Robo-advisors:

How can automated investment advice change risk profiling practices?

Radboud Universiteit

Author:	Sebastiaan P. A. Tillmans
Student ID:	4067584
Supervisor:	prof. dr. S.M. Zeisberger
Faculty:	Faculteit der Managementwetenschappen
Programme:	Master Economics
Specialisation:	Financial Economics
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Abstract

Risk profiling is integral for the construction of portfolio allocations in investment advice. Robo-advisors are a new kind of investment advisor that solely conducts risk profiling through online means. This contrasts with traditional investment advisors, whose focus does not lie solely on provision of investment advice. The aim of this paper was to see whether these robo-advisors can change risk profiling. The differences between the risk profiling process and the methodologies employed were assessed. The future potential for robo-advisors if they use technology efficiently was also assessed. It was found that robo-advisors generally use the same risk profiling process and risk tolerance measures. They also provide advice in the same way as their traditional counterparts, excluding some exceptions. Because of their high interactivity, robo-advisors have the potential to gather and incorporate more data on their clients' lives into their risk profiling. Additionally they can further explore new portfolio allocation theories that incorporate mental accounts. Furthermore, they can extend the scope of their advice to also extend to personal or household finances. Additionally, they have the potential to offer clients new ways in which they can learn about investing. If they incorporate these things, they potentially can change risk profiling.

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Introduction

What investment should I pick? How much money should I invest in this asset? What do I do when my investments are down? These are questions most people who have ever invested or considered to invest, have asked themselves. It takes knowledge, experience, and effort to work out how to get an adequate return on investments. Lacking the necessary mental affinities or willingness to devote time and effort, or both, might induce an individual to make bad decisions or to not invest at all. Van Rooij, Lusardi, & Alessie (2011) find that individuals who exhibit low levels of financial literacy are less likely to participate in the stock market. Additionally, Calvet, Campbell, & Sodini (2007) find that low levels of wealth, income, and education also predict nonparticipation, and also predict lower levels of diversification. Cocco, Gomes, & Maenhout (2005) find that such nonparticipation in equity forms a significant source of welfare loss compared to those who do participate. However, due to lower levels of diversification, even if nonparticipants were to participate, they would still incur a welfare loss compared to an efficient allocation (Calvet, Campbell, & Sodini, 2007). For investors who fall on the low end of the spectrum for one or more of these factors, it can be beneficial to seek help. Such help is available in the form of investment advice. What is then considered investment advice? It can range from a tip on a particular stock that is in vogue at the moment on an internet chat room, to professionals who offers their guidance and expertise in exchange for a fee. The focus in this paper lies on the latter form of commercial investment advice, which is often known under names such as "portfolio management," or "wealth management". More formally investment advice is defined by Article four clause four of The Markets in Financial Instruments Directive (2004) as the provision of personal recommendations to a client, either upon its request or at the initiative of the investment firm, in respect of one or more transactions relating to financial instruments. Such investment advice can thus offer welfare gains to those individuals who do not invest at all or do so inefficiently. However, Collins (2012, p. 319) states "those with low levels of financial literacy were less likely to obtain any advice, and , in general, factors correlated with lower financial capability such as education and income were also related to lower take-up of financial". Additionally Bahttacharya, Hackethal, Kaesler, Loos, & Meyer (2012, p. 1017) state "the more (less) financially sophisticated [financially literate] investors are, the more (less) likely they are to obtain advice". Furthermore, Von Gaudecker (2015, p. 18) states this as: "the largest losses resulting from underdiversification are incurred by those who neither turn to external help with their investments nor have good skills in basic financial-numerical operations and concepts". This seems to indicate that individuals who are most unlikely to participate in the stock market, or who are most likely to make inefficient portfolio decisions when they do participate, are less likely to make use of investment advice, while they have potentially the most to gain from seeking such advice. Recently a new kind of investment advisor has entered the market, one that seeks to change this. This new kind of investment advisor is colloquially known as "robo-advisors". The "robo" refers to the fact that this kind of advisor processes new clients and

delivers them investment advice in an automated fashion over the internet, without a need for human intervention. They make use of computer algorithms to automatically handle all the tasks with the advisory process. Because of this, they do not rely on actual people to process clients at physical offices, which allows them to cut costs significantly compared to more "traditional" advisors who still rely on those things in their advisory process. These lower costs allow robo-advisors to incur lower fees and set low minimum investment amounts. ETFmatic, for example, only requires an initial investment of a 100 euros. Such low costs and entry barriers can allow people who lack some of the necessary aspects to make adequate investment choices, to be more inclined to seek investment advice, and enjoy its fruits. As said before, nonparticipation and inefficient portfolio allocations are welfare losses for the individuals involved. Robo-advisors thus have potential to increase the welfare of these individuals. Additionally there is evidence of increasing pressure on pensions. Oehler and Werner (2008, p. 278) state that "[c]onverging towards a similar situation as in the UK, cut-backs in social security and decreasing levels of the pension net replacement rates in Germany shirt the responsibility for a sufficient provision [of a pension] to the individual". Robo-advisors can potentially allow such individuals to better take care of their pension needs. Other selling points include their ease of use, straightforward fee structure, diversified portfolios, and in countries where this is possible, automatic tax-loss harvesting. Although marketed as selling points, these things are not exactly new to the investment advisory market, and many traditional advisors also offer such services. Additionally robo-advisors pride themselves on their ability to offer personally tailored investing advice. This encompasses the notion that an advisor will take into the wishes and needs of a particular investor and provide recommendations that are in accordance with those wishes and needs. Cavezzali and Rigoni find that these sort of recommendations have the potential to add value for clients (2012). Issuing customized recommendations to clients is however not a new development as advisors have been doing this for decades. As robo-advisors are a new phenomenon, on which not much has been written, nor has much research been done regarding their practices. This paper therefore serves as an exploration of what their practices are. The main question it poses is whether robo-advisors can change how risk profiling of investors is done? To assess this three sub questions have been formulated. First, what does the risk profiling process used by robo-advisors look like? Second, what sort of risk profiling methods are used by robo-advisors? Third, what is the future potential for robo-advisors if they were to make optimal use of the available technology?

This paper is divided into four chapters. The first chapter will provide a review of the literature with regards to risk profiling. It will provide an overview of the various categories of risk profiling methodologies. Additionally, it will also discuss shortcomings or flaws associated with those risk profiling methodologies. The second chapter will discuss the methodology of the analysis more in depth. It will also discuss the specifics of the dataset that has been constructed to facilitate a comparison between robo-advisors and traditional advisors. Additionally, it will discuss how the various categorizations of risk profiling methodologies that are discussed in the theoretical part of this

paper, are to be used in a comparison. The third chapter will discuss the various findings of this paper, with regard to the three sub questions. First it will discuss the risk profiling process as it is used by robo-advisors. Second, there will be a discussion of the various risk profiling methodologies used by robo-advisors, which will be compared to those used by traditional advisors. Third, it will discuss some differences between the manner in which advice is provided. Finally, there will be a discussion of the future potential of robo-advisors. At the end, the paper will conclude with an answer to the overall question regarding how robo-advisors can change risk profiling, combining the findings and answers from the previous chapter.

Literature review

This chapter contains a review of the various literature associated with risk profiling. First, this chapter will explain what is considered to be risk profiling, and what the theoretical background is for it. Additionally, this chapter will discuss how risk profiling is generally conducted. Lastly, this chapter will discuss the various risk profiling methodologies an associated instruments.

