBOE)

b. Correlated Random Effetcs Ordered Probit Model

In order to analyze the response categories, they are recoded accordingly as a number between one and five to recognize responses which contain non-numerical characters, A-E. In the first part of the questionnaire, 'Risk Capacity' questions, some of the responses are an ordered indicator such as wealth or income whereby the highest response category, y=5, represents a more comfortable financial situation than the lowest response category, y=1. Other questions in this part, including employment status, have responses which are purely categorical; self-employed is not 'less than' retired. As outlined earlier, this is the reason why a linear model is not applicable. The controls used in the model are mostly derived from this part of the questionnaire. Each question was considered as a potential control, but some questions have clearer response categories so in combination with the most frequently used demographic controls in previous literature, the controls were narrowed down.

In the second part of the questionnaire, or the 'Risk Appetite' questions, y=5 is a measure of a higher level of risk tolerance compared with the lowest response of y=1, so that each of the twelve questions effectively represent twelve proxy scales of risk tolerance. It is for this reason that the model will be applied to each of the risk appetite questions individually. Furthermore, undertaking the analysis at an individual question level decreases the potential noise which arises from the arbitrary weights applied by the firm to each question in an overall risk tolerance score.

Using a scale for risk tolerance, rather than a combined overall risk tolerance score, means the dependent variable can be classified as categorical and ordered, with each increase in category indicating a higher level of risk tolerance. Therefore, the appropriate method of analysis is that of an ordered probit model because it allows for non-linear prediction. The use of an ordered probit model on questionnaire data is similar to the analysis undertaken in Sahm (2012) and Dohmen (2011); in other previous risk tolerance literature when the data is less complex, or the response category is in binary form, a basic probit model can used. One consequence of using an ordered

response dependent variable mean that the actual value of y is not observed but can be derived using a latent variable, y* (Wooldridge, 2011).

Using a probit method means that the distance between the categories does not have to be equal or proportional. Wooldridge (2011) formalizes a generalized ordered probit model with y_{it}^{*} conditional on the explanatory variables x_{it}, Equation 4.2. The error term, ϵ_{it}, is assumed to be normally distributed and independent of unobserved individual effects, c_i.

Equation 4.2: Generalized Ordered Probit Model.

$$y_{it}^{*} = x_{it}\beta + c_i + \epsilon_{it}$$

Estimating the model using pooled ordered probit will not account for unobserved individual heterogeneity in the error term, which can result in measurement error. This can imply an endogeneity problem whereby the explanatory variables are correlated with the error term. If it is assumed that the endogeneity is due to time-invariant unobserved individual demographic factors, then using a fixed effects model would solve this problem (Nandi & Longhi, 2015). Stata does not have a fixed effects probit model but does have a random effects probit model. However, using random effects does not solve the potential endogeneity problem as it simply assumes any random effects are uncorrelated with the explanatory variables and additionally it applies the same weight even to non-repeated investors, both of which lead to an inconsistent estimator.

For a more precise regression analysis, only the sub-sample of investors who responded to the second questionnaire from after the development of the COVID-19 pandemic will be used. Furthermore, Wooldridge (2011) demonstrates that the random effects assumption can be partly relaxed by allowing correlation between the unobserved effects and the explanatory variables; an idea originally formulated by Chamberlain (1980), and so is referred to as Chamberlain's random effects probit model. The inclusion of the mean values of the time-varying explanatory variables in the model estimates this partially relaxed assumption. Equation 4.3 demonstrates a Mundlak

(1978) version of Chamberlain's assumption where $\bar{x}_i$ is the mean of $x_i, t = 1, \ldots, T$ and σ_a^2 is the conditional variance of the unobserved individual effects, c_i.

Equation 4.3: Mundlak's version of Chamberlain's Random Effects Model

$$c_i | x_i \sim Normal(\psi + \bar{x}_i \xi, \sigma_a^2)$$

It is acknowledged that the time-constant variables, such as gender, will still contain unobserved heterogeneity. Clustering on the panel variable (each client in the sub-sample), will produce a more consistent estimator when the unobserved individual effects are not identically distributed or there is serial correlation in the error term.

Additional to the limitations of analyses using a small sample size, Sahm (2012) classifies two main types of measurement error when using categorical responses from questionnaire data as independent variables: random noise found in questionnaire responses; and simply the use of a questionnaire to infer individuals' preferences. This random noise may lead to bias in the estimates and can be caused during the data collection process, through misinterpreted questions due to framing, or in the modelling which is used to analyze the data afterwards. The use of a questionnaire to infer risk preferences may be a reason for unexplained systematic variation, particularly in the case of an ordered response category whereby the individual's actual risk tolerance is not observed but instead inferred through a category. Finally, addressing the issue of the unbalanced panel by only using the balanced sub-sample, has the potential to create sampling bias; this will be taken into account when interpreting the results.

5. Results

a. Risk Tolerance Model with Demographic Controls

Using an ordered probit regression allows to control for other factors which may have influenced this distributional shift. The model was applied using correlated random effects to partially relax the assumption of zero correlation between the unobserved effects and control variables. Previous research has warned against placing too much diagnostic value on demographic factors, but they nonetheless provide the baseline controls for this analysis. The model, explained earlier in the hypothesis development, is demonstrated in Equation 5.1 without the inclusion of the market indicators. Running the correlated random effects probit model using Equation 5.1 on each of the twelve risk appetite questions is demonstrated in Table 5.1.

Equation 5.1: Risk Tolerance incl. Demographic Controls.

$$Risk\ Tolerance_{it}^{*} = \beta_1 COVID19_t + \beta_2 Age_{it} + \beta_3 Age^2{}_{it} + \beta_4 Female_i + \beta_5 Employment_{it} + \beta_6 Wealth_{it} + \beta_7 Income_{it} + c_i + \epsilon_{it} \qquad t = 1,2$$

In a probit model, the p-value of Chi² estimates the goodness of fit of the regression. A significant p-value indicates that the coefficients have strong explanatory power in relation to the dependent variable. In Table 5.1, seven of the twelve questions (Q26, Q27, Q29, Q31, Q34, Q36, Q37) used as the dependent variable have a significant Chi² p-value at the 5% significance level, suggesting that the model is a good fit for them.

The coefficients in the output of a probit model do not have a simple interpretation; the values of the coefficients are actually taken to be the z-value of a normal distribution. However, the direction and statistical significance of the coefficients can be interpreted from the output and are the focus of this analysis. A positive value corresponds with the likelihood that the client will be in a higher response category – which indicates a higher risk tolerance.

