

# THE INFLUENCES OF FINANCIAL TECHNOLOGY ON RISK TAKING: ROBO-ADVISORS AND PORTFOLIO ALLOCATION



**Radboud Universiteit Nijmegen**

## Master Thesis

*In this research, the influence of financial advice being provided by digital or technological means on investment decisions will be measured through an experiment to see whether portfolio allocation changes based on digital financial advice, with the advice being personalized for each participant through a survey filled out to determine risk preference. The dataset counts 113 completed responses, 55 receiving the treatment with digital personalized advice, or 'robo-advice', and 58 participants receiving the second treatment without any advice. The results of the research suggest that participants change their investment decision significantly after receiving robo-advice, moving closer to the direction that their personalized advice suggests.*

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# TABLE OF CONTENTS

|   |    |
|---|----|
| 1. Introduction .....                           | 3  |
| 2. Literature Review .....                      | 5  |
| 2.1 Financial Technology .....                  | 5  |
| 2.2 Robo-advisory .....                         | 7  |
| 2.3 Portfolio Allocation & Risk Attitudes ..... | 9  |
| 3. Methodology .....                            | 10 |
| 3.1 What is being researched.....               | 10 |
| 3.2 Research Method.....                        | 11 |
| 3.3 Order Effect & Attention Check.....         | 12 |
| 3.4 Contents & Format of the survey .....       | 13 |
| 4. Results .....                                | 17 |
| 4.1 Data .....                                  | 17 |
| 4.1.1 Investment Decisions.....                 | 18 |
| 4.1.2 Risk Attitude.....                        | 19 |
| 4.1.3 Financial Knowledge.....                  | 20 |
| 4.2 Regression Analysis .....                   | 23 |
| 5. Conclusion.....                              | 28 |
| 6. Discussion .....                             | 30 |
| 7. References .....                             | 32 |
| APPENDIX A1. DATA .....                         | 35 |
| APPENDIX A2. FULL SURVEY .....                  | 36 |

# 1. INTRODUCTION

In this Master Thesis, an in-depth look at the influence of financial technology on risk taking will be provided. More specifically, the influence of financial advice being provided by digital or technological means will be measured through an experiment to see whether portfolio allocation changes based on digital financial advice, coming from a survey filled out to determine risk preference. This digitalized process of financial advice is rapidly replacing current day ‘human’ financial advisors, due to lower entry barriers, easier accessibility and lower fees (Jung, Dorner, Glaser & Morana, 2018). Especially when an individual is investing with smaller amounts, an actual human financial advisor is often not an option due to this high minimal capital investment and high fees. Before online advice, this meant that investing smaller amounts would be done manually. Therefore, the research question that will be used throughout this Master Thesis is as follows:

*Do individuals allocate their portfolios differently when they are being advised by robo-advisors compared to manually investing without any prior advice?*

As robo-advisory practices are very modern and expanding rapidly, the research in this area is lacking. There is plenty to be found about the influence of a human financial advisor, but robo-advisory is new grounds for the financial world. Especially the consequences of robo-advisory on certain aspects of investor behavior like portfolio allocation have not been properly mapped out yet and that is where this research will attempt to fill a literary gap and lay foundations for future work in this area.

The main hypothesis that will be tested in this research is that robo-advisory will lead to a significantly different allocation of an individuals’ portfolio compared to manually investing without any prior advice. Besides that, I expect that investors with a small amount of financial knowledge will take less risk than investors with a bigger amount of financial knowledge. In this case, I also expect that investors with a small amount of financial knowledge will be taking more risk when advised by the robo-advisor, as they feel that they are potentially making a more informed decision. This is expected to have a lesser effect on individuals with a higher amount of financial knowledge, since they are more likely to stick to their own knowledge over the financial advice provided by the robo-advisor. In other words, I expect the participants with a lower financial knowledge to follow the advice better.

The research is centered around the consequences of robo-advisory, which will be tested by means of a questionnaire of four parts. Twice the participants will be confronted with the option to invest €20,000 in stocks & bonds or to not invest and receive the flat amount after a year. There are two different treatments to account for the order effect bias. For the first treatment, once they will have no advice,

and once they will receive robo-advice determined by a survey on their risk attitude. After this survey is completed, the two investment opportunities can be compared in order to draw conclusions on the influence of robo-advice on risk taking and portfolio allocation. The other treatment has to make the same investment decision twice, without any advice or survey in between.

The main goal of this thesis is not to state that taking more or less risk is better, but it is about finding out the influence of robo-advisory on the risk attitude of small-budget investors. The two options, when an individual decides they want to invest, are either to invest manually without advice, or to use a robo-advisor. Human advisors are not a possibility since they have too high of an entry barrier (Jung, Dorner, Glaser & Morana, 2018).

The survey has been filled out by 130 participants. The goal was to have at least 50 participants in each of the two treatment groups. Of the 130 participants, 10 did not complete the survey, and 7 got removed due to failing the attention check. 113 participants remained, fully completing the survey. 55 participants received treatment one (with robo-advice), and 58 received treatment two (without robo-advice).

The initial results showed that there was a shift of 5.91% towards bonds in the group which received robo-advice, compared to a shift of only 0.46% towards bonds in the group which did not receive advice. This suggests that participants who have received robo-advice have changed their investment behavior into a more conservative, risk averse allocation. To test whether this shift was significant, a regression analysis has been performed on the allocation difference of all participants. The coefficient 'Advice' which is a dummy variable for whether people received advice or not, was -5.440 and significant at a 5% level. This does mean that the shift that table 2 showed, appears to be significant. Therefore the initial conclusion is that the research performed in this thesis suggests that robo-advice significantly influences investment decisions.

Financial knowledge does appear to influence the amount of risk a participant would assume. The coefficient regarding financial knowledge had a value of 4.043, which means that the more financial knowledge an individual had, the more an individual would invest in stocks compared to bonds. This coefficient is a relatively high positive number which is significant at a 5% level after robustness checks. The hypothesis that financial knowledge influences how well participants listen to advice has not been proven, since the financial knowledge statistic in the regression on allocation difference was not significant, not even at a 10% level. This suggests that regardless of the amount of financial knowledge, participants did not significantly alter their behavior regarding the average difference between the first and the second decision.

## 2. LITERATURE REVIEW

### 2.1 Financial Technology

Financial Technology, often referred to as Fintech, is a broad term describing a new financial industry which includes any form of technology that improves financial activities (Schüffel, 2016). ‘Fintech’ is a relatively new term, but financial technology is as old as technology itself. This also means that this technology isn’t always exclusive to finance like the Automatic Teller Machine (ATM) (Arner, Barberis & Buckley, 2015). Take for example the internet. The internet is one of the most important technological innovations ever created, dating all the way back to 1965 when the first low-speed dial up network ever has been built (Leiner, Cerf, Clark, Kahn, Kleinrock, Lynch, Postel, Roberts & Wolff, 1997). The internet had great consequences almost for every industry in the world, fintech not excluded.

After the Global Financial Crisis in 2008, public perception of financial institutions such as banks became more realistic and pessimistic. Millions of Americans lost their jobs, and especially financial institutions were shaken up massively, reporting worldwide losses of over 1.37 trillion USD, a number larger than the entire GDP of India at the time (Smith & Paterson, 2009).

A global crisis of this size meant that faith in the current system was weakened, which opened many doors for new Fintech to enter the market. Especially due to the fact that many fingers were pointed at the banking system, Fintech evolved into digital means to replace services that are usually provided by banks (Arner, Barberis & Buckley, 2015). Fintech is often referred to as a disruption of the financial industry (Cai, 2018; Arner, Barberis & Buckley, 2015; Scott, Loonam, Kumar, 2017). This ‘disruption’ has taken on many forms. The five main categories that modern Fintech can be divided into are as follows (Arner, Barberis & Buckley, 2015):

1. Finance and investment – Alternative methods for financing, e.g. **crowdfunding**.

Crowdfunding is one of the most common and successful parts of modern Fintech, which directly interferes with banking as financial intermediaries. Equity for new startups is provided by the general public, no bank or other traditional intermediary is involved in this particular method of funding (Cai, 2018). Another major part of this category is robo-advisory. **Robo-advisory** almost entirely cuts out the human middleman in the financial advice branche, by offering digital algorithm-based financial advice for portfolio allocation derived by questionnaires or surveys (Jung, Dorner, Glaser, Morena, 2017). A more in-depth look at robo-advisory will be provided in the following section 2.2.