Risk profiling

Risk profiling forms an important part of providing investment advice. But what is risk profiling exactly? Risk profiling is the assessment of an investor's preferences for risk and return. It forms an important part for the construction of an optimal portfolio allocation. Markowitz (1952, 1959) laid the groundwork for modern portfolio theory. He put forward the notion that an efficient frontier of portfolio allocations of different assets, could be created based on the assets return, variance, and covariance. From this efficient frontier, investors can then choose a portfolio that is preferred based on individual preferences (as cited (Elton & Gruber, 1997)). Thus, because in essence all investment decisions depend on the investor's preferences for risk and return, it is of utmost importance that these preferences are correctly assessed. A mismatch between an investor's portfolio and his or her preferences for risk and return can potentially lead to problems for the investor. When an investor has taken on too much risk in his or her portfolio compared to his or her true appetite for risk and return, it is possible that the portfolio will incur losses that are too great for the investor's tastes. Conversely, when an investor has taken on too little risk in his or her portfolio compared to his or her true appetite for risk and return, it is possible that the portfolio will leave too many return opportunities unused for the investor's tastes. There are a multitude of terms used in the literature to refer to the tastes for risk and return that investors exhibit. Grable (2000, p. 625) defines financial risk tolerance as "the maximum amount of uncertainty that someone is willing to accept when making a financial decision". Barksy, Juster, Kimball, and Shapiro (1997) define (relative) risk tolerance as the inverse of risk aversion. In line with thinking about risk aversion, Scherer (2017) states that it forms a proxy for the willingness to incur risk. Both Corter and Chen (2006) as well as MacCrimmon and Wehrung (1985) use the term risk propensity, which refers to the degree of (financial) risk that a person is willing to incur. Weber, Blais, and Betz (2002) use the term risk attitude, which describes where on the continuum from risk aversion to risk seeking a person stands. This plethora of similar sounding terms which all refer to the same thing, can be a source of confusion. For example, the terms (risk) propensity and risk (attitude) are thrown out there by several authors (Corter & Chen, 2006; MacCrimmon & Wehrung, 1985; Weber, Blais, & Betz, 2002). Although they assign a similar meaning to what both terms refer to, namely how willing a person is to incur certain risks, the meanings of the words "propensity" and "attitude" are not the same, and other authors have used these words to differentiate between more specific aspects of risk tolerance. Therefore, it seems most apt to make use of the least debatable term, risk tolerance, which encompasses the fundamental meaning the

most. This multitude of terms is the result of a lack of consensus on the manner in which risk tolerance can be measured. Various authors have constructed instruments that in their eyes can measure risk tolerance. However, they all differ somewhat in their definition of the construct risk tolerance. Some of the terms previously mentioned also somewhat mention in what direction the authors were looking when they constructed their measures. The next section will explain in more detail what these differences entail. How is risk profiling generally conducted then, one might ask? There are various methods available to elicit a person's risk tolerance, like for example lab experiments or observing their real-life behavior. However, in the context of investment advice these techniques are not feasible because of the costs involved, and effort needed to use them. Therefore risk profiling is generally done by asking individuals survey questions in a questionnaire. MacCrimmon and Wehrung (1986) recommend questionnaires because they remove the influence of the analyst on the respondent, and allow large numbers of respondents to participate (as cited in Grable & Lytton, 1999). Additionally, with the advent of the internet, questionnaires allow for a rapid circulation of said questionnaire to the relevant clients. Furthermore, it allows for rapid adjustments. New findings from the academia can be incorporated in a timely fashion, and clients can be asked to periodically answer such a questionnaire again, in order to see if their risk tolerance stays the same. In this sense robo-advisors have an advantage compared to their more traditional pen-and-paper counterparts as they exist only online.

Risk tolerance measurement

Risk profiling for providing investment advice is in general done using questionnaires. What sort of instruments are then included in such questionnaires? Before such instruments can be discussed, it is important to note that risk tolerance consists of two parts. Hanna and Chen (1997, p. 17) state: "this article proposes that risk tolerance be into two parts: subjective risk tolerance based on the economic concept of risk aversion, and objective risk tolerance, based on […] the objective financial situation of the household". This split of risk tolerance in two parts is important for risk profiling, as both kinds of risk tolerance measures each require different approaches. The next sections will discuss the two in more detail.

Subjective risk tolerance measures

Subjective risk tolerance can be categorized into two groups. There are measures based on the expected utility framework, and there are measures based on psychometrics, also described as multi-item scales (Pennings & Garcia, 2001; Pennings & Smidts, 2000). An analysis will be conducted whether investment advisors make use of either or both of these subjective measurement techniques in their risk profiling processes. The following sections will explain the assumptions behind the instruments found in the literature. Furthermore, it will also provide examples of instruments for each of the categories. Potential advantages as well as disadvantages of instrument categories as well as individual instruments will be discussed as well.

Expected utility framework

The expected utility framework can be described as follows: "the expected utility model formulates decision making under risk as choices among lotteries, each represented by a probability distribution. Decision makers are assumed to have a preference ordering defined over the probability distributions, represented by the utility function u(x). The curvature of the utility function reflects risk attitude [risk tolerance] for a specific domain (e.g. monetary outcomes of a business) (Keeney and Raiffa 1976)" (as cited in Pennings & Smidts, 2000, p. 1337). Thus by measuring an individual's utility function, it is possible to derive the risk tolerance of that person. How can an individual's utility function then be mapped? Wärneryd (1996, p. 752) identifies five ways of eliciting risk aversion attitudes (risk tolerance):

(1) A choice between a certain (certainty) alternative and a probable alternative

(2) Choice between two probable alternatives with the same or unequal expected value

(3) Request for a certain value equivalent to a probable value (certainty-equivalent technique)

(4) Request for a probability statement which makes the subject/respondent indifferent between two alternatives one of which is certain (lottery-equivalent technique)

(5) Request for a probability that makes the subject indifferent between two alternatives one of which has a known probability

Although all five are valid ways of determining a person's risk tolerance, there are some differences in the ease of use. While the first two categories only require a respondent to make a choice, the latter three categories require the respondent to give a certain value equivalent or a probability statement. Which requires more mental effort from a respondent, as he or she has to think in abstract terms of equivalence or probability. It is for this reason that most measures in the literature opt for the first two categories, where they are often called hypothetical choice dilemmas. Several authors recommend their use in risk tolerance assessments (Cordell, 2001; Grable & Lytton, 1999; Iezzi, 2008; MacCrimmon & Wehrung, 1985; Barsky, Thomas Juster, Kimball, & Shapiro, 1997). An overview of such measurement items is shown in table one in the appendix. Items one and two fall into the first category as identified by Wärneryd (1996). Items three and four seem to be combinations of the first two categories, as they combine not only the choice between a certain alternative and probable alternative, but also have multiple alternative options, between which a choice can be made. According to the answers given respondents are grouped into risk tolerance categories.

Risk perception vs risk tolerance

There are however some problems associated with such assessments. Pan and Statman (2012) argue that the perception of risk can lead to substantial differences in the results from such measures. For a

rich person a fifty-fifty gamble to win €300 or lose €100 might be perceived as a low-risk gamble because a €100 loss is very small compared to his or her wealth. However, for a poor individual such a gamble might be perceived as high-risk because it is a considerable amount for them. Therefore an instrument which uses such predetermined amounts of money can produce biased results. This is particularly true for the first four instruments shown in table one. A solution to this is to pose such questions not with nominal amounts of money, but rather in abstracted terms that are proportional to the wealth level of the respondent.

Proportional gambles

Such proportional gambles are proposed by Barsky, Juster, Kimball, and Shapiro (1997) and Hanna, Gutter, and Fan (2001). Rather than make use of gambles with predetermined amounts of rewards, they pose their questions respectively in the terms that are proportional to individuals' "lifetime income" or "pension". These measures in essence fall into the third category as identified by (Wärneryd, 1996). This is because respondents are asked up to what percentage decrease in lifetime income or pension they are willing to accept before becoming indifferent between the gamble and the sure amount. Items five, six, and seven are examples of such instruments.

There are however also problems associated with formulating such problems in abstracted lifetime income or pension terms. Kapteyn and Teppa (2011) argue that the language used in such questions makes it difficult for respondents to understand them. This leads to decreased reliability. Cordell (2001) also points out this, noting the importance of financial knowledge for choice dilemmas. When a person lacks understanding of financial instruments, the economy in general, or the risk-return trade-off, it can be questioned how accurate such a person's comparison and subsequent choice between risky alternatives is.