Table 5.1: Random Effects Probit Model incl. Demographic Controls (without Market Indicators)

Variable	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37
COVID19	-1.248***	-0.771	-0.855**	-1.207***	-0.360	-1.195***	-0.829	-0.463	-0.508*	0.382	-1.382***	-1.494**
	(0.430)	(0.470)	(0.413)	(0.400)	(0.451)	(0.463)	(0.657)	(0.718)	(0.295)	(0.536)	(0.456)	(0.590)
Age	0.936**	0.323	1.575**	-0.809	1.031	1.393*	1.123*	1.284*	0.991	-0.0255	1.577**	1.807**
	(0.465)	(0.424)	(0.711)	(0.745)	(0.665)	(0.733)	(0.593)	(0.699)	(0.629)	(0.490)	(0.744)	(0.776)
Age^2	-0.00527	-0.00233	-0.0131**	0.00789	-0.00867	-0.00838	-0.00876*	-0.0118*	-0.00722	-0.00302	-0.00990*	-0.0127**
	(0.00420)	(0.00387)	(0.00597)	(0.00628)	(0.00574)	(0.00610)	(0.00449)	(0.00606)	(0.00542)	(0.00424)	(0.00588)	(0.00610)
Female	-0.160	-0.528	-1.233*	-0.0156	-0.285	-0.984	-0.516	-0.803	-0.239	0.0645	-0.518	-0.778
	(0.482)	(0.531)	(0.719)	(0.543)	(0.568)	(0.695)	(0.473)	(0.550)	(0.432)	(0.554)	(0.570)	(0.925)
Employed	0.238	0.452	0.772	-1.220	-0.945	-0.776	-0.455	1.159	-0.636	1.653*	0.212	-0.839
	(0.498)	(0.578)	(0.612)	(1.140)	(0.868)	(0.623)	(0.662)	(1.094)	(0.670)	(0.913)	(0.559)	(0.630)
Self-Emp.	-0.714	-0.586	-0.283	-0.964	-0.136	-1.856*	-0.352	-0.449	-1.267	0.279	-1.310	0.304
	(0.588)	(0.677)	(0.662)	(1.135)	(0.923)	(0.953)	(0.494)	(0.688)	(0.848)	(1.110)	(0.840)	(0.686)
F_Independent	-1.786**	-0.931	-0.00629	-1.012*	-0.953*	-1.803**	-0.628	0.186	0.177	1.059*	-0.750	-1.512
	(0.832)	(0.712)	(0.519)	(0.556)	(0.541)	(0.717)	(0.497)	(0.962)	(0.914)	(0.638)	(0.575)	(1.404)
Wealth	0.429	-0.422	0.912**	0.168	-0.348	0.452	0.682*	0.393	0.277	1.346**	0.254	0.713
	(0.361)	(0.403)	(0.462)	(0.357)	(0.279)	(0.546)	(0.405)	(0.460)	(0.255)	(0.554)	(0.363)	(0.736)
Income	-0.230	0.0660	-0.974**	-0.776*	0.218	-0.194	-0.333	-0.328	0.652	-0.0235	-0.189	-1.486***
	(0.366)	(0.421)	(0.392)	(0.404)	(0.424)	(0.285)	(0.327)	(0.426)	(0.397)	(0.297)	(0.297)	(0.496)
Chi^2	0.003***	0.0489**	0.0681*	0.0015***	0.0919*	0.0262**	0.0530*	0.1527	0.0007***	0.3387	0.0000***	0.0379**

The reported coefficients are of a correlated random effects ordered probit model.
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Using these initial demographic controls, seven of the questions demonstrate significant negative COVID-19 coefficient estimates, five of which are significant at the 1% level. As mentioned in the hypothesis development, this is the variable of interest in the null hypothesis. For these seven questions, the COVID-19 estimates suggest that the null hypothesis, which states that under rational expectations investor risk tolerance does not decrease following the occurrence of a risk tail event, can be rejected at the respective significance levels.

The most significant and negative coefficient on COVID-19 is with question 36 as the dependent variable; 'What decrease of your managed assets will make you feel uncomfortable?'. This is also the question with the most significant p-value for Chi^2, indicating the goodness of fit of the model. Moreover, out of the remaining five questions, four demonstrate negative coefficient estimates for COVID-19. Although they are not significant, they do provide an overall indication that lower response categories will be chosen after a risk tail event like COVID-19, which in turn indicates lower risk tolerance.

However, in the twelve risk appetite questions, there is one positive COVID-19 coefficient estimate in Q35. This question records the clients' interpretation of the influence of previous financial crises on their investment decisions. This would indicate that a higher risk tolerance is more likely for this question after the development of COVID-19. This also brings forward whether the client themselves truly understands their risk appetite following a risk tail event – as all other questions indicate a decrease in risk tolerance. Nevertheless, this question has the lowest goodness of fit, which may indicate that there are variables missing which better explain the responses.

As already mentioned, question 36 in Table 5.1 demonstrates the best fit for the model (Chi^2 p-value = 0.000) so the controls will be discussed in relation to this question. Although the estimates of the controls are not consistent across the questions, they can be interpreted in a similar way. The coefficient estimate for Age is positive and significant at the 5% level and the coefficient

estimate of the polynomial Age^2 is negative and significant at the 10% level. This indicates that an older client is more likely to respond to this question in a higher response category but that the rate of this effect of age decreasing so that each additional full unit of age, for example a year, is associated with less than a full unit of corresponding risk tolerance. The negative sign on the Female variable, although not significant, does suggest that a female client is more likely to have a lower response category than a male client, and therefore lower risk tolerance. These first three controls exhibit a similar relationship to risk tolerance as found in previous literature.

Employed, Self-Employed and Financially Independent are part of the Employment Status categorical variable which was included with Retired as the base category. For this reason, the corresponding estimated coefficients are interpreted in relation to retired clients. In this question, employed clients are more likely to be in a higher response category than retired clients, demonstrating a higher risk tolerance. However, both self-employed and financially independent clients are more likely to be in a lower response category and therefore have a lower risk tolerance than retired clients when it comes to a decrease in the value of their assets. This makes sense for self-employed individuals who may have more instability in their other incomes.

The coefficient estimate on wealth is consistent with Dohmen et al. (2011) who note that higher wealth can indicate higher risk tolerance because of the security it provides when considering potential losses. The coefficient on income is negative which would suggest that clients with higher income are more likely to be in a lower response category. This is an interesting result as Dohmen et al. (2011) also expect that income would have the same effect as age and increase risk tolerance, however in this question, higher income indicates a lower risk tolerance.