2. Financial operations and risk management – Financial institutions are seeking to build better **compliance systems** due to the enormous regulatory changes that were caused by the financial crisis of 2008. Besides this, an increasing amount of money is being spent at developing digital systems to manage risk and maximize the profit associated with this risk (Arner, Barberis & Buckley, 2015).
3. Payments and infrastructure – The **digitalization of payments** through the internet and mobile phones has been an increasingly large part of Fintech, starting with the internationalization of electronic payments (Arner, Barberis & Buckley, 2015). More recently, digitalized trading of securities and derivatives are increasingly excluding traditional financial institutions as middlemen, finding new intermediaries in Fintech companies. An example of excluding banks is PayPal, an alternative to banks for online payment and money storage (an electronic wallet). Paypal was founded in 1999 and surging to the top with an all-time high of 200 million users as of march 2019, indicating that it is very much a growing business<sup>1</sup>.
4. Data security and monetization – This category mainly refers to the **monetization of personal data**. Buying and selling data about people has been a returning topic in global news. On the 17<sup>th</sup> of March 2018, the massive Cambridge Analytica & Facebook scandal was brought to light<sup>2</sup>. This is a breaking example where over a million dollars was spent in order to target 50 million Facebook users to influence the American election.
5. Customer interface – The last category mentioned by Arner, Barberis & Buckley (2015) is customer interface. This category is a direct competitor for traditional banks in the sense that major, already existing companies could implement a form of financial product or service to their many customers with ease.
6. Blockchain & Cryptocurrencies – This is not a specific category mentioned by Arner, Barberis & Buckley (2015) nor does it fit in well with any of the others, but it is a big development worth mentioning. In the world of Fintech it is all about financial services or products replacing or competing with what is currently in flavor. Scott, Loonam & Kumar (2017) call blockchain technology a potential disruptor for the financial industry, with the main cryptocurrency Bitcoin based on this technology as the main antagonist for the banking sector, striving for disintermediation, decentralization and anonymity.

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<sup>1</sup> All information on PayPal has been retrieved from <http://paypal.com>

<sup>2</sup> The Guardian, 2018. Source: <https://www.theguardian.com/news/2018/mar/17/cambridge-analytica-facebook-influence-us-election>

## 2.2 Robo-advisory

Now that the importance and broadness of Fintech has been explained, a more in-depth look at one of the bigger and rapidly increasing parts of Fintech can be offered. Robo-advisory was briefly mentioned in the finance and investment category of Fintech, stating that robo-advisory almost entirely cuts out the human middleman in the financial advice branche, by offering digital algorithm-based financial advice for portfolio allocation derived by questionnaires or surveys (Jung, Dorner, Glaser & Morena, 2017). This is being expanded upon and upgraded rapidly. The most modern form of robo-advisory doesn't only give advice and invests accordingly, but also has a self-learning algorithm and automated rebalancing meaning that the entire managing of your portfolio will be done for you in a very mathematically complex manner. This form of robo-advisory has already entered the market, and is expected to have over \$16 trillion assets under management by 2025 (Moulliet, Stolzenbach, Majonek & Völker, 2016).

Robo-advisory fits in the market because there is a clear gap when an individual is looking for financial investment advice. To have a traditional human wealth manager, a relatively large minimum investment is required in order to start investing (Jung, Dorner, Glaser & Morena, 2017). This means that an average household investor could either invest the money by acquiring a portfolio manually, or not invest at all since the household investor does not have enough financial knowledge to be able to, or even want to invest. Robo-advisors fill in the gap for low-wealth investments, since there is little human interaction and investment recommendations are usually including low-cost Exchange Traded Funds which lowers transaction costs even more, allowing for smaller fees than traditional advisors usually maxing out at 0.5% (Fulk, Grable, CFP, Watkins & Kruger, 2018). If a human advisor would take such a small fee, even considering the maximum of 0.5%, it will not be worth the time for the human advisor if the amount invested is too low. For example, if an individual wants to invest \$1,000, an annual fee of 0.5% would only be \$5, which is hardly worth a few minutes of the advisors time. Robo-advisors don't need human interaction so time spent is not an issue, making these low fees still a profitable option.

Due to the fact that robo-advisory is a completely digitized product, your portfolio and advice is available 24/7 and adjustments can be made fast and easy, which is another advantage compared to a human advisor where you either need to set up a meeting over the phone, or meet with the advisor in person, which takes more time and effort. However, a minor downside is that you do need an internet connection, and a device to access your portfolio when using a robo-advisory service. Besides this, there are also risks of glitches or server errors which could cause all kinds of unimaginable trouble.

The main arguments against robo-advisory are not of technical nature or fear of errors or glitches, but more aimed at the lack of a human to overview your portfolio. Without a human, you miss personal interaction and you have zero relationship with the financial planner. Unique needs or desires might not get perfectly picked up by the algorithm, and the algorithm might not be flexible enough to deal with extreme outliers or inconsistent answers in the questionnaire (Fulk, Grable, CFP, Watkins & Kruger, 2018). The lack of flexibility is not only aimed at inconsistency or outliers, but also more personal goals like early retirement portfolios, funding education for children, big future expenses etcetera. Lastly, less tech-savvy customers could make mistakes in the interface and less financially-savvy customers could make mistakes in the questionnaire, misunderstanding the consequences of their answers (Gomber, Kauffman, Parker & Weber, 2018).



## 2.3 Portfolio Allocation & Risk Attitudes

Robo-advisory gives an investor advice for portfolio allocation based on their risk attitude, which is derived from a set of questions asked through a digitalized survey. Portfolio allocation is about the allocation of funds in your portfolio among many different financial assets available (Detemple, 2012). The contents of a portfolio could vary between any financial assets, mainly stocks and bonds, but also currencies, cash equivalents, mutual or exchange traded funds, real estate, private investments and many more financial assets. However, the trade-off always remains the same. Risk versus return, a potential higher pay-off will be accommodated with a higher risk in the form of volatility, or chance of default. The way an individual looks at this trade-off is decided by a combination of economics and psychology, often referred to as risk attitude (Weber, 2009). As Weber (2009) puts it, risk attitude decides how an individual makes a choice when encountered with a scenario that involves risk.

Individuals can either be risk neutral, risk averse, or risk seeking. Risk attitude determines how much utility you get from a gamble, which makes it a characteristic of the typical utility function of money (Wärneryd, 1996). There are several personal traits that significantly affect the willingness of an individual to take risks, such as gender, age, height and parental background (Dohmen, Falk, Huffman, Sunde, Schupp & Wagner, 2011). These influence the risk attitude, which matters when selecting an investment portfolio, which is expected from participants of the experiment in this research.

Selecting a portfolio can be divided in two parts. First of all, observing the possibilities and assessing potential future performance. Secondly, with the knowledge from the first step a decision will be made in selecting the preferred portfolio (Markowitz, 2007). In the case of portfolio allocation, risk attitude is the determinant of how much will be allocated to risky assets with higher potential returns, like low market cap stocks or low risk assets with lower potential returns, like bonds. This is also how portfolio allocation will be presented in this research, with a simplified choice between high risk high potential reward versus lower risk and lower potential rewards. Participants will make decisions based on expected utility, what allocation yields the most optimal risk and return for them.

However, in order to make an educated decision based on someones risk attitude, they first need to fully understand the decision that they are about to make in order to establish how much utility each choice yields. Financial knowledge is relevant to this in the sense that understanding profits, percentage calculations, the basics of stocks and bonds, will affect how individuals allocate their portfolio. Research shows that more financially knowledgeable investors go for a higher risk-adjusted return than the less financially knowledgeable employees, while also on average taking on more risk (Clark, Lusardi & Mitchell, 2014).