Second, Kapteyn and Teppa (2011) argue that the respondents' current financial situation has an influencing effect on the answers they give. For example, more risk tolerant individuals with risky portfolios may be tempted to choose a safe income stream, because they are already subject to considerable risk. Conversely, less tolerant individuals with safe portfolios are able to incur more risky choices. Both of these reasons lead to a weakened relationship between the measured risk tolerance, and the actual or "true" risk tolerance for portfolio choice, if the advisor does not take explicit steps to rectify these issues.

Psychometric framework

Risk tolerance is considered to be not directly observable within the psychometric approach. This means that it has to be measured using variables that are observable. Such variables are called indicators and consist of questions and items. Likert scales are often used in such questions and items (Pennings & Garcia, 2001). Weber, Blais, Betz (2002) describe an often used straightforward way in which risk tolerance can be measured. It asks how they view their participation in certain risky behavior or situations. Such situations or behaviors could for example include smoking cigarettes,

driving without a seatbelt, or skydiving among many other possibilities. The underlying assumption here is that increased willingness to participate in these risky behaviors or situations would indicate a higher tolerance for risk in general and by extension also a higher risk tolerance when investing. More specific it is assumed that people exhibit a general attitude towards risk taking that is invariant over the domain from which it is elicited. However, Weber, Blais, and Betz, (2002) analyzed in their paper whether such self-assessed likelihood of participation in risky behavior resulted in stable risk tolerance assessments across domains. The domains included in their study were: investing, gambling, health/safety, recreation, and social. They found that such a global risk tolerance index across content domains does not exist. Corter and Chen (2006) state that "investment risk tolerance is a domain-specific trait that varies across individuals and reliably predicts investment behavior" (p. 380). Furthermore, Charness, Gneezy, and Imas (2013) also warn against the use of risk tolerance measurements in other domains than the one in which they are first done. Dohmen, Huffman, and Sunde (2011) find that questions that specifically ask respondents to assess their willingness to take risk in a specific context results in the best predictor of actual risk taking in that context. Thus in the context of investing, asking for willingness to engage in behavior that is associated with this context, such as investing in stocks, provides more accuracy when assessing overall risk tolerance. Thus, items assessing risk tolerance through psychometrically constructed questions regarding risky behavior or risky situations, should strictly fall within the financial domain. With this need for domain specificity in mind, there are two broad categories of measurement items for risk tolerance left within the psychometric framework: (1) General risk attitude, and (2) emotional association. For each of the two categories there will be a discussion of the corresponding literature, measurement items, and potential advantages and disadvantages.

General financial risk attitude

This category includes self-assessment questions, where the respondent is asked to classify in what abstracted risk tolerance level or group he or she falls. Table two in the appendix provides an overview of such items. Although there is substantial variation in the exact wording of the questions in this category, in essence they all ask the same thing from the respondent, namely to classify their own behavior or attitudes into abstracted risk tolerance levels or groups. Additionally, it should be noted that some of the questions in this list share similarities with some of the questions shown in the expected utility framework. The distinction in these cases rests on the fact that these questions specifically offer answer categories with abstracted risk and return. They thus do not require the respondent to make an explicit calculation. Fox example, instrument six in table two in the appendix offers the respondent answers which exhibit increasing levels of risk and return. A savings account or money market mutual fund is generally considered to be safer than a mutual fund that owns socks and bonds, and also has lower return potential, and a portfolio of fifteen common stocks in turn generally offers more risk and return than a mutual fund that owns stocks and bonds.

There are several advantages as well as disadvantages related to the use of measures such as these. Iezzi (2008) states that "it offers a direct measure of individual attitudes, avoiding the need to recover behavioral parameters by making restrictive identifying assumptions. However, this measure [general financial risk attitude] has some theoretical and empirical problems. One of the most serious limitations concerns the fact that the measure comes from an absolutely subjective question and there is now way to reliably assess whether their [respondents'] actual behavior would mimic their answers" (p. 13). Hallahan, Faff and McKenzie (2004) find that this is more or less the case, as they find that respondents have a tendency to understate their self-assessed risk tolerance level. According to them this can pose problems when risk tolerance is only or predominately measured subjectively. Possibly leading to wrong investment advice or investment advice that is too moderate. Furthermore, Yao, Sharpe, and Wang (2011) state that the use of terms that are open to interpretation by the respondent can contribute to significant variation across respondents. Because most of the questions include some form of ambiguous terminology, for example "substantial" or "very high," this can become an issue. Furthermore, the need for domain specificity within subjective measures of risk tolerance means that a questions regarding risk taking, should explicitly mention that it is referring to financial or investment risk.

Some of the instruments offer a scenario to the respondent in which he or she either receives a specified amount of money. Then the respondent is asked to specify what he or she would do in that scenario. The underlying assumption is that the respondent would answer how he or she would invest that money, as if it was their own. As previously mentioned there are possible issuers with this assumption. First, just like with the expected utility framework instruments, the risk perception varies with the level of wealth of the respondent (Pan & Statman, 2012). Second, a respondent's current financial situation can influence the choice he or she makes when answering subjective questions regarding risk tolerance (Kapteyn & Teppa, 2011). Third, if the respondent lacks understanding of financial matters, and thus maybe does not correctly understands a question, it can be argued how well a chosen answer then reflects that person's true risk tolerance (Cordell, 2001).

Emotional association

This grouping within the psychometric framework argues that risk tolerance can be assessed through the emotions that a respondent experiences when making such a financial decision. Multiple authors have constructed measures within this category (Grable & Lytton, 1999; Lim & Teo, 1997; Yamauchi & Templer, 1982; Yook & Everett, 2003). An overview of the instruments that they have constructed can be seen in table three in the appendix.

The work of Yamauchi and Templer (1982), and Lim and Teo (1997) is more specifically tailored to elicit emotional responses to money. However, as investing is closely related, it is possible to extend their measures to the investing context instead. Such instruments still fall within the larger correct context of the financial domain. The most prevalent emotion asked for in such instruments is anxiety. Gambetti and Giusberti (2012) find that individuals who exhibit the anxiety trait, are less willing to invest in low risk investment products. Indicating a low level of risk tolerance. Maner et al. (2007) also find a connection between dispositional anxiety and risk-aversion. Thus asking respondents if the associate anxiety with investing, can give an indication of their risk tolerance level. Additionally, Pan and Statman (2012) argue that the current economic climate can influence the emotions felt by individuals. Periods of low returns can induce anxiety and periods of high returns can induce exuberance. Both influence the level of risk tolerance than can be assessed.

Another emotion associated with risk tolerance is sensation seeking. This notion was first developed by Zuckerman (1994). He argues that persons who exhibited an increased need for sensation, also called “sensation seeking” individuals, as having increased risk tolerance. However more recent studies have found little to no evidence of such a connection (Corter & Chen, 2006; Weber, Blais, & Betz, 2002).

Bailey and Kinerson (2005) also identify regret as a possible emotional response to investing. They argue that when a person has experienced regret with investing in particular assets in the past, this person will be less inclined to want to invest in similar assets now. A measure that includes items regarding regret can indicate whether an assessment using other measures might be biased due to this regret skewing the result.

Other emotional aspects such as power, achievement, ethics, and obsession have historically also been linked to money in research papers (Keller & Siegrist, 2006; Lim & Teo, 1997). However, the links between those factors and investing were found to be weak at best.

Objective risk tolerance

Objective risk tolerance as previously mentioned is defined as the risk tolerance inferred from objective variables or truths pertaining the respondent. In general there are a multitude of objective factors about the financial situation of an individual investor or household that can define how (objectively) risk tolerance they are. Cordell (2001) argues that risk propensity, which he describes as the real-life decision that a person or household has made previously, can be a source from which one can infer some knowledge about a person's (objective) risk tolerance. The basic notion here is that a person or household that is more willing to incur risk, in other words, has a higher (objective) risk tolerance, will have evidence suggesting this in their historical investment behavior or current portfolio allocation. Conversely, a person with a low risk tolerance will have evidence suggesting this in their historical investment behavior or current portfolio allocation. MacCrimmon and Wehrung (1985) categorize this as revealed behavior in naturally-occurring risky situations. Using this last notion one can think of many measures of objective risk tolerance. Indeed Cordell (2001) develops such an inclusive list, which can be seen in table four in the appendix.