Table 5.2: Random Effects Probit Model incl. both Demographic Controls and Market Indicators

Variable	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37
COVID19	-1.511*	-0.538	-0.244	-0.807	-0.502	-1.460	-0.443	-1.701	-0.865	0.105	-2.627***	2.172
	(0.773)	(1.157)	(1.406)	(1.776)	(1.006)	(1.400)	(1.284)	(1.155)	(1.054)	(1.307)	(0.891)	(1.513)
Age	1.073**	0.646	2.126***	-0.992	1.049	1.494**	1.234**	1.221*	1.099*	-0.107	1.598**	2.873***
	(0.455)	(0.517)	(0.675)	(0.758)	(0.657)	(0.759)	(0.577)	(0.697)	(0.565)	(0.556)	(0.703)	(0.852)
Age^2	-0.00569	-0.00259	-0.0147***	0.00850	-0.00893	-0.00856	-0.00877**	-0.0122**	-0.00722	-0.00298	-0.0104*	-0.0146**
	(0.00403)	(0.00413)	(0.00566)	(0.00668)	(0.00577)	(0.00609)	(0.00433)	(0.00588)	(0.00482)	(0.00424)	(0.00550)	(0.00644)
Female	-0.199	-0.602	-1.403*	-0.0764	-0.355	-1.070	-0.541	-0.866	-0.273	0.0671	-0.575	-0.969
	(0.490)	(0.591)	(0.779)	(0.528)	(0.529)	(0.724)	(0.455)	(0.534)	(0.449)	(0.557)	(0.585)	(1.047)
Employed	0.0335	0.224	0.522	-1.096	-0.962	-0.912	-0.547	1.179	-0.873	1.718*	0.133	-1.411**
	(0.560)	(0.479)	(0.568)	(1.101)	(0.894)	(0.640)	(0.677)	(1.161)	(0.642)	(0.903)	(0.594)	(0.695)
Self-Employed	-0.916*	-0.763	-0.529	-0.886	-0.154	-1.984*	-0.418	-0.505	-1.481	0.309	-1.465**	0.246
	(0.548)	(0.528)	(0.611)	(0.973)	(0.909)	(1.069)	(0.483)	(0.758)	(0.939)	(1.084)	(0.633)	(0.671)
F_Independent	-2.132***	-1.542**	-0.492	-0.607	-1.002	-2.149***	-0.726	-0.00460	-0.283	1.116*	-1.187*	-1.881
	(0.766)	(0.672)	(0.589)	(0.702)	(0.610)	(0.749)	(0.538)	(1.032)	(0.822)	(0.657)	(0.627)	(1.538)
Wealth	0.436	-0.557	0.884*	0.196	-0.347	0.456	0.643	0.481	0.276	1.386**	0.307	0.514
	(0.329)	(0.458)	(0.459)	(0.349)	(0.278)	(0.544)	(0.395)	(0.451)	(0.214)	(0.573)	(0.291)	(0.805)
Income	-0.110	0.276	-0.868**	-1.023**	0.232	-0.0934	-0.298	-0.247	0.856**	-0.0478	-0.0344	-1.797***
	(0.355)	(0.434)	(0.382)	(0.508)	(0.411)	(0.290)	(0.336)	(0.429)	(0.378)	(0.334)	(0.329)	(0.583)
VIX	0.0113	-0.0330	-0.0630	-0.0270	0.0100	0.0119	-0.0305	0.0844	0.0185	0.0217	0.0811	-0.297***
	(0.0525)	(0.0725)	(0.102)	(0.122)	(0.0668)	(0.0987)	(0.0733)	(0.0805)	(0.0734)	(0.0892)	(0.0668)	(0.105)
Equity P/C	3.516	7.033**	7.692***	-5.713*	0.291	2.877	1.827	1.578	5.037*	-1.140	3.106	6.853***
	(2.320)	(2.957)	(2.124)	(3.369)	(2.480)	(2.837)	(2.517)	(2.649)	(2.649)	(2.878)	(2.639)	(2.627)
Chi^2	0.0067***	0.2738	0.000***	0.0027***	0.0805*	0.0316**	0.0904*	0.0021***	0.0001***	0.2786	0.0000***	0.0061***

The reported coefficients are of a correlated random effects ordered probit model.
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

b. Risk Tolerance Model with Demographic Controls and Market Indicators

Reflecting on Roszkowski and Grable's (2005) warning about placing to much diagnostic value on demographic factors alone and consistent with the outlined equation (4.1) in the hypothesis development, two market indicators are added. Equation 5.2 reproduces the full equation with the market indicators, Volatility Index and Equity-only Put/Call ratio, included. The results of the estimation for each question using this equation are displayed in Table 5.2. As indicated by the Chi² p-value, this complete version of the model is a better fit for most of the questions and eight of the twelve questions have significant p-values (Q26, Q28, Q29, Q33, Q34, Q35, Q36, Q37).

Equation 5.2: Risk Tolerance incl. Demographic Controls and Market Indicators.

$$Risk\ Tolerance_{it}^{*} = \beta_1 COVID19_t + \beta_2 Age_{it} + \beta_3 Age^2{}_{it} + \beta_4 Female_i + \beta_5 Employment_{it} + \beta_6 Wealth_{it} + \beta_7 Income_{it} + \beta_8 VIX_{it} + \beta_9 Equity\ {}^{Put}/_{Call_{it}} + c_i + \epsilon_{it} \qquad t = 1,2$$

Question 28, "Compared to other people, how much risk do you like to take?" now has a p-value of the same significance of question 36 (0.000). This indicates that the model is a good fit for both these questions. In comparing the estimated coefficients of these two questions, they almost all demonstrate the same sign, either both positive or both negative, depending on the control. However, the controls indicate differing levels of significance in each question, and the estimated coefficient for VIX is negative in question 28, but positive in question 36.

The sign on the COVID-19 coefficient estimate in question 37, where the investor is asked to self-evaluate their own risk tolerance, is now positive. Although it is not significant, the direction suggests that some investors see themselves as more risk tolerant. This is similar to the positive COVID-19 estimate in question 25, with more investors seeing crises as opportunities. Both of these questions, although framed differently, ask the investor to evaluate their own risk

tolerance. The remaining ten questions maintain a negative sign on the COVID-19 estimate, so it is possible that the investor does not understand their own tolerance.

Furthermore, the inclusion of these market indicators as controls decreases the number of significant COVID-19 coefficient estimates to only question 26 and 36. This indicates that market volatility and market direction can account for even more of the variation between the questionnaires than including the demographic factors alone. This decrease in the number of questions which have a significant estimate would suggest that the null hypothesis is only rejected at the respective levels for the two questions, (Q26, Q36). However, the coefficients on both market indicators exhibit some significance in the questions, especially the estimated coefficient on Equity-only Put/Call ratio which indicates market direction.