## 3. METHODOLOGY

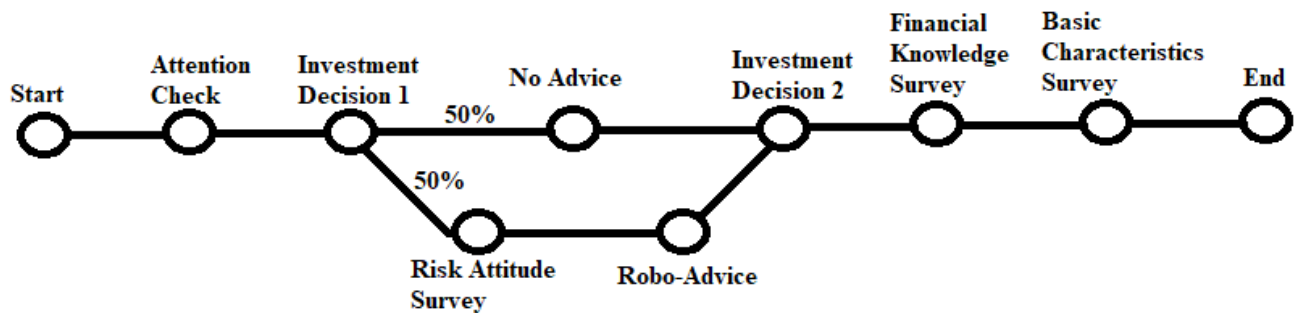
### 3.1 What is being researched

Former research on the impact of financial advice by Hoechle, Ruenzi, Schaub & Schmid (2017) shows that financial advice in general is not good for an investors trading performance, although they do tend to remove some behavioral biases (albeit not enough to overcome the underperformance). In this research they separate their data in informed investors versus uninformed investors, which is something that is key to this research as well. Although, instead of informed investors being informed by a physical human being, they will be informed by means of a questionnaire, algorithmically deciding the risk preference of an individual, replicating the process of a robo-advisor. So the initial research will be focused on the difference between receiving advice from a robo-advisor and not receiving any advice at all.

The main research question at hand is to see whether individuals allocate their portfolios differently when they are being advised by robo-advisors compared to manually investing without any prior advice. How much risk will individuals assume initially and how they change it when they are advised by robo-advisors are the two most important questions that are being asked in this research. When dealing with human financial advisors, the influence they have on the risk their client takes can not be underestimated. Especially since human financial advisors gain a higher fee for not pursuing arbitrage but become noise traders and essentially take more risk due to a higher volatility of the market caused by this, the trust a client has in their financial advisor could lead them into taking more risk due to being ‘talked into it’ (Gennaioli, Shleifer & Vishny, 2015). The same is suggested by the findings of Chalmers & Reuter (2015), where portfolio’s of broker clients have on average a lower risk-adjusted return for the same amount of risk. On the other hand, financial advice gives guidance for people with money to invest but lack the knowledge to invest all by themselves. Financial advice helps individuals to start investing where otherwise they would not invest at all (Hackethal, 2018).

So it is clear that human advice often leads to higher risk taking, but it is even more important to establish what we already know about robo-advisors and risk taking, in order to proceed with this research. Hackethal (2018) notes a few interesting findings, where investors using robo-advisory services have a higher chance to enter the stock market than individuals without robo-advice. This is something that could also be occurring in the research done in this Master Thesis, as participants will have the option to go for the risky stocks, or stick to the safe bonds. To sum it up, what is being researched is: the influence of robo-advice on risk taking (e.g. do investors allocate their portfolio differently after receiving robo-advice). This is strictly comparing investing without advice, to investing with robo-advice, since human advice is not an option for small budget investing.

## 3.2 Research Method



**Graphical Timeline 1: The Survey Format**

The survey will have two different treatments. Each individual is asked to make a simple investment decision. Then, the robo-advisor will give the individual financial advice based on a questionnaire which gives an estimation of their personal risk attitude. After the advice is given, the participant is asked to make the same investment decision again, but now with the additional knowledge supplied by the Robo-Advisor. Half of the individuals will not receive this advice, and have to make the same investment decision without any advice.

After the investment decisions, a general survey of relevant characteristics and financial knowledge will be performed in order to get a thorough understanding of what the properties of the subject group are, and this can later be used to identify whether any of these characteristics have influence on the results. Because of this, in the general survey a wide array of control variables will be included, to ensure the influence of robo-advice is isolated properly. A few examples of control variables could be gender, age, height, parental background as predetermined characteristic traits, since these influence risk attitude (Dohmen, Falk, Huffman, Sunde, Schupp & Wagner, 2011). A more detailed description of each part of the survey will be given in part 3.4, where each individual question will be highlighted and explained in-depth.

As of 2019, the total assets under management by Robo-Advisors worldwide is \$980,540,800,000, spread over 45,773,900 users<sup>3</sup>. This means that the average assets under management of Robo-Advisors is roughly \$21,421 per user. There is no data available to calculate the median, only the total amount of users and total amount of assets under management are publically available which means the average can be calculated but not the median. Therefore, for this study, I will round the average off to \$20,000, which each individual then can invest in either stocks or bonds.

<sup>3</sup> Source: <https://www.statista.com/outlook/337/100/robo-advisors/worldwide>, - 22<sup>nd</sup> May 2019

### 3.3 Order Effect & Attention Check

In order to get an as accurate as possible result, certain precautions were taken. If the data is contaminated by participants not reading the questions or participants being vulnerable to biases, the results might differ from a realistic scenario which could significantly lower the validity of any potential conclusions. In this section, two influential problems are explained and dealt with accordingly.

The order effect is a bias that relates to the design of a questionnaire or experiment. Order effect states that the sequence of the questions is important for the outcome, since participants might answer two of the same question differently dependant on the order the questions are presented in (Perreault, 1975). In this case, the study is designed in a way that participants have to answer two exactly similar investment decision questions.

What the research is aimed at, is to see whether individuals allocate their portfolios differently when they are being advised by robo-advisors, compared to manually investing without any prior advice. This can be measured by looking at the change in the first and the second answer based on digital investment advice. However, if order effect plays a role, people might answer the second investment decision differently, regardless of whether they received advice or not. In order to combat this, a second treatment has been installed. This treatment will not receive advice at all, and will just answer the same investment decision twice, so that it becomes clear to what degree people tend to change their answer even without investment advice. I expect that the treatment with advice will have a significantly larger difference between the two investment decisions than the treatment with no advice.

A second potential caveat of surveys in general is the lack of 'serious' responses. The survey, especially this one with a relatively small sample size, could have its results influenced by participants who only participate for the reward, and go through each question as quick as possible instead of taking their time and thinking about what answers they give. In order to combat this, an attention check was installed to filter out participants not taking the study seriously and participants who answered questions without reading them fully beforehand. I will come back to this in the following section, where the survey is explained in detail.

## 3.4 Contents & Format of the survey

In the following section there will be an overview of the survey and how each component works. The full survey in original form is displayed in Appendix A2, which will be an exact replica of what the participants saw.

The survey starts off with an explanation of what the participants are expected to do, and what the study is about. After making themselves identifiable through an unique Mechanical Turk ID, the study begins. The first question that the participants encounter is the attention check. The participants have to select the third answer, otherwise they will get instantly removed from participating without their monetary reward. This was explicitly stated in the question, so if the participants were paying full attention and read the question properly, they would answer it correctly.

After removing the participants who picked the wrong answer at the attention check, the core of the research, the first investment decision is displayed to the participants.

**Make a decision:** *You have the option to invest \$20,000 for 1 year in a combination of stocks and bonds. Volatility is a statistical measure of the dispersion of returns for the stocks and bonds. In this case, the higher the volatility, the riskier the security. Stocks have a volatility of 25-50% and an expected return of 15-24%. Bonds have a volatility of 7-11% and an expected return of 3-6%. What percentage of the money do you invest in stocks and, and what percentage do you invest in bonds?*

The numbers on the return and volatility on stocks and bonds have been exaggerated in order to make the difference more clear for participants. This decision is important, but not the most important one of the research. For the core research it doesn't matter what percentage the participants choose, as the dependent variable will be the difference between the first and second decision. For example, if a participant invested 40% in stocks and 60% in bonds the first time around, but 60% in stocks and 40% in bonds the second time around, the difference will be +20% stocks -20% bonds.

After the decision to invest and allocate has been made, step 2 of the research begins. Half of the participants will be shown that they will not receive robo-advice and have to make the investment decision again, without advice.