The most substantial objective measure would be the ratio of high-risk to low-risk investments. Basically it infers an individual's risk tolerance from the portfolio allocation he or she currently possesses. However, there are significant shortcomings associated with this manner of risk tolerance elicitation. Which by extension are also applicable to the other measures in the list developed by Cordell (2001). First of all, not everyone of the general public participates in the stock market. This thus means that even if the objective measure just described was correct, it would not yield useable results for some individuals.

Furthermore, there is no way, apart from asking for tax-return forms and the like, to know for certain that an individual is truthful with the answers he or she provides. Hence, doubts can be cast on the correctness of risk tolerance as assessed through such measures. This was also a problem with subjective risk tolerance, as also there respondents can lie about their true attitudes and emotions. Additionally, even if you assume that a respondent answers truthfully, doubts can be cast on whether the current portfolio allocation, if there exists one, is the direct result of the respondent's own actions, and thus whether by extension his or her portfolio allocation is representative of his or her risk tolerance. There are several possibilities why this could be the case. For example, it could be that through some random occurrence, like an inheritance or previous misaligned investment advice, the respondent's current portfolio allocation first came into existence or was changed (Cordell, 2001).

Moreover, just like with subjective instruments for risk tolerance, the respondent's financial literacy forms an important influencing factor. Cordell (2001) and Schooley and Worden (1996) point out that when the fundamental assumption that the respondent understands the risk-return trade-off is not met, assessing risk tolerance using objective measures can become hard if not impossible. For These shortcomings are not exclusive to an individual's current portfolio allocation, as they generally persist for the other measures in the list. First, because of a lack of applicability to some parts of the

public who do not own a portfolio or the other proxy for risk tolerance. Second, because it is generally impossible to check whether an individual answers truthfully without a thorough background check. Third, no clarity exists whether conscious action or outside influence first created or altered the current level of an objective measure. Four, the level of financial literacy can influence the level or even existence of an objective measure (Cordell, 2001).

Perhaps an exception to this is asking whether an individual has ever traded assets that are considered to be highly risky. Selling short or writing options, to name but a few of such possible transactions, are generally considered to be risky endeavors for common household investors. While the majority of household investors is unlikely to have ever traded in such assets, and thus their risk tolerance cannot be assessed in this way, individuals who have traded in such assets can possibly be regarded as having a higher risk tolerance. However, it is still possible that some individuals have traded in such products by accident.

Financial knowledge and experience

As mentioned previously, both subjective as well as objective risk tolerance measures are dependent on the assumption that the respondent has some form of understanding of finances and investing. When this knowledge or understanding is lacking, it can be argued that the items that require it can result in a faulty assessment of risk tolerance. Either because respondents make mistakes or are ignorant of certain aspects of the world. Therefore it is important to also assess the level of financial knowledge and experience as to correct for such issues. Additionally, some authors argue that respondents who categorize themselves as more experienced investors or as having more knowledge about financial matters, tend to be more subjectively risk tolerant compared to others (Grable & Lytton, 1999). A related concept is that of overconfidence. Overconfident investors might perceive risk as lower than less-overconfident investors, which in turn can lead to upward biased risk tolerance measurements (Pan & Statman, 2012). To combat this, advisors need to be aware whether an investor is overconfident or not. To assess overconfidence, it can prove useful to assess the level of financial knowledge and experience in some objective manner. For example, a high risk tolerance level assessed trough some measure combined with a low level of financial knowledge or experience, can indicate overconfidence. Thus it can be prudent for advisors to temper risk tolerance scores in response to this. Nosic and Weber (2010) and Grable and Lytton (1999) develop instruments that assess this. Table five shows an overview of these in the appendix. The main problem with such assessments of financial knowledge and experience is that they are self-reported. Therefore, they do not necessarily return a valid representation of the respondents' abilities.

Shortcomings of modern portfolio theory

As previously mentioned modern portfolio theory is one of the cornerstones of modern investing theory. However, there are some severe limitations associated with this framework.

Consider two investors two investors who have similar risk tolerance levels, but have a different outlook with their investments. One is looking to invest for a retirement fund, thirty years from. The other is just looking to invest some spare money for four years. According to mean variance portfolio theory both should have exactly the same portfolio allocation. As both have the same risk tolerance, they also should have identical portfolio allocations. As the optimal portfolio along the efficient frontier is only dependent on the risk tolerance level (Cavezzali & Rigoni, 2012). But, how realistic is this? Brennan, Schwartz, and Lagnado (1997) state that in general investors are not necessarily interested in minimizing variance for one period, but rather interested in maximizing their wealth level over a longer time span. For example, a particular important reason to invest might be to facilitate an income stream when a person is retired. Thus, investors are interested in what their wealth level can be, say thirty years from now, and what this entails for their portfolio allocation. On the subject, Das, Markowitz, Scheid, and Statman (2011, p. 25) state "[m]ean-variance portfolio theory is a "production" theory. Investors in that theory produce portfolios that combine expected returns and standard deviation of returns at levels that are best for them. […] The production of mean-variance efficient portfolios is only a station on the way to investors' ultimate goals, yet mean-variance portfolio theory is silent about these goals." Linking to the example of an individual who wants to invest for retirement, Brennan, Schwartz, and Lagnado (1997, p. 1402) state that "an investor's time horizon has a significant effect on the composition of the optimal portfolio. […] The reason for this is the mean reversion in both bond and stock returns that makes these assets less risky from the viewpoint of a long-term investor. Equivalently, investments in stocks and, more particularly, bonds provide the long-term investor with a hedge against future adverse shifts in the investment opportunity set – by buying long-term bonds the investor protects himself against declines in future interest rate." Thus, other objective variables are also of importance to the construction of an optimal portfolio allocation, and should be taken into account. Such variables are called risk capacity variables and they define the level of risk an investor is able to incur or needs to incur to achieve investment goals. Together with risk tolerance they should define the portfolio allocation. This extension of modern portfolio theory is also called the strategic asset allocation approach (Cavezzali & Rigoni, 2012; Cordell, 2001).

Risk capacity

Risk capacity variables can be grouped into five broad categories: (1) Portfolio goals and constraints, (2) income, (3) expenses, (4) balance sheet, and (5) financial obligations (Cordell, 2001, p. 38). Table six in the appendix provides an overview of variables associated with each category.

Portfolio goals and constraints

Within this categorization there are several variables that influence the risk capacity of the investor. Fundamentally it depends on five things: (1) the goal for the portfolio, (2) the time in which to achieve that goal (investment horizon), (3) income needs, and (4) tax considerations (Cordell, 2001).

Goals

It should come as no surprise that the goal an investor has in mind for a portfolio, and the rate of return needed to achieve that goal severely change the portfolio. When an investor wants to achieve capital preservation, he or she might be limited to asset classes, such as government bonds, that are considered safe, but also have a low return corresponding to their high level of safety. Conversely, when an investor wants to achieve growth, he or she might be constrained to assets that have larger associated risks.

Investment horizon

The time frame in which the investor wishes to achieve this goal also significantly influences the level of risk capacity. It is based on the notion that young investors possess more human capital, which is the stream of future labor income, compared to older investors. Because market returns and human capital are not closely related, young investors can better diversify against equity market risk (Cocco, Gomes, & Maenhout, 2005). Hanna and Chen (1997) also find empirical evidence in favor of this notion. For long investment horizons (20 years or over) portfolios with a large amount of stocks, dominate (have a higher expected utility) any other portfolio, for any level of financial assets or relative risk aversion level. This indicates that even when a person is significantly risk averse (has a low risk tolerance), when investing for a long time (20 years or over), the expected utility of a portfolio containing more risky assets is higher than that of a portfolio that contains less risky assets that are more in line with the lower risk tolerance level of this individual.