As demonstrated in Table 5.1, the model with only demographic controls, COVID-19 has significant coefficient estimates in seven of the risk appetite questions. The extended analysis which includes market indicators, shown in Table 5.2, reveals significant COVID-19 estimates on two questions only. However, this intervening effect of the market indicators is most likely attributable to COVID-19, which suggests that the COVID-19 pandemic is still a significant factor in a lower risk tolerance.

Moreover, it can be argued that investors whose risk tolerance is overly explained by the market are not being driven by rational expectations, but instead by a behavioral response such as regret avoidance or the projection bias. This relationship between risk tolerance and booms and busts is reflective of the findings in Sahm (2012) around the tech stock bubble.

6. Discussion and Conclusion

Investors have rational expectations according to classical finance theory. This implies that their risk appetite should be more or less constant, because they correctly evaluate the risk of both current and future events when they initially form their beliefs; this is based on the assumption that the occurrence of risks is normally distributed and can be straightforwardly projected. This thesis investigated whether rational expectations hold when faced with the risk tail event of the COVID-19 pandemic, and contributes to a growing body of research which demonstrates that changes in risk tolerance are associated with macroeconomic conditions.

The quasi-experiment conducted with clients from the Dutch wealth management firm generated the data for this thesis. The distributional shift to the left in the client responses to the risk appetite questions reflect a lower risk tolerance. The regression analysis enabled demographic factors which may have influenced the distributional shift to be controlled; but the results are consistent and demonstrate significant negative estimates on COVID-19 in seven of the risk appetite questions. The inclusion of market indicators reduced the significance of the COVID-19 estimate. However, any market fluctuations are most likely attributable to the COVID-19 pandemic, which suggests the effect of COVID-19 is still demonstrated through these indicators. Moreover, the questions which had positive COVID-19 estimates may indicate that the client does not recognize their own risk appetite – as these questions were based on the clients' own evaluation of their tolerance.

So, if investors are not guided by rational expectations, which factors do predict the relationship between risk tolerance and macroeconomics? The field of behavioral finance allows for many biases which are associated with investors incorrectly forming beliefs, but they can be categorized into two arguments: cognitive biases and emotional biases (Pompian, 2012). Cognitive biases offer a potential explanation as to why there is survey response error as a result of incorrect information processing when responding to a risk tolerance questionnaire. If an investor responds

to a hypothetical gamble which they misunderstand because of its framing, it is likely that they will not be satisfied when there is a shock to the market. Emotional biases, which can overpower during times of stress, are of particular interest to this thesis. The questions which indicate that more investors see financial crises as opportunities (Q35), and place themselves higher on a risk tolerance scale (Q37) after COVID-19 are possibly explained under this bias. Overconfidence is an emotional bias which can drive the most risk tolerant investors when they feel under pressure.

For the wealth management industry, this thesis finds that investment advisors and asset managers should spend a considerable amount of time getting to know their clients. Moreover, the exploration of a policy, which incorporates personality tests or otherwise to indicate an investor's propensity for behavioral biases, in MiFID could be beneficial for all European investment advisors. An ongoing dialogue is important, especially in reminding the client of the portfolio which best corresponds with their level of risk tolerance. This may be a portfolio constructed to limit the downside risk in times of crisis, which in turn which sacrifices the potential large gains during a period of market growth. Furthermore, to prevent a loss of relationship between advisor and client, educating both parties on behavioral biases would help the advisor to recognize situations when they might emerge and would challenge the client to understand how basic psychological concepts are getting in the way of making rational investment decisions – or worse, getting in the way of satisfaction with their investments.

The findings of the analysis are broadly in agreement with previous studies, yet in this thesis the magnitude associated with of the effect cannot be inferred from the probit model alone. Additionally, there may be biases in the estimated coefficients associated with the sample selection and the resulting sample size in this analysis. Furthermore, the time period studied is very recent, which is a key difference between this paper and the framework found in Sahm (2012) and Gerrans, Faff & Hartnett (2015). Suggestions for further research involve conducting an analysis of investor risk tolerance around the COVID-19 pandemic, with a larger sample pool, and at a

later date. This will allow time for a full realization of the macroeconomic impact. It is plausible to predict an even bigger shift in risk tolerance if the economy sees a further decline. Investors often need to see a major downturn to anticipate the risks associated with these risk tail events.

7. References

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8. Appendices

Appendix A: Overview of summary statistics from Grable (2016).

Individual Characteristic	**Assumed More Risk Tolerant**	**Level of Support in Literature**
Gender	Male	High
Age	Young	Moderate
Marital Status	Single	Moderate
Marital/Gender Interaction	Single Male	High
Income	High	Moderate
Net Worth	High	High
Financial Satisfaction	High	High
Financial Knowledge	High	High
Education	Bachelor's Degree +	Moderate
Employment Status	Full-Time Employed	Moderate
Income Source	Business Owner	High
Income Variability	Stable and Predictable	High
Self-Esteem	High	High
Personality	Type A	High
Sensation Seeking	High	High

Appendix B: Table 3.1a.

Table 3.1a: Demographics of Balanced Panel of Sub-Sample of Clients with Repeat Responses.

Variable	**Category**	**Balanced Panel Descriptive Statistics**			
		T=1	(%)	T=2	(%)
Age:	Minimum:	31		35	
	Maximum:	74		76	
	Mean:	58.5		60.4	
	Standard Deviation:	10.2		10.2	
Gender:	Male:	36	(76.6)	36	(76.6)
	Female:	11	(23.4)	11	(23.4)
Education Level:	Secondary:	10	(21.3)	11	(23.4)
	HBO:	22	(46.8)	21	(44.7)
	WO:	15	(31.9)	15	(31.9)
Employment:	Employed:	17	(36.2)	13	(27.7)
	Self-Employed:	11	(23.4)	10	(21.3)
	Financially Independent:	3	(6.4)	5	(10.6)
	Retired:	16	(34)	19	(40.4)
Gross income: (per year, €)	< 25,000:	4	(8.5)	6	(12.8)
	25,000 – 75,000:	28	(59.6)	28	(59.5)
	75,000 – 125,000:	9	(19.1)	7	(14.9)
	125,000 – 250,000+:	6	(12.8)	6	(12.8)
Wealth: total assets excl. those invested (€):	0 - 150,000:	16	(34)	13	(27.7)
	150,000 - 500,000:	17	(36.2)	16	(34)
	500,000 - 1,000,000:	8	(17)	11	(23.4)
	1,000,000 +:	6	(12.8)	7	(14.9)

Appendix C: Table 3.1b.