*“In order to advice small budget investors, Robo-Advisors are entering the market in order to replace the often expensive human advisors. After filling out this questionnaire on your risk-attitude, the Robo-Advisor will give you a suggestion for optimal portfolio allocation based on your personal risk attitude.”*

Then, participants will fill out a relatively short questionnaire to determine risk attitude, following Dohmen, Falk, Huffman, Sunde, Schupp & Wagner (2011) methodology, the risk attitude questionnaire starts off with a hypothetical investment question.

*You win €100,000 in a lottery. Your bank informs you that there is an opportunity to invest in an asset, with 50% chance to double your investment or half your investment. How much of your lottery winnings would you be willing to invest, in this financially lucrative but risky investment?*

0 – 20,000 – 40,000 – 60,000 – 80,000 – 100,000

Following this hypothetical investment question, a self-assessment question is asked, in order to find out how participants see themselves (Ding, Hartog & Sun, 2010).

*How willing are you in general to take risks? Compared to the average population I am:*

- 1 – Not at all willing to take risks
- 2 – Willing to take a less than average amount of risks
- 3 – Willing to take an average amount of risks
- 4 – Willing to take a more than average amount of risks
- 5 – Very willing to take risks

Lastly, five more hypothetical lottery questions are asked to get a broad comprehension of the risk attitude of the participants. The questions come from former successful research on risk attitude (Donkers, Melenberg & van Soest, 2001).

*We flip a coin. Choose one of the following options:*

- Receive €1,000 with either heads or tails
- Receive €2,000 on heads, €0 on tails
- I am indifferent between the two options

*Pick an option:*

- A lottery ticket with 80% chance to win €45, and 20% chance to win €0
- A guaranteed €30
- I am indifferent between the two options

*Pick an option:*

- Lottery ticket with 25% chance to win €100, and 75% chance to win €0
- Lottery ticket with 20% chance to win €130, and 80% chance to win €0
- I am indifferent between the two options

*Pick an option:*

- Lottery ticket with 2% chance to win €3000, and 98% chance to win €0
- Lottery ticket with 1% chance to win €6000, and 99% chance to win €0
- I am indifferent between the two options

*Would you accept the following agreement, yes or no:*

- Heads you win €1500, tails you lose €1000

At the end of this part of the questionnaire, the Robo-Advisor will divide the participant in one of the five categories of risk attitude based on the answers they chose: very risk averse, risk averse, risk neutral, risk seeking, very risk seeking. Very risk averse would get an advice to invest mostly in bonds, and very risk seeking would get the advice to invest mostly in stocks. Each of the 7 questions can maximally assign 50 points, which means the maximum is 350, and minimum is 0. The more points you have, the more risk seeking you are.

**0-70: Very Risk Averse;**

Advice: Invest at least 80% into bonds, and invest no more than 20% into stocks.

**71-140: Risk Averse;**

Advice: Invest at least 60% into bonds, and invest no more than 40% into stocks.

**141-210: Risk Neutral**

Advice: Invest 50% into bonds, and invest 50% into stocks.

**211-280 Risk Seeking**

Advice: Invest no more than 40% into bonds, and invest at least 60% into stocks.

**281-350 Very Risk Seeking**

Advice: Invest no more than 20% into bonds, and invest at least 80% into stocks.

After the recommendation is given, the participants will receive the same investment opportunity again as introduced in step 2. The question will be exactly similar, including volatility and expected return of both stocks and bonds.

**Make a decision:** *You have the option to invest \$20,000 for 1 year in a combination of stocks and bonds. Volatility is a statistical measure of the dispersion of returns for the stocks and bonds. In this case, the higher the volatility, the riskier the security. Stocks have a volatility of 25-50% and an expected return of 15-24%. Bonds have a volatility of 7-11% and an expected return of 3-6%. What percentage of the money do you invest in stocks and, and what percentage do you invest in bonds?*

The study ends with a survey of financial knowledge and basic demographic questions, checking all the boxes of what could potentially influence results.

**Financial knowledge** – in order to understand our subjects behavior, it is key to know whether the subject has proper financial knowledge, and whether the subjects overestimates their own financial knowledge, in accordance with the overconfidence bias (Nosic & Weber, 2010). People with less financial literacy are less likely to participate in stock market trading (van Rooij, Lusardi & Alessie, 2011)

- Experience in stock/bonds trading (Nosic & Weber, 2010).
- Rate own financial knowledge 1 – 5 (Nosic & Weber, 2010).
- Rate own statistical knowledge 1 – 5 (Nosic & Weber, 2010).
- Basic & Advanced Financial Literacy Questions:

**Numeracy:** calculate with percentages (basic question):

- *“Suppose a stock is worth €100,- and is expected to rise 10% in value per year over the next 5 years. How much would this stock be worth after 5 years if the expectation was correct?”*  
*More than 150, exactly 150, or less than 150?* (van Rooij, Lusardi & Alessie, 2011)

**Knowledge:** Difference between stocks & bonds, properties and risk difference of stocks & bonds (advanced question)

- *“Stocks are usually riskier than bonds. True or false?”* (van Rooij, Lusardi & Alessie, 2011)
- *“Suppose that in January, the stock market falls by 10%. What do you believe this tells you about the stock market's return during the next month, February?”* *Increased return, same return, or lower return?* (Beshears, Choi, Laibson & Madrian, 2011)

Then lastly, at the end of the survey so it does not interfere with any of the other questions, the basic demographic questions are asked.

- **Age** (Dohmen et al., 2011)
- **Height** (Dohmen et al., 2011)
- **Gender** (Dohmen et al., 2011)
- **Parental background** (educational level parents) (Dohmen et al., 2011)
- **Education** (Dohmen et al., 2011)



## 4. RESULTS

### 4.1 Data

The survey was created in Qualtrics and distributed through Amazon Mechanical Turk. The initial aim was to receive roughly 50 participants for both of the treatments (with robo-advice versus without robo-advice). To account for potential exclusion of certain participants, the total participants was set to roughly 120. The initial total amount of participants was 130, however 10 did not manage to complete the survey. The survey included an attention check, anyone who failed the attention check, was immediately removed from participating any further. After the attention check 7 out of 120 remaining participants have been removed, leaving 113 total participants. Of these participants, every single one of them answered every required question, which means that no more participants have to be excluded. 55 participants received treatment 1 (with robo-advice), and 58 had treatment 2 (without robo-advice), as is shown in table 1.

|   | <b>Amount of people</b> | <b>Male<sup>4</sup></b> | <b>Female<sup>6</sup></b> |
|---|-------------------------|-------------------------|---------------------------|
| Amount of total participants            | 120                     | -                       | -                         |
| Amount of participants excluded         | 7                       | -                       | -                         |
| Amount of participants after exclusion  | 113                     | 69<br>(61.06%)          | 44<br>(38.94%)            |
| Amount of participants with treatment 1 | 55                      | 36<br>(65.45%)          | 19<br>(34.55%)            |
| Amount of participants with treatment 2 | 58                      | 33<br>(56.90%)          | 25<br>(43.10%)            |

**Table 1: Initial analysis of participants.**

The amount of participants remaining is slightly higher than expected. The aim was to have at least 50 participants in each of the two treatments in order to be able to draw a generic conclusion from statistical analysis. However, the amount of participants is not high enough to say that it is a completely accurate representation of the American people. This will be further highlighted in the discussion chapter. There are no significant differences between treatment 1 and treatment 2 except for gender. There are a significantly larger percentage of males in treatment 1 compared to treatment 2. The influence of this will be measured in the upcoming regressions. Age and height are very similar

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<sup>4</sup> For the excluded participants, the gender is unknown since they never made it to that part of the survey. This is irrelevant for all further analysis since they are excluded anyways.

between the two groups, with treatment 1 averaging 34 years old and treatment 2 averaging 35 years old, and both groups are on average 168 cm tall. More of this information can be found in the appendix A1.