Income needs

Whether an investor is dependent on income from his investments can also lead to significant changes in the portfolio allocation. For example, if an investor is dependent on investment income to fulfill his daily consumption needs, he or she might require that the portfolio includes stocks that have a large dividend. This can thus limit his or her options to portfolios that are more risky compared to those that do not have those particular dividend requirements.

Tax considerations

Tax considerations are perhaps only relevant for investors located in countries where capital gains are taxed. In such countries, it can prove beneficial to change the portfolio allocation in order to minimize the tax burden.

Income

As previously mentioned, the time frame of an investment can have a significant influence on the level of risk as it influences human capital. Ceteris paribus, higher human capital, in the form of higher income, can also allow an investor to invest in more risky assets (Cocco, Gomes, & Maenhout, 2005).

Expenses

The amount of expenses a person has, whether fixed or discretionary also have an influence on the amount of risk he or she is able to incur. The notion here is that to sustain him or herself, a person needs to have a financial buffer in order to incur expenses. When such a buffer does not exist, it can lead to liquidity problems for the investor. This can lead to additional losses when assets need to be sold at a discount.

Balance sheet

An individual's current portfolio allocation constrains the possibilities he or she has for additional investment portfolios. As one should always consider ones total portfolio allocation when investing, including all assets and liabilities, existing allocations can reasonably constrain an investors potential allocations. Cavezzali and Rigoni (2012, p. 152) state that "[a]dvisors deal with the assets side of investors' balance sheets (the wealth to be invested) and neglect the liability side (the financial borrowing). The presence of debt has a leverage effect on portfolio investment and, in the same way as when a financial future is bought, the impact of market volatility on gains and losses is amplified. Most investors are probably not aware of this, but their advisors should be, and as a consequence they should suggest more caution in taking risks".

Financial obligations

The presence of financial dependents also has an influence on the level of risk an investor is able to incur. Cavezzali and Rigoni (2012) state the following with regard to this: "[t]he fact of having children [or other dependents] introduces a constraint that should suggest more prudence; a couple might better diversify everyday work and ordinary life risks, such as illness or accidents, and therefore could take more financial risks" (Cavezzali & Rigoni, 2012, p. 151).

Mental accounting based investing

In the strategic approach mentioned previously, both risk tolerance as well as risk capacity factors are combined to create and overall portfolio allocation. Risk tolerance has more influence on the asset mix in the risky portfolio, whereas risk capacity has more influence on the allocation between the risky portfolio and cash (Cavezzali & Rigoni, 2012). However, this strategic approach is still based on the notion that an individual or household has a single level of risk tolerance when making an investment.

Behavioral economics has provided insights that question the existence of an overall risk tolerance of individuals. Regarding this, Das, Markowitz, Scheid, and Statman (2011, p. 27) state that in: “[m]ean-variance investors have a single attitude toward risk, not a set of attitudes mental account by mental account. In contrast, behavioral investors have many attitudes toward risk, one for each mental account, so they might be willing to take a lot more risk with some of their money“. Thus, they propose a model of portfolio optimization that makes use of these multiple mental accounts. The notable difference is that in effect risk tolerance is assessed separately for each mental account.

Methodology

Now that the literature regarding the measurement of risk tolerance, and related concepts of risk capacity and financial knowledge have been explained, it is time to move on to the analysis method of robo-advisors and traditional advisors. In order to answer how robo-advisors can change risk profiling for investors, it is important to measure their practices against the current status quo of so called traditional investment advisors. A dataset was constructed, consisting of both robo-advisors as well as traditional advisors. It includes data on the instruments used in the risk profiling, the way in which advice is provided, and the portfolio allocations offered by robo-advisors. This data was then ordered according into the categories mentioned in the literature review. The findings will be discussed in four sections. First, there will be a discussion of the risk profiling process as it is used by robo-advisors. This will provide information about the manner in which this risk profiling is conducted. Furthermore it will also explain in which manner information is provided to clients. Second there will be a discussion of the risk profiling instruments used by both robo-advisors as well as traditional advisors. Additionally, it will also look at risk capacity measures and the incorporation of goal setting is allowed for by the advisors. Third, there will be a discussion on the advisory process that is employed by robo-advisors. In the literature review some different views regarding the application of portfolio theory were discussed. The combination of the sort of instruments used, the views regarding the advisory process, and the implied portfolio allocation theory followed, will provide insight in the potential differences between robo-advisors and their more traditional counterparts. Fourth, there will be discussion of the sort of potential robo-advisors have if they were to employ the technology that is available to them most efficiently. This view of the future potential will tie in with the conclusion, whether risk profiling can be changed by robo-advisors.

Dataset composition

Figure one, shown on the next page, provides an overview of the robo-advisors and traditional advisors in the dataset. The robo-advisors included in the dataset were well known players in their respective markets according to various media sources, which are mentioned in the margin of the figure. The majority are from the European Union and the United Stated, with one exception. Stockspot, which is based in Australia. Information regarding the robo-advisors was gathered by posing as a new client. Fake personal characteristics such as a name, e-mail and physical addresses, social security numbers, phone numbers, etc., were used in order to gather the relevant information for the dataset. Due to the scope of this paper as a master-thesis, and the author's unwillingness to use his own personal details, robo-advisors which required either payment, a valid bank account with IBAN number in a specific country, or a copy of a passport, were omitted from the list. Furthermore, some robo-advisors from the original list became insolvent or were taken over by another company during the writing process of this paper. These were also removed from the list. All in all the final dataset thus contains information of 25 remaining robo-advisors.

The criteria for inclusion of the traditional advisors were quite different. Their inclusion was based on whether they had risk questionnaires available through Google.com. Both electronic and physical, also called pen-and-paper, risk profiling questionnaires were accepted. This list contains firms that offer the more traditional spectrum of financial services, such as banking, asset management, mutual funds, retirement planning, or insurance, or a combination of these. Though some of their risk profiling questionnaires are also electronic, just as those of the robo-advisors, they are notably different in that these firms have physical offices, in other words that they also offer a more face-to-face approach than the robo-advisors, and that they in general offer more services such as those previously mentioned. All in all the final dataset contains information of seventeen traditional advisors.

Figure 1

Overview of robo-advisors and traditional advisors in dataset

Robo-advisors	Traditional advisors
Betterment	ANZ
Binck Forward	BMO
Easyfolio	Charles Schwab
Easyvest	Citibank
ETFmatic	Credit Suisse
Fiver-a-day	Fidelity
Fundshop	HSBC
FutureAdvisor	Lloyds
Ginmon	Merril Lynch
Growney	Morgan stanley
JustETF	Morningstar
MoneyFarm	RBS Morgans
Motif Investing	Standard Life
Nutmeg	Swedbank
Quirion	UBS
Scalable.capital	Vanguard
Stockspot	Wells Fargo
Swanest	
Vaamo	
Wealth Horizon	
WealthFront	
Wealthify	
Whitebox	
WiseBanyan	
Yomoni	

Sources used to compile this list: (Williams, 2015) (Robo Advisors Europe, 2017) (Berger, 2015) (Kumok, 2016)

Findings

Risk profiling process

In general the risk profiling process consists of three phases. In the first part the client is asked to fill in some general information about him or herself. The information that is asked for, consists for example out of variables such as age, date of birth, nationality, bank account numbers, etc. Some advisors also ask clients what sort of goals or objectives they have in mind with the investment they are going to make. This goal setting is important to know as it provides information on the portfolio allocation methodology.