Table 3.1b: Demographics of Non-Responding Clients vs. Responding Clients (T=1).

Variable	**Category**	**Descriptive Statistics N=213, T=1**			
		N=166	(%)	N=47	(%)
Age:	Minimum:	20		31	
	Maximum:	96		74	
	Mean:	58.5		58.5	
	Standard Deviation:	12.7		10.2	
Gender:	Male:	121	(72.9)	36	(76.6)
	Female:	45	(27.1)	11	(23.4)
Education Level:	Primary:	2	(1.2)	0	
	Secondary:	49	(29.5)	10	(21.3)
	HBO:	67	(40.4)	22	(46.8)
	WO:	84	(28.9)	15	(31.9)
Employment:	Employed:	53	(31.9)	17	(36.2)
	Self-Employed:	58	(35)	11	(23.4)
	Financially Independent:	7	(4.2)	3	(6.4)
	Retired:	48	(28.9)	16	(34)
Gross income: (per year, €)	< 25,000:	26	(15.6)	4	(8.5)
	25,000 – 75,000:	70	(42.2)	28	(59.6)
	75,000 – 125,000:	41	(24.7)	9	(19.1)
	125,000 – 250,000+:	29	(17.5)	6	(12.8)
Wealth: total assets excl. those invested (€):	0 - 150,000:	51	(30.7)	16	(34)
	150,000 - 500,000:	50	(30.1)	17	(36.2)
	500,000 - 1,000,000:	36	(21.7)	8	(17)
	1,000,000 +:	29	(17.5)	6	(12.8)

Appendix D: Table 3.2a.

Table 3.2a: Risk Appetite Questions; Initial Sample vs. Sub-Sample

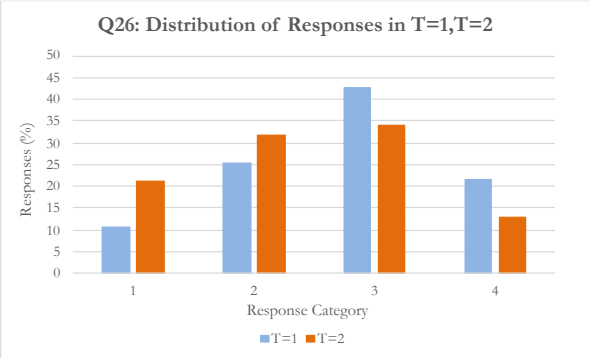
Question (Risk Appetite)	**Category**	**Unbalanced Panel; T=1, T=2** N=213	(%)	N=47	(%)
Q26. What is the max. variation is acceptable for your assets?	0-10%:	15	(7)	10	(21.3)
	10-25%:	60	(28.2)	15	(31.9)
	15-20%:	100	(47)	16	(34)
	20+%:	38	(17.8)	6	(12.8)
Q27. What is the annual return you expect from the investments?	0-3%:	5	(2.3)	4	(8.5)
	3-5%:	89	(41.8)	27	(57.4)
	5-7%:	96	(45.1)	13	(27.7)
	7%+:	23	(10.8)	3	(6.4)
Q28. Compared to other people, how much risk do you like to take?	I'm much more risk averse:	3	(1.4)	5	(10.6)
	I'm a little more risk averse:	26	(12.2)	8	(17)
	I'm average in my risk-taking:	103	(48.4)	21	(44.7)
	I take a little more risk:	67	(31.4)	10	(21.3)
	I take much more risk:	14	(6.6)	3	(6.4)
Q29. How do you feel about the future of our financial system?	Very pessimistic:	0		1	(2.1)
	Pessimistic:	9	(4.2)	7	(14.9)
	Neutral:	107	(50.2)	20	(42.6)
	Optimistic:	94	(44.2)	19	(40.4)
	Very Optimistic:	3	(1.4)	0	
Q30. How do feel about financially being less profitable?	Uncomfortable:	6	(2.8)	4	(8.5)
	Somewhat uncomfortable:	90	(42.3)	22	(46.8)
	Pretty easy:	92	(43.2)	17	(36.2)
	Fine:	25	(11.7)	4	(8.5)
Q31. What word do you associate with risk?	Danger:	2	(1)	1	(2.1)
	Uncertainty:	85	(39.9)	23	(48.9)
	Chance:	124	(58.1)	21	(44.7)
	Excitement:	2	(1)	2	(4.3)
Q32. What probability of loss would you accept in 5 years' time?	Maximum 5%:	18	(8.5)	8	(17)
	Maximum 10%:	90	(42.2)	24	(51.1)
	Maximum 16%:	61	(28.6)	9	(19.1)
	Could be 16%+:	44	(20.7)	6	(12.8)
Q33. What motivates you more in financial decisions?	Always possible losses:	2	(1)	2	(4.3)
	Usually possible losses:	26	(12.2)	13	(27.6)
	Usually possible profits:	163	(76.5)	20	(63.8)
	Always possible profits:	22	(10.3)	2	(4.3)
Q34. What do you look for in a new job?	Good fixed salary:	29	(13.6)	10	(21.3)
	Reasonable fixed salary, some bonus:	84	(39.4)	19	(40.4)
	Modest fixed salary, good bonus:	85	(39.9)	16	(34)
	Little fixed salary, mainly bonus:	15	(7.1)	2	(4.3)
Q35. Have previous crises influenced your investor behavior?	Yes, I invest less: binary	7	(3.3)	9	(19.1)
	Yes, but I invest the same:	42	(19.7)	8	(17)
	No, risk is a part of investing:	145	(68.1)	23	(49)
	No, crises are opportunities:	19	(8.9)	7	(14.9)
Q36. What decrease of your managed assets will make you feel uncomfortable?	Any decrease:	5	(2.3)	4	(8.5)
	10%:	57	(26.8)	18	(38.3)
	25%:	111	(52.1)	18	(38.3)
	40%:	34	(16)	6	(12.8)
	50%+:	6	(2.8)	1	(2.1)

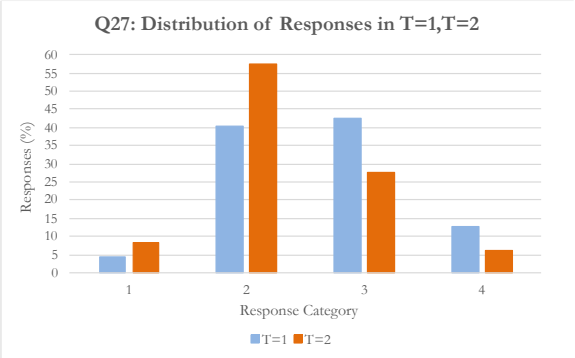
Table 3.2a: Risk Appetite Questions; Initial Sample vs. Sub-Sample