### 4.1.1 Investment Decisions

In table 2 you see the initial data of the investment decisions made by the participants. On first glance it becomes obvious that the average investment for group one barely changed. In the first investment decision the average spread was 57.79% stocks and 42.21% bonds, and the second investment decision for group one had an average spread of 57.33% in stocks and 42.67% with bonds, which indicates a shift of 0.46% towards bonds. The second group has a much larger shift than the first group. Initially, 49.35% is invested in stocks, and 50.65% in bonds. However, after advice, this changed to 43.44% in stocks and 56.56% in bonds. This means that there was a shift of 5.91% towards bonds, which indicates that participants have changed their investment behavior into a more conservative, risk averse allocation.

|  | <b>Both Treatments</b>     | <b>Treatment 1<br/>(no advice)</b> | <b>Treatment 2<br/>(with advice)</b> |
|--|----------------------------|------------------------------------|--------------------------------------|
| Average Investment Stocks<br>First Time  | 53.68%                     | 57.79%                             | 49.35%                               |
| Average Investment Bonds<br>First Time   | 46.32%                     | 42.21%                             | 50.65%                               |
| Average Investment Stocks<br>Second Time | 50.57%                     | 57.33%                             | 43.44%                               |
| Average Investment Bonds<br>Second Time  | 49.43%                     | 42.67%                             | 56.56%                               |
| <b>Average Change Stocks<br/>(bonds)</b> | <b>-3.11%<br/>(+3.11%)</b> | <b>-0.46%<br/>(+0.46)</b>          | <b>-5.91%<br/>(+5.91%)</b>           |

**Table 2: Investment Decisions of participants.**

Another notable thing regarding is that the group of treatment 1 is much more aggressively investing than the group of treatment 2. This could be caused by the fact that treatment 1 has a larger percentage of males, 65.45%, compared to group 2, 56.90%, as seen in table 2 of the previous section. As mentioned in the literature section, males are shown to exhibit more risk seeking behavior compared to females (Dohmen, Falk, Huffman, Sunde, Schupp & Wagner, 2011). Besides this, other potential causes for the big difference could be age, height, educational level and parental background will be tested in a regression in section 4.2.

## 4.1.2 Risk Attitude

Table 3 shows us that the majority of participants are risk averse. This is in line with most literature, suggesting that humans are risk averse (Dohmen, Falk, Huffman, Sunde, Schupp & Wagner, 2011; Rooij, van, Lusardi & Alessie, 2011; Nasic & Weber, 2010). A small percentage of combined 14.55% of participants falls in the Risk Seeking or Very Risk Seeking category which means they got advised a more aggressive investment strategy of more stocks than bonds. In the Risk Neutral category are 23.64% of participants. They got advised a 50/50 strategy in both stocks and bonds. In the Risk Averse and Very Risk Averse categories, where the majority of participants reside (61.83%), the advice of more bonds than stocks was given. Since the majority of participants got given an advice to invest in more bonds than stocks, the expectation would be that the second investment decision will be on average more 'safe' than the initial investment decision. As displayed in table 2, this also appears to be the case.

| <b>Risk attitude</b> | <b>Amount of people</b> |
|----------------------|-------------------------|
| Very Risk Averse     | 15<br>(27.28%)          |
| Risk Averse          | 19<br>(34.55%)          |
| Risk Neutral         | 13<br>(23.64%)          |
| Risk Seeking         | 7<br>(12.73%)           |
| Very Risk Seeking    | 1<br>(1.82%)            |

**Table 3: Risk attitude of participants.**

Based on these numbers we can calculate the average advice that was given to the participants. If they would adhere perfectly to the advice, then the average advice will be the same as the investment decisions they made. The average advice can be calculated by using a formula which multiplies the amount of participants times the advice of what percentage they should invest in stocks, divided by the total amount of participants. As the advice of stocks plus the advice of bonds always totals up to 100%, the formula for the average advice of bonds is simply 100% minus the average advice of stocks.

$$\begin{aligned}
 \text{Average Advice \% Stocks} &= \frac{\sum(\text{Weight} \times \text{Advice})}{\sum \text{Weight}} \\
 &= (15 \times 20\% + 19 \times 40\% + 13 \times 50\% + 7 \times 60\% + 1 \times 80\%) / 55 \\
 &= \mathbf{40.18\%}
 \end{aligned}$$

$$\begin{aligned}
\text{Average Advice \%Bonds} &= 100 - \text{Average Advice \%Stocks} \\
&= 100 - 40.18\% \\
&= \mathbf{59.92\%}
\end{aligned}$$

Based on the advice, if the participants of treatment 2 all adhered perfectly to the advice, they would on average invest 40.18% into stocks, and 59.92% into bonds, regardless of what they chose in the first investment round. If you compare that to how the participants actually behaved in the study, participants changed their average investment from 49.35% stocks to 43.44% stocks, and 50.65% bonds to 56.56% bonds, which means they are most likely responding significantly to the robo-advice received, making massive shifts in the advised direction. This will be verified through regression analysis in section 4.2.

### 4.1.3 Financial Knowledge

Research shows that more financially knowledgeable investors go for a higher risk-adjusted return than the less financially knowledgeable employees, while also on average taking on more risk (Clark, Lusardi & Mitchell, 2014). This would suggest that the more financially knowledgeable participants would invest more in stocks compared to the less financially knowledgeable participants. Secondly, what needs to be tested is whether participants with more financial knowledge act differently on the advice they receive. The hypothesis is that more financial knowledge leads to a higher disregard of financial advice.

|   | <b>Yes</b>     | <b>No</b>      |
|---|----------------|----------------|
| Do you have any experience at all in buying, selling or trading stocks, bonds or exchange traded funds? | 56<br>(49.56%) | 57<br>(50.44%) |

**Table 4: Financial knowledge, results question one.**

Almost half of the participants (49.56%) has experience in buying, selling or trading stocks, bonds or exchange traded funds as is displayed in table 4. This is almost a perfect split of the participants, which is advantageous for a regression in section 4.2 on this particular subject as the sample size will be equal.

| On a scale of 1 – 5,<br>compared to the average<br>population I am: | <b>Not at all<br/>knowledgeable</b> | <b>Below average<br/>knowledgeable</b> | <b>Averagely<br/>knowledgeable</b> | <b>Above average<br/>knowledgeable</b> | <b>Very<br/>knowledgeable</b> |
|---|-------------------------------------|--|------------------------------------|--|-------------------------------|
| Financial knowledge   | 18<br>(15.93%)                      | 28<br>(24.78%)                         | 41<br>(36.28%)                     | 24<br>(21.24%)                         | 2<br>(1.77%)                  |
| Statistical knowledge   | 26<br>(23.01%)                      | 19<br>(16.81%)                         | 44<br>(38.94%)                     | 20<br>(17.70%)                         | 4<br>(3.54%)                  |

**Table 5: Financial knowledge, results question two and three.**

Table 5 shows how the participants rated themselves on a scale of 1 to 5 how knowledgeable they are, both financially and statistically. Both are of equal importance in this research since they need to understand the difference between stocks and bonds, and also the consequences of this difference when making the investment decision. The table shows that the participants are slightly more confident in their financial knowledge opposed to their statistical knowledge, which we can verify or reject by looking at tables 6, 7 and 8.

|   | <b>More than<br/>\$150</b> | <b>Exactly \$150</b> | <b>Less than \$150</b> | <b>I don't know</b> |
|---|----------------------------|----------------------|------------------------|---------------------|
| Suppose a stock is worth \$100,-<br>and is expected to rise 10% in<br>value per year over the next 5<br>years. How much would this stock<br>be worth after 5 years if the<br>expectation was correct? | 70<br>(61.95%)             | 30<br>(26.55%)       | 4<br>(3.54%)           | 9<br>(7.96%)        |

**Table 6: Financial knowledge, results question four.**

Table 6 is the first question that combines both financial and statistical knowledge. The question is a simple calculation of  $100 \times 1.1^5 = 161.05$ , however it only asks for an approximate answer. Even without a calculator, basic statistical knowledge would lead you to picking “More than 150\$” as an answer. The vast majority of participants (61.95%) answered this question correct.

|   | Yes            | No             | I don't know |
|---|----------------|----------------|--------------|
| Stocks are usually riskier than bonds. True or false? | 88<br>(77.88%) | 18<br>(15.93%) | 7<br>(6.19%) |

**Table 7: Financial knowledge, results question five.**

Table 7 shows the results of a basic financial question, whether bonds are more risky than stocks. This is a very important question to answer correct for this research, as the investment decision the participants had to make solely relies on knowing the difference between stocks and bonds. Again, the majority (77.88%) of the participants answered this one correctly.

|   | Return will go up | Return is not influenced | Return will go down | I don't know   |
|---|-------------------|--------------------------|---------------------|----------------|
| Suppose that in January, the stock market falls by 10%. What do you believe this tells you about the stock market's return during the next month, February? | 22<br>(19.47%)    | 40<br>(35.40%)           | 20<br>(17.70%)      | 31<br>(27.43%) |

**Table 8: Financial knowledge, results question six.**

Table 8 displays the answers to the final question, about the influence of previous returns of a stock market on the future returns of that same stock market. The correct answer would be that the return is not influenced by past results. This is the answer that the most participants picked (35.40%), however that does mean that the majority of the participants had this question wrong.