The second phase is where the actual risk profiling is conducted. It should be noted however that depending on the advisor, phase one and two might be combined into one larger phase. The risk profiling is always done through the use of a questionnaire in some form or another. Questions posed to respondents have either multiple-choice answers, are numerical in nature and any number can be given as an answer, or respondents are provided with a slider, similar to a Likert scale, which allows them to choose an answer with greater accuracy that predetermined answers. Additionally, robo-advisors provide numerous ways in which general information about investing, products, risk, etc. can be found by respondents. It is either communicated to the client directly during the questionnaire process, or sometimes only available by clicking on a question mark. If a client has a wish for increased understanding of a robo-advisors strategies, he or she can often find these explained on dedicated pages of their websites. There the advisors usually provides a clear and concise explanation of the employed strategies and methodologies. It should be noted that these explanations are explained in language that is relevant for the client, and not in language which is of particular interest to a researcher. An advisor might explain why certain variables might be important for creating an optimal portfolio allocation, but the specifics are not explained.

The third phase consists of a presentation of the results from the questionnaire and the corresponding portfolio allocation. During this phase the advisor recommends a portfolio allocation. In general tobo-advisors (apart from two outliers which will be discussed later) construct a portfolio allocation for each of the levels of risk tolerance they identify. Figure one, as shown in the appendix, will provide an overview of various risk tolerance levels used by each of the robo-advisors in the dataset. The large majority of robo-advisors use approximately ten levels of risk tolerance. Interestingly there are some advisors, FutureAdvisor, MoneyFarm, and Motif Investing, which have a rather simple division into three risk profile levels. It can be questioned how tailored investment advice really is when there are just three possible portfolio allocations provided. Conversely, when there are many possible risk tolerance levels, such as offered by Betterment, JustETF, Scalable.capital, and Wealthfront, are enough instruments used to accurately distinguish between those different risk tolerance levels.

Apart from the portfolio allocation, statistics and data that are also of interest to the client, such as the expected annual return and volatility, are presented here as well. Often both numerically as well as visually. The visual representation is often done through a graph showing the historical performance and a Monte Carlo simulation of the possible future development of the portfolio allocation. Figure two, shown in the appendix, gives an example of how this presentation phase can look like for a typical robo-advisor, in this case taken from the website of Stockspot.

It should be noted thought that the manner in which risk is presented to the respondent is strictly based on description according to the description method as developed by Hertwig et al. (Hertwig, Barron, Weber, & Erev, 2004). There is no case of simulated experience in the process used by any of the robo-advisors in the dataset. Kaufmann et al. (2013, p. 335) state that "a risk-presentation format that incorporates experience sampling and distributions of returns may help investors by increasing decision commitments, confidence, and recall ability as well as reducing known biases as the overestimation of the loss probability. These factors result in an increased willingness to accept risk in one's portfolio". These results are also confirmed by Bradbury et al. (2016). This perhaps indicates a missed opportunity for robo-advisors to strengthen their risk profiling validity as well as explore new directions for the risk profiling that they employ.

Comparison of risk profiling instruments

This section will discuss the findings from the dataset per category and mention differences between robo-advisors and traditional advisors. After dividing all the different questions from questionnaires into the four main categorizations, figure three was constructed, which can be found in the appendix. It provides a detailed overview of the amount of instruments used by the different advisors in each category, as well as an insight into the mixture of instruments which are used. At first glance there seem to be little differences between the two sorts of advisors. However, there are several robo-advisors who stand out from the rest of the advisors in the dataset.

Subjective measures

This section will discuss the findings regarding subjective measures in more detail. Figure four in the appendix provides an overview of the sorts of subjective measures used by the advisors in the dataset. All advisors seem to make use of some subjective measures except for Betterment, who eschews their use completely in favor of risk capacity measures. This is noteworthy as Betterment is by far the largest robo-advisor in the world, and apparently does not believe in subjective measures for risk tolerance (Cohan, 2017).

Expected utility framework

Looking at expected utility framework measurements, traditional advisors seem to make more use of such measures, but the differences in general are quite small. Perhaps there are some differences in the manner in which these instruments are constructed or formulated. However, this seem not to be the case, as the problems associated with the influence of risk perception on assessment of risk tolerance, as mentioned by Pan and Statman (2012) are not taken into account. Of the 28 instruments used in the dataset that fall within the expected utility framework, only one is stated in abstracted income terms such as developed by Barsky et al. (1997). Strangely enough this instrument is not the one which was developed by Barksy et al. (1997) but rather a variation on the instrument developed by Grable and Lytton (1999). It seems that those who use objective measures, seem unaware of the problems associated with them.

General financial risk attitude

General financial risk attitude instruments are the most used instrument, both by robo-advisors as well as traditional advisors. Apart from two exceptions, none of the instruments in this category fall outside the financial or investing domain. The two outlying questions follow the example of instrument five from table two in the appendix, as set up by Grable and Lytton (1999), and simply ask how friends or family would describe the risk taking of the respondent. In this context both groups of advisors seem aware of the issues that lack of domain specificity can bring forward. The most prevalent instrument that is used, by both traditional as well as robo-advisors, simply asks respondents “how risk tolerant are you?”.

The reliance on general financial risk attitude instruments is not necessarily problematic. However, when advice is based solely or predominately on self-assessed risk tolerance measures, there is a tendency for this advice to be biased (Hallahan, Faff, & McKenzie, 2004). Several robo-advisors stand out for their sole reliance on a single general financial risk attitude instrument. These outliers are FutureAdvisor, JustETF, Scalable.capital, Swanest, and Whitebox. FutureAdvisor, JustETF, Swanest, and Whitebox directly ask respondents how risk tolerant they perceive themselves to be. Scalable.capital takes a different approach and asks respondents what negative performance they would accept in a poor stock market year. To fix the potential issues with bias, these advisors should either include more of these kind of instruments, or instead rely on different methods to assess their clients' risk tolerance.

Emotional association

Inquiring into the emotional associations respondents have with regard to investing seems to be used more often by robo-advisors compared to traditional advisors. However a significant proportion of both do not make use of them. Perhaps this is due to difficulties of quantifying answers to such questions to applicable advice and corresponding portfolios. The most prevalent inquiries are similar to instrument number three from table three in the appendix, as they ask respondents what word they associate most with risk or investing money. Another frequently used metric asks respondents how secure, comfortable, or stressed out they feel when investing in the stock market. Though using different wording they basically measure the same thing. Other instruments ask for the emotional response to losses, and two instruments ask whether respondents have ever regretted financial decisions. Lastly there is also one question regarding sensation seeking behavior, which is used by Nutmeg. The is little to no evidence of a connection between sensation seeking and risk tolerance (Corter & Chen, 2006; Weber, Blais, & Betz, 2002). Thus such a question should not be included.

Objective measures

Figure five in the appendix gives an overview of the amount of objective measures used by the advisors in the dataset. The picture it paints it pretty clear as the large majority of both robo-advisors as well as traditional advisors do not make use of such measures. Only one of the robo-advisors and six of the traditional advisors in the dataset make use of objective measures. Looking more closely at the instruments used might provide some insight. Three of the five traditional advisors ask for the current portfolio allocation of respondents to infer risk tolerance. This sort of inquiry has many flaws associated with it why it cannot be used. In general this is due to the fact that the current portfolio a person has does not need to reflect any conscious action on his or her part. The sole robo-advisor does make use of a correct instrument as it pertains to insurance coverage. Such an instrument is much more useful for inferring risk tolerance levels, as it is generally a result of deliberate action by the respondent, and also less influenced by outside factors. It should be noted however, that the two other traditional advisors, Standard Life and UBS, do make use of adequate objective measures. The instruments they ask are asking specifically for participation in highly risky investment products. Such instruments are generally considered good indicators for increased risk tolerance. All in all not enough advisors make use of instruments that fall into this category to generate significant differences. Most likely both traditional as well as robo-advisors are well aware of the problems associated with objective risk tolerance measures and therefore do not make use of them.