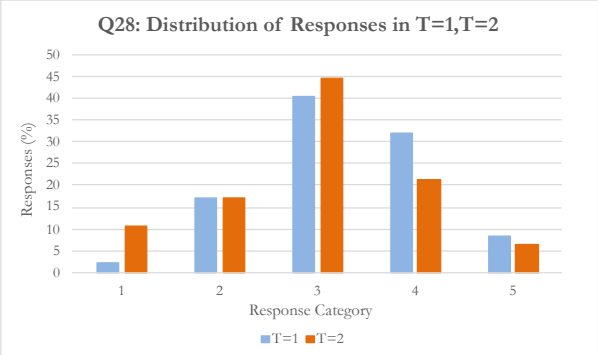
Q37. Self-evaluated Risk Tolerance: (0 – 100) **	0 – 20:	2	(1)	5	(10.6)
	20 – 40:	26	(12.2)	7	(14.9)
	40 – 60:	105	(49)	20	(42.6)
	60 – 80:	75	(35.2)	12	(25.5)
	80 – 100:	5	(2.3)	3	(6.4)

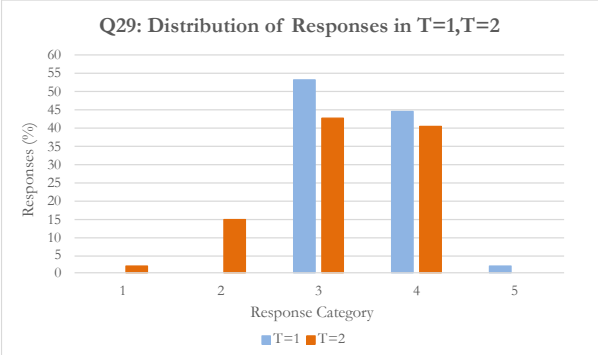
**Investors told tolerance is normally distributed.

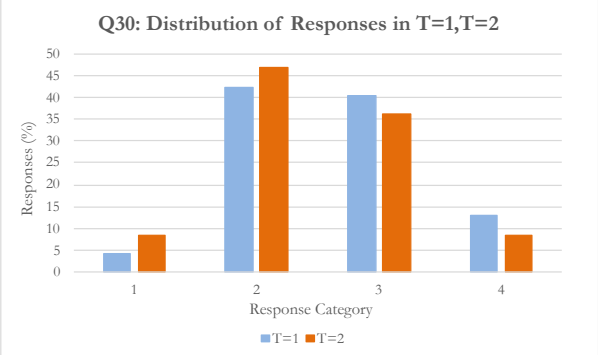
Appendix E: Distribution of 'Risk Appetite' Questions (Balanced Panel of N=47)