Each individual question will be analyzed through regressions, in order to find out whether financial knowledge had a significant impact on the investment decisions made by the participants. It will also be used in order to find out whether the participants with more financial knowledge follow the advice worse than participants with less financial knowledge.

## 4.2 Regression Analysis

First of all, a regression with the allocation difference as dependant variable will be performed.

Allocation difference is a variable created by subtracting the second investment decision by the first investment decision. An allocation difference of -20 means that the participant invested 20% less in stocks, and 20% more in bonds the second time compared to the first time. There will be several independent variables that are used as control variables. The main effect that we want to measure is whether the allocation difference changes significantly when the individuals receive robo-advice, which will be measured by  $\beta_1$ .

Secondly, the hypothesis that individuals with more financial knowledge are more stubborn and therefore will not change their allocation difference will be tested by including the questions which test financial knowledge. Question one, four, five and six have been transformed into dummy variables where 1 is correct and 0 is incorrect. Question two and three are self-assessment questions and do not have a correct or incorrect answer so they will not be transformed. Each of the four dummy variables regarding financial knowledge will be combined into one new generic ‘financial knowledge’ variable. This variable is created by adding the other dummy variables up to eachother, since 1 equals correct and 0 incorrect, this variable will have a maximum value of 4, which means they answered 4 questions correctly.

Lastly, a number of control variables have been added to see whether they influence allocation difference, like gender ( $\beta_3$ ), age ( $\beta_4$ ), educational level of parents ( $\beta_5$  for father,  $\beta_6$  for mother), and educational level of the participant ( $\beta_7$ ).

$$\text{Allocation Difference} = \alpha + \beta_1 \text{Adv} + \beta_2 \text{FKD} + \beta_3 \text{GENDERD} + \beta_4 \text{AGE} + \beta_5 \text{BDFD} + \beta_6 \text{BDMD} + \beta_7 \text{BDPD} + \varepsilon$$

The control variable height has been excluded due to a very high amount of missing variables and a generally inaccurate representatation. This was caused by the difference in measurement systems, Americans are unfamiliar with their own height in centimeters and mostly only know their height in inches and feet. This was an oversight that will be further discussed in the discussion sector, but it should not have a significant impact on this research since it is only a control variable.

| VARIABLES                            | (1)<br>Allocation<br>Difference | (2)<br>Jackknife Allocation<br>Difference |
|--------------------------------------|---------------------------------|---|
| Advice (ADV)                         | -5.440**<br>(2.700)             | -5.440**<br>(2.685)                       |
| Financial Knowledge (FKD)            | -1.379<br>(1.368)               | -1.379<br>(1.506)                         |
| Gender (GENDERD)                     | 5.058*<br>(3.000)               | 5.058<br>(3.251)                          |
| Age (AGE)                            | 0.116<br>(0.149)                | 0.116<br>(0.139)                          |
| Educational Level Father (BDFD)      | -2.209<br>(3.621)               | -2.209<br>(3.462)                         |
| Educational Level Mother (BDMD)      | 5.882<br>(3.926)                | 5.882<br>(4.049)                          |
| Educational Level Participant (BDPD) | -3.013<br>(3.193)               | -3.013<br>(2.669)                         |
| Constant                             | -3.796<br>(6.187)               | -3.796<br>(6.100)                         |
| Observations                         | 113                             | 113                                       |
| R-squared                            | 0.086                           | 0.086                                     |

**Table 9: Regression analysis with allocation difference as dependant variable. Standard errors in parentheses, stars indicate significance level. \*\*\* means significant at a 1% level, \*\* means significant at a 5% level, and \* means significant at a 10% level.**

Table 9 shows the regression performed with allocation difference as dependant variable, and advice, financial knowledge, gender, age, and educational levels as independent or control variables. The table shows both the coefficient (beta's) as well as the standard deviation in the parentheses. In line with hypothesis, advice is significant on a 5% level with a coefficient of -5.440. This suggests that participants who received robo-advice invested significantly less in stocks, and significantly more in bonds after receiving robo-advice. This is in line with the results found earlier, where the average advice given was much more conservative (ergo less invested in stocks and more in bonds) than how the participants originally invested.



Financial knowledge has a small negative coefficient, but is not significant at any level. This suggests that financial knowledge does not significantly influence allocation difference between two investment decisions. The hypothesis regarding financial knowledge therefore does not hold up. Gender did seem to have a significant influence, males invested more in stocks the second time around compared to females which goes directly against the advice. However, this is only significant at a 10% level, and to draw conclusions at least a significance at the 5% level is necessary.

The influence of age, and educational levels is not yet fully tested. They are not significant in this regression, which means that these variables do not influence the allocation difference between the two investment decisions. However, the literature suggests that the expectation is that these variables influence how much participants invest in stocks, and this is not measured by including them in the regression on allocation difference (Dohmen, Falk, Huffman, Sunde, Schupp & Wagner, 2011).

As a form of robustness check, the jackknife allocation difference has been included. Jackknife is a Stata command which performs the same regression once for each observation in the dataset, leaving each observation out of the estimations once.<sup>5</sup> The coefficients should not be influenced and will therefore remain the same as the initial regression, but the standard deviation and significance might change. In this case, gender becomes less significant to the point that this variable is no longer significant, not even at a 10% level. It has no further implications on any of the other variables.

A second regression will be performed, with the variable Percentage Stocks 1 as dependent variable. This regression will give a clear view on the influence of these variables on investment decisions, most importantly whether participants invest significantly more or less in stocks due to one of these variables. Advice or no advice does not matter since it is the first investment decision, therefore it will not be included.

$$\text{Percentage Stocks 1} = \alpha + \beta_1 \text{FKD} + \beta_2 \text{GENDERD} + \beta_3 \text{AGE} + \beta_4 \text{BDFD} + \beta_5 \text{BDMD} + \beta_6 \text{BDPD} + \varepsilon$$

The coefficient  $\beta_1$  will be measuring the influence of financial knowledge on the percentage invested into stocks. It will also use the generic financial knowledge variable, similarly to regression one.

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<sup>5</sup> This information has been found in the STATA manuals, source: <https://www.stata.com/manuals13/rjackknife.pdf>

The variables that were used as control variables in the first regression are used in this one as well, gender ( $\beta_2$ ), age ( $\beta_3$ ), educational level of parents ( $\beta_4$  for father,  $\beta_5$  for mother), and educational level of the participant ( $\beta_6$ ).

Again, unfortunately, the control variable height has been excluded due to a very high amount of missing variables and a generally inaccurate representation. For this regression, the literature suggest that height could be potentially influential, so it would have been a good control variable to have (Dohmen, Falk, Huffman, Sunde, Schupp & Wagner, 2011).

| VARIABLES                            | (1)<br>Percentage Invested in<br>Stocks | (2)<br>Jackknife Percentage<br>Invested in Stocks |
|--------------------------------------|---|---|
| Financial Knowledge (FKD)            | 4.043*<br>(2.106)                       | 4.043**<br>(2.000)                                |
| Gender (GENDERD)                     | -5.961<br>(4.607)                       | -5.961<br>(4.687)                                 |
| Age (AGE)                            | -0.303<br>(0.229)                       | -0.303<br>(0.242)                                 |
| Educational Level Father (BDFD)      | 5.364<br>(5.574)                        | 5.364<br>(6.165)                                  |
| Educational Level Mother (BDMD)      | -12.48**<br>(6.027)                     | -12.48*<br>(6.793)                                |
| Educational Level Participant (BDPD) | 6.070<br>(4.914)                        | 6.070<br>(5.577)                                  |
| Constant                             | 57.12***<br>(9.307)                     | 57.12***<br>(10.95)                               |
| Observations                         | 113                                     | 113   |
| R-squared                            | 0.087                                   | 0.087   |

**Table 10: Regression analysis with percentage invested in stocks as dependant variable. Standard errors in parentheses, stars indicate significance level. \*\*\* means significant at a 1% level, \*\* means significant at a 5% level, and \* means significant at a 10% level.**

Table 10 shows the regression analysis with PS1, percentage invested in stocks in the first investment decision, as dependant variable. The variable financial knowledge is significant on a 10% level, and even becomes significant on a 5% level after the robustness test. This means that financial knowledge influences the percentage people invest in stocks. The coefficient is 4.043, which is fairly high and positive, indicating that the participants with more financial knowledge invested more in stocks compared to participants with a lower financial knowledge. Gender and age are both not significant and therefore suggest no influence on the percentage invested in stocks.