Financial knowledge and experience

As was mentioned earlier, subjective and objective risk tolerance measures can be dependent on whether the respondent has understood the risk-return trade-off. Therefore, when one makes use of such measures, it is useful to also include some measure of the financial knowledge and experience of the respondent. Figure six in the appendix graphs amount of subjective and objective risk tolerance measures in combination with the amount of knowledge and experience questions. One would perhaps expect the advisors that rely more on subjective assessments of risk tolerance to include more checks to see whether respondents have understood the risk-return trade-off. This however does not seem the case, as both groups display somewhat similar choices in that regards. Some advisors include knowledge and experience measures and some do not. Ten out of seventeen traditional advisors include some measure of the level of financial knowledge and experience into their questionnaires. Compared to ten out of 25 of the robo-advisors. Thus, robo-advisors are less inclined to include such measures in their questionnaires. However, the robo-advisors that do include such measures, are more inclined to make use of more instruments. Robo-advisors are however more inclined to use more questions regarding the level of financial knowledge and experience than the traditional advisors. Some of those robo-advisors, such as MoneyFarm, Easyvest, Vaamo, and Scalable.capital make use of significant numbers of such measures when compared to the level of subjective risk tolerance measures they make use of.

Measuring knowledge objectively

Two of the robo-advisors, Easyvest and ETFmatic, have a slightly different approach to testing the financial knowledge and experience of respondents. Instead of just asking clients to categorize themselves according to their perceived level of financial knowledge and investing experience, they ask some quiz questions to test the financial knowledge of respondents. This is a rather interesting way of measuring the financial knowledge of clients. It should be noted however, that ETFmatic does not include these questions in their risk profiling questionnaire, but rather uses it as a test for clients that wants to unlock the advanced feature of creating their own portfolio from scratch.

Other factors

Apart from the sort of instruments that are used to measure risk tolerance and the level of financial knowledge and experience, there are also other factors that are of interest to both groups of advisors. Some shortcomings of modern portfolio theory were discussed in the literature review. The main issue put forward there was that not only risk tolerance, but also personal characteristics and circumstances of the individual have an influence on what can be considered an optimal portfolio allocation (Cavezzali & Rigoni, 2012).

Limits of the dataset

Before moving on with the discussion of the various categories, it is important to discuss the fact the omission of a risk capacity measure or personal characteristic from the risk profiling questionnaires used by traditional advisors does not provide proof that they do not take such factors into account when assessing a new client. As the available data only reflects what is found in the questionnaires it is not possible to draw hard conclusions regarding those questionnaires. However, as the majority of the traditional advisors do include risk capacity measures, and there are only two of them that do not, the author does feel that the information on those that do use it can be helpful. Particularly because had they believed in a certain risk tolerance measure to have an effect, while they explicitly ask for several others, they would have included that other measure. That said, the ones that do not incorporate risk capacity measures, Standard Life and Lloyds, will not be used in comparison with the robo-advisors.

Risk capacity measures

An overview of the risk capacity measures used by the advisors in the dataset is shown in figure seven in the appendix. Capacity measures are very much used by both robo-advisors as well as traditional advisors, although robo-advisors seem to use them in a greater numbers than the traditional advisors do. It also seems to be the case that robo-advisors make use of a more inclusive set of capacity measures, pulling from more of the subcategories which were mentioned in the literature review. There are however several notable exceptions to this. JustETF and Swanest do not include risk capacity measures into their risk profiling at all. Additionaly, Fundshop and Nutmeg only use one risk capacity measure. Fundshop sees only interested in the stability of clients' income. Whereas Nutmeg is only interested in the investment horizon their clients have. Robo-advisors seem particularly interested in the personal financial characteristics of their clients. Most notably they inquire into the level of expenses that clients have. During the intake process several of these robo-advisors even require clients to have financial buffers so they can cover their expenses for several months. If clients do not currently possess an adequate buffer, they cannot invest with that particular robo-advisors. This is a noteworthy novelty of the robo-advisors. Not only do they provide investment advice, but they also give advice regarding the adequate managing personal finances.

Goal setting

Goal setting is an extension of the previously mentioned risk capacity measures. Some robo-advisors allow clients to pick a goal among several possibilities during the risk profiling questionnaire. This goal setting is then incorporated as a risk capacity measure in the optimal portfolio allocation. Other robo-advisors allow their clients to name the goal or portfolio allocation before or outside of the risk profiling process. Whether they incorporate that goal into the portfolio allocation or not is unclear as the data does not permit to check for this. However, given the fact that they choose to ask for it outside of the employed questionnaire, which in most cases still includes other risk capacity measures, seems to indicate that the naming of the goal for the portfolio does not affect the portfolio allocation process. Additionally, there are two robo-advisors who allow client's to set multiple goals. This extension of goal setting will be discussed in more detail in the next section on the differences in the advisory process. It should be noted that three of the traditional advisors in the dataset, BMO, HSBC, and Morgan Stanley, also offer their clients the ability to explicitly put their portfolio in a mental account Thus, this option is not necessarily exclusive to robo-advisors. Table seven in the appendix provides an overview of which robo-advisors allow clients to do so. What this allows clients to do is to place the investment and corresponding portfolio allocation into a mental account. Placing the portfolio into a mental account has the advantage of allowing respondents to be more specific and accurate in their assessment of risk tolerance (Das, Markowitz, Scheid, & Statman, 2010). The goals clients can choose include common financial goals people can have for certain investments, such as: retirement, buying a house, a bequest to family members, a college/education fund, a safety net, etc..

Different views regarding advisory process

Robo-advisors generally offer their clients three sorts of advisory processes: (1) informed portfolio choice, (2) goal based choice between portfolios, and (3) portfolio creation. Although similar, there are some differences between each of these. Some of the robo-advisors offer multiple of these services, but these are the exception rather than the rule. Table eight in the appendix gives an overview of the various views regarding the advisory process that the robo-advisors have.

Informed Portfolio Choice

The first form of advisory service that robo-advisors offer is the informed portfolio choice. This entails that the client receives his or her advice in the form of a risk tolerance score, as assessed in the questionnaire. The client is then able to make a choice between several pre-constructed portfolios or other investment products, that correspond with different risk tolerance levels. This is a direct application of the risk tolerance scale levels to a portfolio allocation as discussed earlier. This is the most prevalent way of doing things for the robo-advisors in the dataset. It is also the way in which twelve of the seventeen traditional advisors provide advice. It should be noted that the manner of advice given by the other five is unknown.

Within this categorization there are some differences. Generally these can be divided into two camps. One the one hand there are those that do not provide any guidance apart from mentioning which allocation fits the client's risk profile, allowing the client free reign to choose any of the available products or allocations. On the other hand, there are those that impose further guidance to the client by limiting or constraining the freedom of choice of portfolio allocations that the client has. Table nine in the appendix provides an overview of the different levels of advice given in this category.

Free choice

As the name implies, within this group, after an assessment is made, through whatever means, the client receives the result of this and is left to his or her own devices to make a decision to invest. Clients are completely left free to choose any portfolio allocation that the advisor offers. For example, a client who receives a very low risk tolerance score can still choose to pick a portfolio that corresponds to a much higher risk tolerance level. This form of advice allows clients to make mistakes.

Other robo-advisors do issue a warning when a client makes a choice that does not correspond to the advised level of risk they should take on. However, apart from a verbal warning to the client that their choice might not be correct and explaining why this is the case, the client is still free to make his or her own decisions.

Constrained choice

There are also those robo-advisors who do not let a client make a free choice after receiving advice regarding an adequate level of risk to take. Simply put, they limit the choices that are available to the client to choose from, based on the assessment of the level of risk that corresponds with the client.

Three robo-advisors who fall into this category assess both risk tolerance and risk capacity. When one of these two is larger than the other, the client is limited to the lower value of the two. Thus, a client attaining a risk tolerance score of, say, six, and a risk capacity score of, say, four. This client will be constrained in his choice to those portfolios up to the risk level of four. The three robo-advisors who do so are Fiver-a-day, Wealth Horizon, and Vaamo.