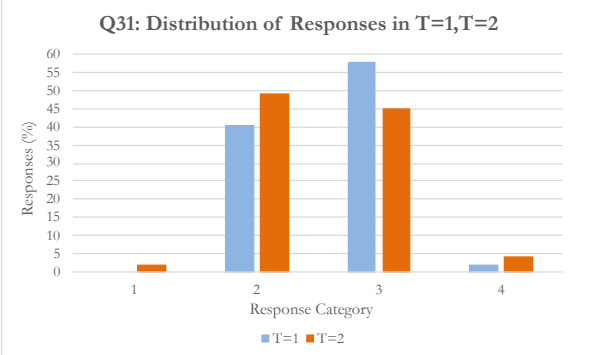


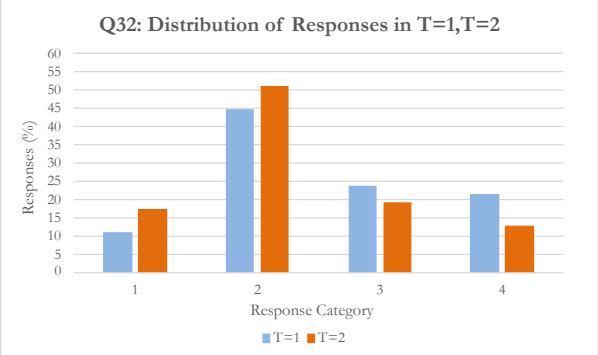


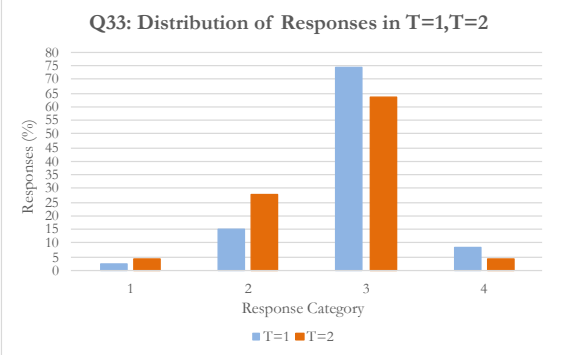


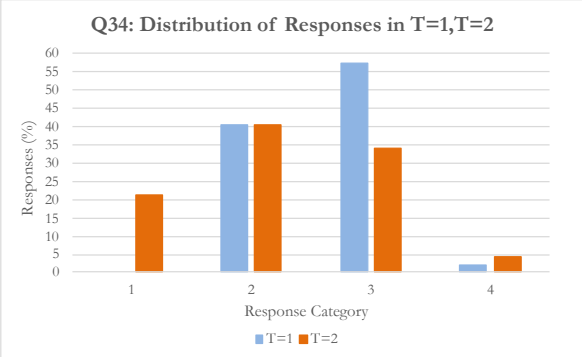


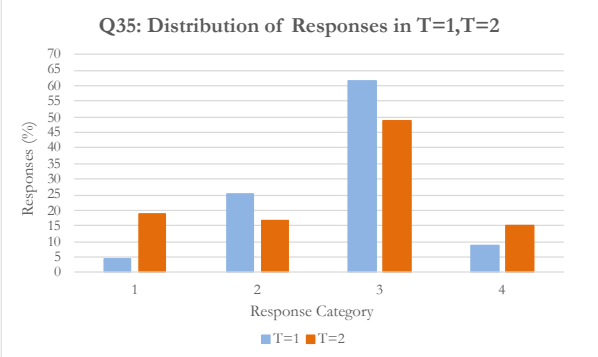


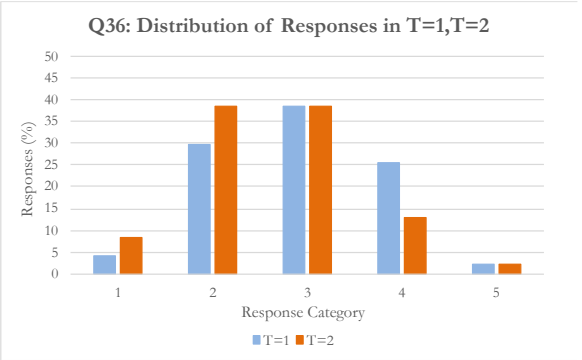


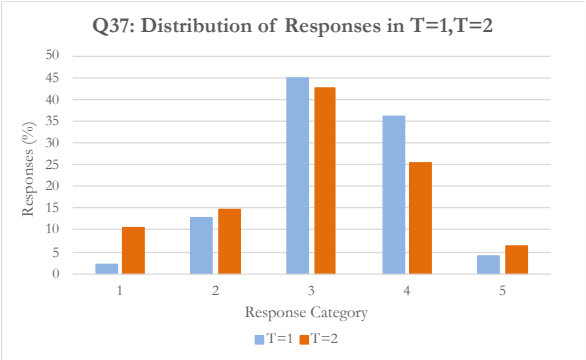





Q34: Distribution of Responses in T=1,T=2
Responses (%)
Response Category
T=1 T=2


Q35: Distribution of Responses in T=1,T=2
Responses (%)
Response Category
T=1 T=2


Q36: Distribution of Responses in T=1,T=2
Responses (%)
Response Category
T=1 T=2


Q37: Distribution of Responses in T=1,T=2
Responses (%)
Response Category
T=1 T=2

Appendix E: Risk profiling questionnaire from the wealth management firm.

General Questions:

1. What age group do you fall into?
[ ] Under 50 years of age
[ ] between the ages of 50 and 65
[ ] over 65 years old

2. I'm filling out this profile for you:
[ ] Private
[ ] Joint account
[ ] Legal entity (BV, NV, Stichting)

3. What is your level of education?
[ ] Primary education
[ ] Secondary education / MBO
[ ] HBO
[ ] WO

4. I'm mainly employed...
[ ] Employed
[ ] Self-employed
[ ] Not working anymore because I'm financially independent.
[ ] Not working anymore because I'm on (pre)retirement.

5. Which asset management situation applies
[ ] Asset management for my personal assets
[ ] Asset management within the framework of a foundation, pension B.V. or annuity policy
[ ] Wealth advice where I agree to the proposed transactions
[ ] Asset advice where I want to be in charge of transactions myself ('execution-only').

Questions about investing in general:

6. How long have you been investing?
[ ] 1 year or less
[ ] 1 to 5 years
[ ] 5 to 10 years
[ ] for more than 10 years

7. What is the nature of your experience?
[ ] No experience
[ ] I've had my assets managed by an asset manager in the past...
[ ] I've always given orders myself in the past.
[ ] I've both given orders in the past and had my assets managed by an asset manager

8. In the past, I have mainly invested / had my assets invested in? Please note: please tick one option.

[ ] Stocks
[ ] Bonds
[ ] Investment funds
[ ] Derivatives
[ ] Structured products
[ ] Not applicable

9. How much knowledge do you have about shares?
[ ] None to little
[ ] Average
[ ] Deep

10. How much knowledge do you have about investment funds?
[ ] None to little
[ ] Average
[ ] Deep

11. How much knowledge do you have about bonds?
[ ] None to little
[ ] Average
[ ] Deep

12. How much knowledge do you have about derivatives?
[ ] None to little
[ ] Average
[ ] Deep

13. How much knowledge do you have about structured products?
[ ] None to little
[ ] Average
[ ] Deep

14. How do you characterise your own experience as an investor?
[ ] Experienced
[ ] Average
[ ] Not experienced

15. What was your transaction volume in the past year, i.e. what percentage of your portfolio did you change into in the past year (if and to the extent that asset management has not been used)?
[ ] Less than 25%
[ ] Between 25 and 100%
[ ] Over 100%.
[ ] Not applicable, because I didn't manage my own assets

16. What was your transaction frequency in the past calendar year (if and to the extent that it was not used of asset management)?
[ ] Weekly
[ ] Monthly

[ ] Less often or not applicable because I'm not investing

17. What is the purpose of your investments?
[ ] Pure capital growth
[ ] Pure income growth, there will be periodic withdrawals
[ ] Capital growth combined with income growth (i.e. part of annual withdrawal of profits)
[ ] Pension accrual
[ ] Supplementary pension

18. What percentage of your freely available assets do you invest?
[ ] 0 to 10 %
[ ] 10 to 20%
[ ] 20 to 40%
[ ] 40 to 60%
[ ] 60 to 100 %

19. How large is your total assets (investments and savings)? Excluding the assets that will become invested (with the firm).
[ ] between €0 and €150,000
[ ] between €150,000 and €500,000
[ ] between €500,000 and €1,000,000
[ ] over €1,000,000

20. How long are the funds available for investment?
[ ] less than 5 years
[ ] 5 to 10 years
[ ] 10 to 15 years
[ ] for more than 15 years

21a. Is part of your investments at the firm financed with borrowed money?
[ ] No, nothing at all.
[ ] Yeah, a small part (up to 15%)
[ ] Yeah, quite a bit. (up to 30%)
[ ] Yeah, a big part (over 30%)

21b. If you answered question 21a with Yes, please enter the percentage of your total power that you have invested or are going to invest with borrowed money: _____%

Financial Situation:

22. In which category does your current (gross) income fall?
[ ] less than € 25,000 per year
[ ] between € 25,000 and € 75,000 per year
[ ] between € 75,000 and € 125,000 per year
[ ] between € 125,000 and € 250,000 per year
[ ] more than € 250,000 per year

23a. My current income is?
[ ] Not enough for my fixed expenses and livelihood; my assets must provide additional returns.

[ ] Sufficient for my fixed expenses and subsistence.

23b. Current annual expenditure (excluding mortgage interest/taxes payable) is :
[ ] less than € 50,000 per year
[ ] between € 50,000 and € 100,000 per year
[ ] between € 100,000 and € 150,000 per year
[ ] more than €150,000 per year

23c. Can you break down your total income in percentages by source of income?
1. Occupation/AOW/Pension approximately [ ]%
2. Savings/investments around [ ]%
3. Rent approximately [ ]%
4. Profits from significant shareholdings around [ ]%
5. Otherwise, around [ ]%.