Of educational levels, only the educational level of the mother seems to significantly affect the percentage of funds invested in stocks at a 5% level. The coefficient is a large negative number, -12.48, which suggest that a highly educated mother would significantly decrease the percentage of funds invested in stocks. This could have a number of implications, for example that a higher educated mother means that the child is more careful as a result. However, the significance drops drastically after the jackknife robustness check, which makes it significant only at a 10% level.

## 5. CONCLUSION

In this Masters Thesis the question was asked whether individuals allocate their portfolios differently when they are being advised by robo-advisors compared to manually investing without any prior advice. This was researched by performing a survey, which resulted in a dataset of 113 American participants fully completing the survey.

The initial analysis of the data suggested a few things. Table 2 shows that there was a shift of 5.91% towards bonds in the group which received robo-advice, compared to a shift of only 0.46% towards bonds in the group which did not receive advice. This suggests that participants who have received robo-advice have changed their investment behavior into a more conservative, risk averse allocation. The average advice given was also more conservative than their initial investment due to the risk averse nature of the participants, and the fact that the results here are significant show that participants actively followed the advice, lowering the percentage of investing in stocks and raising the amount of investing in bonds.

To test whether this shift was significant, a regression analysis has been performed on the allocation difference of all participants. The coefficient 'Advice' which is a dummy variable for whether people received advice or not, was -5.440 and significant at a 5% level. This does mean that the shift that table 2 showed, appears to be significant. Therefore it is safe to conclude that the research performed in this thesis suggests that robo-advice significantly influences investment decisions. The external validity of this research is explained further in the discussion section, but it is fair to say that this research mainly suggests an outcome, and does not supply a definitive truth or law of nature.

Some separate hypotheses that are discussed in this thesis have also been tested. The theory that financial knowledge influences how well participants listen to advice has not been proven, since the financial knowledge statistic in the regression on allocation difference was not significant, not even at a 10% level. This suggests that regardless of the amount of financial knowledge, participants did not significantly alter their behavior regarding the average difference between the first and the second decision. However, financial knowledge did seem to influence the amount of risk a participant would assume. The more financial knowledge, the more an individual would invest in stocks compared to bonds. The coefficient regarding financial knowledge had a value of 4.043, a relatively high positive number, significant at a 5% level after robustness checks.

The only other variable that appears to have a significant influence on the percentage of funds invested in stocks is the variable for the educational level of the mother of the participant. Initially, it was

significant at a 5% level. The coefficient is a large negative number, -12.48, which suggest that a highly educated mother would significantly decrease the percentage of funds invested in stocks. This could have a number of implications, for example that a higher educated mother means a more careful child as a result.

However, the significance drops drastically after the jackknife robustness check, which makes it significant only at a 10% level. It is unreasonable to assume that at this point the educational level of the mother had a significant influence, as it rather likely to be a coincidence.

A larger sample size would give a more definitive and generalizable answer on most of the questions asked in this research, which is further explained in the discussion section. This research mostly offers a broad suggestion of what the influence of robo-advice might be, namely that participants who have received robo-advice have changed their investment behavior into a more conservative, risk averse allocation.

## 6. DISCUSSION

In this section, the research performed in this thesis will be discussed including all potential flaws, caveats, what should be done differently and which direction future research in the same area can go.

The most progress can be made in the data gathering section of this research. The survey has been extensively worked on and optimized heavily, but still some flaws were discovered when working with the data. The biggest flaw that actually had some influence on this research is the difference in system of measurement between Europe and America. As this research was originally aimed at European participants, some changes had to be made to make it suitable for Americans. Euro's have been changed into dollars, and other language options have been removed as the assumption is that most, if not all Americans speak the English language.

What I failed to realize in time is that Americans use the the imperial system instead of the metric system. Some Americans therefore do not know what imperial units translate to in metric units. There was one question in the survey where this issue became abundantly clear, which was the question regarding the height of each participant. Some answers were normal, in the 1.50m – 2.00m range, but a lot of the answers made no sense, like 61cm, 55cm, etcetera. This could potentially be their height in inches and feet, since 6'1 and 5'5 are normal human heights. However this is a very big assumption, as it could very well just be a random number they picked because they did not know their own height in centimeters.

Unfortunately, due to this the variable height had to be dropped from the regressions as there were just too many missing variables, and variables with answers that are physically impossible unless the survey was filled in by an army of leprechauns. Height was used as a control variable, as previous research suggest that it could potentially influence investment decisions, as taller people tend to take more risk than less tall people (Dohmen, Falk, Huffman, Sunde, Schupp & Wagner, 2011). Fortunately, it was only a control variable and not the most important one, so the research is barely compromised by the lack of this variable.

The dataset initially had 130 participants, as the goal was to have at least 50 participants in each of the two treatment groups. Of the 130 participants, 10 did not complete the survey, and 7 got removed due to failing the attention check. 113 participants remained, fully completing the survey. 55 participants received treatment one, and 58 received treatment two. This is enough for this research, since it give a good approximation of how people respond to robo-advice. However, if you want the research to be more externally valid, a larger group of participants is required. Further research could be done with a

larger group, potentially with a group like the one in this research (average joe's, with a very mixed amount of experience and knowledge about financial assets and investment), and with a group of more experienced investors.

When performing the regression on allocation difference, two different approaches regarding the influence of financial knowledge were tried. One approach had each question regarding financial knowledge included, and the other approach had the amount of correctly answered questions added up for each individual, creating a generic 'financial knowledge' variable. This variable would have its values lie between 0 and 4, which stands for the amount of questions answered correctly. However, the first method using each question separately did not really measure financial knowledge, it only measured how each participant performed on one question. It made more sense to me to use the generic 'financial knowledge' variable, since it accurately represents how many questions each participant answered correctly. The results regarding financial knowledge did become more significant as side effect using this method, albeit only at a 10% level.

The influence of Fintech on investment behavior is something that could be very interesting for the future. This thesis only looked at robo-advisory, but as mentioned in the literature section, Fintech is much broader than robo-advisory alone. This research indicates that robo-advisory might lead to a change in investment behavior, but how other parts of Fintech affect investment decisions was not researched. An interesting example for further research in this aspect might be forming a similar question about the influence of cryptocurrencies on investment behavior.

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## APPENDIX A1. DATA

|  | <b>Both Treatments</b> | <b>Treatment 1<br/>(no advice)</b> | <b>Treatment 2<br/>(with advice)</b> |
|--|------------------------|------------------------------------|--------------------------------------|
| Average Duration   | 402 seconds            | 441 seconds                        | 361 seconds                          |
| Average Duration (after removal extreme outliers) <sup>6</sup> | 270 seconds            | 223 seconds                        | 317 seconds                          |
| Average Age (years)  | 35 yrs                 | 34 yrs                             | 35 yrs                               |
| Average Height (cm) <sup>7</sup>                               | 168 cm                 | 168 cm                             | 168 cm                               |
| Amount of Fathers with Bachelors Degree or higher              | 58                     | 30                                 | 28                                   |
| Amount of Mothers with Bachelors Degree or higher              | 72                     | 34                                 | 38                                   |
| Amount of Participants with Bachelors Degree or higher         | 39                     | 19                                 | 20                                   |
| Amount of Males  | 69                     | 36                                 | 33                                   |
| Amount of Females  | 44                     | 19                                 | 25                                   |

**Table 11: Detailed breakdown of characteristics of the participants.**

<sup>6</sup> Some participants went all the way up to a duration of 6550 seconds, which is over one and a half hours. This survey was much shorter than that and could be completed anywhere between 2 and 5 minutes depending on treatment. These outliers were caused by leaving the survey open when taking breaks, and have therefore been excluded from the calculations of average duration.

<sup>7</sup> With the ‘height’ question it became noticeable that some participants did not answer this question correctly, leaving answers like 62 cm or just 0 cm. After excluding the outliers, the results became more ‘normal’. However, too many results had to be excluded. This is further discussed in the discussion section.

# APPENDIX A2. FULL SURVEY

## 1. Introduction

**Radboud University**

Nijmegen, the Netherlands



Hi! Welcome and thank you for participating in this study. It should take around 5 minutes of your time. This study is about investment decisions and the influence of Robo-Advice.

This study has four parts. First of all, you are asked to make a simple investment decision. Then, a **Robo-Advisor** will give you financial advice based on a questionnaire which gives an estimation of your personal risk attitude. After the advice is given, you are asked to make the same investment decision again, but now with the additional knowledge supplied by the **Robo-Advisor**. Afterwards, you will receive a short general survey of relevant characteristics and financial knowledge.

A Robo-Advisor is a digitalized version of a financial advisor, which gives portfolio allocation advice based on a short questionnaire with which it will determine your risk attitude. Based on this risk attitude, personal advice is given, much like a human financial advisor would do, but this time automated and algorithmically determined.

Each step will be explained in more detail once you get there, please read each part carefully!

Please enter your MTurkID here:

## 2. Attention Check

Many assets exist, and individuals can invest in many different assets. Please select the third answer to this question, it is just an attention check. If you do not select the third answer the survey will be terminated.

Stocks

Bonds

Funds

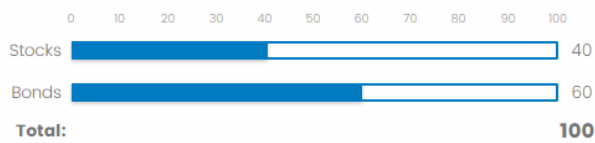


### 3. Investment Decision 1

Suppose you want to invest \$20,000 for 1 year. You have the option to invest in stocks, bonds, or a combination of stocks and bonds. Volatility is a statistical measure of the dispersion of returns for the stocks and bonds. In this case, the higher the volatility, the riskier the security.

Stocks have a volatility of 41% and an expected return of 22%.  
Bonds have a volatility of 8% and an expected return of 5%.

What percentage of the money do you invest in stocks and bonds, if any?



### 4. Risk Attitude Measurement (Robo-Advice Segment)

In order to inform small budget investors, Robo-Advisors are entering the market in order to replace the often expensive human advisors. After filling out this questionnaire on your risk-attitude, the Robo-Advisor will give you a suggestion for optimal portfolio allocation based on your personal risk attitude.

You win \$100,000 in a lottery. Your bank informs you that there is an opportunity to invest in an asset, with 50% chance to double your investment or half your investment. How much of your lottery winnings would you be willing to invest, in this financially lucrative but risky investment?

- \$0
- \$20,000
- \$40,000
- \$60,000
- \$80,000
- \$100,000

How willing are you in general to take risks?

Compared to the average population I am:

- Not at all willing to take risks
- Willing to take a less than average amount of risks
- Willing to take an average amount of risks
- Willing to take a more than average amount of risk
- Very willing to take risks

We flip a coin. Choose on of the following options:

- Receive \$1,000 with either heads or tails
- Receive \$2,000 on heads, \$0 on tails
- I am indifferent between the two options

Pick an option:

- A lottery ticket with an 80% chance to win \$45, and 20% chance to win \$0
- A guaranteed \$30
- I am indifferent between the two options

Pick an option:

- Lottery ticket with 25% chance to win \$100, and 75% chance to win \$0
- Lottery ticket with 20% chance to win \$130, and 80% chance to win \$0
- I am indifferent between the two options

Pick an option:

- Lottery ticket with 2% chance to win \$3000, and 98% chance to win \$0
- Lottery ticket with 1% chance to win \$6000, and 99% chance to win \$0
- I am indifferent between the two options

Would you accept the following agreement:

We flip a coin. Heads you win \$1500, tails you lose \$1000

- Yes
- No

### 5. Treatment 2 (No Advice):

Sorry, you do not receive Robo-Advice. Not every participant receives Robo-Advice.

- I understand

## 6. Advice Outcomes

The Robo-Advisor has calculated your risk-attitude and decided the following:

You are **Very Risk Averse**. This means that you don't like to take risks at all, therefore it is wise to invest at least 80% into bonds, and to invest no more than 20% into stocks.

I understand

The Robo-Advisor has calculated your risk-attitude and decided the following:

You are **Risk Averse**. This means that you don't like to take much risks, therefore it is wise to invest at least 60% into bonds, and to invest no more than 40% into stocks.

I understand

The Robo-Advisor has calculated your risk-attitude and decided the following:

You are **Risk Neutral**. This means that you go for high returns, and will sometimes assume risk to do so. Therefore it is wise to invest 50% into bonds, and to invest 50% into stocks.

I understand

The Robo-Advisor has calculated your risk-attitude and decided the following:

You are **Risk Seeking**. This means that you go for high returns, and will often assume high risk to do so. Therefore it is wise to invest no more than 40% into bonds, and to invest at least 60% into stocks.

I understand

The Robo-Advisor has calculated your risk-attitude and decided the following:

You are **Very Risk Seeking**. This means that you go for the highest returns, and always assume high risk to do so. Therefore it is wise to invest no more than 20% into bonds, and to invest at least 80% into stocks.

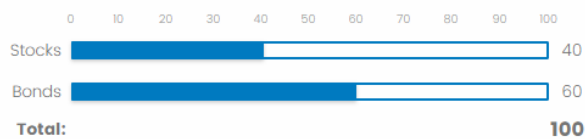
I understand

## 7. Investment Decision 2

Suppose you want to invest \$20,000 for 1 year. You have the option to invest in stocks, bonds, or a combination of stocks and bonds. Volatility is a statistical measure of the dispersion of returns for the stocks and bonds. In this case, the higher the volatility, the riskier the security.

Stocks have a volatility of 41% and an expected return of 22%.  
Bonds have a volatility of 8% and an expected return of 5%.

What percentage of the money do you invest in stocks and bonds, if any?



## 8. Financial Knowledge Measurement

The following section will determine your basic Financial Knowledge. Please read each question carefully and answer them to the best of your ability.

Do you have any experience at all in buying, selling or trading stocks, bonds, or exchange traded funds?

Yes

No

On a scale of 1 - 5, rate your own **financial** and **statistical** knowledge.

Compared to the average population I am:

- 1: Not at all knowledgeable
- 2: Below average knowledgeable
- 3: Averagely knowledgeable
- 4: Above average knowledgeable
- 5: Very knowledgeable

0 1 2 3 4 5  
Financial Knowledge



Statistical Knowledge





Suppose a stock is worth \$100,- and is expected to rise 10% in value per year over the next 5 years. How much would this stock be worth after 5 years if the expectation was correct?

More than \$150,-

Exactly \$150,-

Less than \$150,-

I don't know

Stocks are usually riskier than bonds. True or false?

True

False

I don't know

Suppose that in January, the stock market falls by 10%. What do you believe this tells you about the stock market's return during the next month, February?

The return in February will go up due to lower returns in January

The return in February is not influenced by the return in January

The return in February will go down due to lower returns in January

I don't know

## 9. Basic Demographic Questions

This is the last part of the study. Please answer the following basic demographic questions to the best of your ability:

What is your age?

0 10 20 30 40 50 60 70 80 90 100

Age (years)



What is your height?

0 22 44 66 88 110 132 154 176 198 220

Height (cm)



What is your gender?

Male

Female

Other

Does your father have a Bachelors Degree or higher?

Yes

No

I don't know

Does your mother have a Bachelors Degree or higher?

Yes

No

I don't know

Do you have a Bachelors Degree or higher?

Yes

No

Not yet, but I'm currently following education at Bachelor level or higher

## 10. End of Survey

**Radboud University**

*Nijmegen, the Netherlands*



Thank you for participating in this survey. Personal survey code:

**SK201805RU**