24. Have you (had) dealings in financial instruments on a professional basis?
[ ] Yes.
[ ] No.

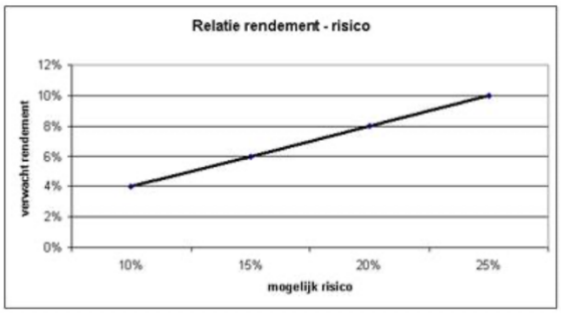
25. Have you received training in which you have acquired knowledge of financial instruments
[ ] Yeah.
[ ] No.

Risk Appetite:

26. Investments fluctuate in value, upwards, but sometimes also downwards. Yields may be better than expected (higher and disappointments (lower than expected). The extent to which investments can be favourable or disappointing depends on depending on how agile or volatile the returns are. Mobility or volatility is a measure of risk. The agility is normally expressed in terms of a percentage in which a given investment may fluctuate on an annual basis (with 68% reliability). An instrument with a mobility of 5% is thus assumed to go up and down by 5% on an annual basis. The following is an indication of agility (also known as volatility) of some investment categories:

High-rated government bonds (AAA-AA) 3.5%
High-rated corporate bonds (investment grade) 5.0%
High-yield corporate bonds 15.0%
Developed country equities 17.5%
Emerging market equities 22.5%
Real estate 9.5%

In general, a portfolio with a higher expected return carries a higher risk, in terms of mobility or volatility, it should be. See also the appendix to the asset management contract relating to risk. The graph below shows the relationship between the expected return and the possible risk (the graph is indicative, the actual ratio differs per portfolio).



What maximum mobility in percentages per year is still acceptable to you?
This question is only meant to measure your risk appetite, it is not a guarantee regarding the maximum loss on your investments. It is not possible to achieve a high expected return at low risk.
[ ] between 0% and 10% per year
[ ] between 10% and 15% per year
[ ] between 15% and 20% per year
[ ] more than 20% per year

27. Depending on the risk you are prepared to take, it is possible to generate a certain expected return. It is not possible to realise a high expected return with a low risk. What is the annual return that you expected from your investments?
[ ] between 0% and 3% per year
[ ] between 3% and 5% per year
[ ] between 5% and 7% per year
[ ] more than 7% per year

28. Compared to other people, how do you estimate how much risk you normally dare to take?
[ ] I'm much more risk-averse than most people
[ ] I'm a little more risk-averse than most...
[ ] I'm average in my risk appetite
[ ] I dare to take a little more risks than most...
[ ] I dare to take much more risk than most...

29. What do you feel when you think about the future of our financial system / the world economy?
[ ] Very pessimistic
[ ] Pessimistic
[ ] Neutral
[ ] Optimistic
[ ] Very optimistic.

30. How do you feel when things are (financially) less profitable than initially thought?
[ ] Uncomfortable
[ ] Somewhat uncomfortable
[ ] Pretty easy
[ ] Fine.

31. When you think of the word "Risk," what do you think of?

[ ] Danger
[ ] Uncertainty
[ ] Chance
[ ] Excitement

32. In the case of investments, there are no guarantees. What chance do you accept that the final capital in five years' time will be lower than the
initial capital (without deposits and withdrawals)?
[ ] Maximum 5% (i.e. probability of 1 in 20 to end up with less capital started)
[ ] Maximum 10% (probability of 1 in 10)
[ ] Maximum 16% (probability of overall 1 in 6)
[ ] I don't have a percentage for five years in my head. It could be more than 16%.

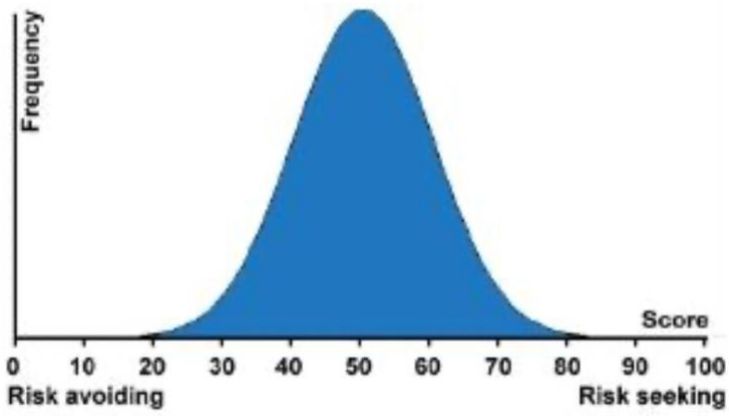
33. If you have to make financial decisions, are you more with the potential losses or more with the potential losses?
making profits?
[ ] Almost always with the possible losses
[ ] Usually with the possible losses
[ ] Usually with the possible profits
[ ] Almost always with the possible profits

34. Suppose you're looking for a new job. Which form of reward is best for you?
[ ] Good fixed salary
[ ] Reasonable fixed salary, plus a small bonus opportunity in case of good performance
[ ] Modest fixed salary, plus reasonably good bonus opportunity in case of good performance
[ ] Little fixed salary, but very good bonus opportunity if you perform well.

35. The last ten years we have had the necessary stock market crises, such as the bursting of the internet bubble (2000-2003), the bursting of the property bubble (2007-2009) and the credit crisis. Did these crises affect your influenced investment behaviour?
[ ] Yes, I've become more cautious and tend to invest less actively.
[ ] Yeah, I've become more cautious, but I'm still inclined to invest just as actively
[ ] No, this hasn't affected me. I know that risk is part of investing and it always has been.
[ ] No, I see those crises as opportunities, to possibly invest extra at lower levels...

36. What can go up hard can also go down hard temporarily. What decrease (in percentage) of your assets managed at the firm is going to make you feel uncomfortable?
[ ] Every drop actually makes me uncomfortable
[ ] 10%
[ ] 25%
[ ] 40%
[ ] More than 50%.

37. Your risk score, which will be determined on the basis of the answers to the above questions, will be given a score of 0-100 (0 is very defensive and 100 is very offensive). This score forms the so-called normal distribution ('bell-curve'), where most people end up around 50. Where do you think your score will come out?



[ ] Between 0 and 20
[ ] Between 20 and 40
[ ] Between 40 and 60
[ ] Between 60 and 80
[ ] Between 80 and 100