There is one advisor, Scalable.capital, who takes similar but different approach to imposing limitations on clients' choices. It limits choices based on Value-at-Risk (VaR). The answers given by the respondent during the questionnaire lead to the advisor constructing a maximum VaR value. The portfolios available to the client to choose from are then limited to those that have a lower VaR value than that limit.

No choice

Lastly, there is one robo-advisor in the dataset, Yomoni, which enforces a strictly limiting portfolio advisory process. This means that the level of advised risk to take on that the respondent receives and the corresponding portfolio allocation is not a choice at all, but a fixed allocation. The only way for the client to get a different portfolio is to redo the questionnaire and provide different answers, and thus possibly lie to the advisor and perhaps to him or herself.

Goal based portfolio choice

In a previous section there was a small discussion on robo-advisors allowing clients to put the investments they have into mental accounts according to the goal they have in mind for that particular investment. It was also mentioned there that the large majority of those advisors only allow clients to pick a single goal. In effect these advisor offer informed choice between portfolios for that singular goal. Apart from that, there are two robo-advisors who offer clients the option to choose a different portfolio allocation for multiple goals. These two robo-advisors are ETFmatic and Whitebox. There are however some differences between these two, regarding the way in which they accomplish this. Mental accounting based investing is based on the nation that an individual does not have an overarching risk tolerance for his or her whole portfolio, but rather, that it consists of the multiple different risk tolerances that an individual has for each of the different mental accounts that make up his or her investment portfolio. The idea that there are multiple risk tolerances is thus fundamental for this approach. Whitebox allow its clients can pick additional goals for which they revolve through the risk profiling process again. Thus for each goal an appropriate risk level is assessed. ETFmatic, however, also allows their clients to pick multiple goals for their investments, but, risk tolerance is assessed in an overall fashion. When a client then creates an additional goal, the sub portfolio allocation of this goal is then compared to the overarching risk tolerance level. Similarly as the constrained choice between portfolios, they only allow the client to pick portfolios between a range around the assessed risk tolerance level. This range is quite limiting. For example an individual with a risk tolerance score of three would be limited to choose portfolios that fall between risk tolerance

scores of two and four. This aspect of their advisory process is noteworthy because it implies that individuals can have different portfolio allocations for different goals, but they cannot be different by too large a margin. This in a way defeats the purpose of offering different mental accounts in the first place. It should be noted that clients at ETFmatic also have the option to create their own portfolio from scratch. Thus allowing those to circumvent the advisory limitations that are imposed when choosing an allocation. Morgan Stanley, while offering clients to pick multiple goals, does not allow for multiple risk tolerances for those goals at all, rather depending on one overall assessment of risk tolerance. Thus it does not offer goal based portfolio choice, but rather informed choice between portfolios. The next section will discuss portfolio creation in more detail.

Portfolio creation

This is the last category of advisory service that is offered by the robo-advisors. Portfolio creation entails exactly that, client are left to their own devices to create the portfolio allocation as they want to have. Three robo-advisors from the dataset offer this service. These three are, ETFmatic, JustETF, and Swanest.

Swanest does not actually offer clients the option to invest. Rather, it is a free advisory tool that allows clients to create their own portfolio. Swanest asks clients whether they want to make use of their globally diversified portfolio. If they do choose to do so, they receive a portfolio that is diversified in frequently used asset categories, such as European shares, emerging markets, North American shares, Commodities, Bonds, etc.. However, clients have the freedom to add whatever asset or asset class they want to this allocation. Additionally, if they so choose, they are free not to make use of the diversified portfolio, and can create a portfolio completely from scratch. When the choice for the assets to include in the allocation is done, the client is asked to fill in a risk profiling questionnaires, and Swanest calculates the optimal portfolio weights for the portfolio in accordance with the risk tolerance level. Furthermore, it also provides an expected return and volatility of the portfolio. Additionally is displays a Monte Carlo projection of the possible development the portfolio could take in the future. The client is then left to his or her own devices to invest according to the presented plan through some investment channel of their own choosing.

JustETF has a more hands-off approach. Clients are asked to define their risk share, which corresponds to the allocation between risky assets, such as stocks and commodities, and more safe assets, such as bonds and cash, on a percentage slider. When this allocation is chosen, the client can then indicate what sort of products he or she wants to include in either share. The products are limited to ETFs. For example, choosing emerging markets would include an emerging markets ETF into the portfolio allocation. This in effect this allows the client to create a portfolio allocation from scratch (containing ETFs) themselves. When the allocation is finished the advisor calculates the fees per annum, the expected return, volatility, and for paying members, a Monte Carlo simulation of the portfolio in the future.

ETFmatic also allows clients to create their own portfolio, however, this is an advanced option that is not available to new clients straightaway. It has to be unlocked by filling in a quiz that tests the financial knowledge of the client. When the client passes the test questions, by correctly answering four out of five questions, he or she is free to make use of the creation tool. The clients is left free to change the most important aspects of the portfolio allocation. A client could, for example, completely allocate a portfolio in one asset category if he or she so pleases. The only limitations are such that the client is not free to choose the exact asset, but is limited to the asset classes that are also used by ETFmatic in their regular portfolio advice. Thus a client may choose to put all of his or her portfolio allocation in emerging market stocks, but this only means that 100% of the allocation is put into the proprietary mix of ETFs that ETFmatic use to represent the emerging market equity market.

Technological potential for robo-advisors

As shown in the previous sections, robo-advisors in general do not necessarily offer different services compared to their traditional counterparts. However, there are still some avenues in which robo-advisors show increased potential. Particularly because robo-advisors in a way only exist online, they are impacted most by technological advances. In general the construction of a risk profile takes little to no effort to fill in for an individual who is reasonably competent with a personal computer. Filling in all the information takes perhaps ten to fifteen minutes of time. This ease of use is one of the main features of robo-advisors. However, some of the traditional advisors from the dataset also had online risk profiling questionnaires. It is therefore not unimaginable that other investment advisors and other financial intermediaries will also translate or construct their risk profiling questionnaires into an online form. Being an innovator or early adopter does mean that robo-advisors have to stay ahead of the game, so to speak, if they are to survive.

More data

The online nature of robo-advisors allows them to have access to large amounts of data on their clients. While there are limits to what robo-advisors can offer, particularly due to the costs of analyzing that data, more knowledge of a client can lead to better optimized portfolio allocations for that client. While the current set of variables is quite inclusive, it could be expanded upon. Because clients have to log in at some point to check on their investments, there is an opportunity for the advisor to ask additional questions. For example, clients could be asked whether some of their personal characteristics or circumstances have changed, or whether the assessed risk tolerance level and advice given is still in line with their needs. Considering that the largest robo-advisor in the world, Betterment, has 250,000 clients (Cohan, 2017). There is the potential for robo-advisors to have access to gigantic datasets. Those datasets would not just be of interest to the robo-advisors themselves, but also to economic research in general.

Explore new portfolio allocation theories

As was mentioned in the previous section, there are two robo-advisors who allow their clients to pick multiple goals and have different risk tolerances and corresponding portfolio allocations for them. As mentioned this makes it easier for clients to assess their risk tolerance for a particular goal, leading to better accuracy (Das, Markowitz, Scheid, & Statman, 2010; Das, Markowitz, Scheid, & Statman, 2011). Some of the robo-advisors currently allow their clients to pick a single goal only, and others even offer no opportunity for goal setting or naming at all. There is thus room for improvement by these other robo-advisors to also incorporate this framework. But why stop at setting up multiple goals.

Proactive role

Additionally, advisors can take a proactive role in providing investment advice. Potentially even anticipating changes in personal circumstances. For example, consider an advisor that asks for an update on the personal circumstances of a client. The client has found a partner and states this information to the advisor. The advisors can then, for example, not only take into account the impact of having a partner on the optimal portfolio allocation, but also recommend the client to start an education fund for eventual children that might be born. Numerous other examples can be thought of in which robo-advisors can take a more proactive role.

Not limited to investment

Additionally, this advisory role should not necessarily be limited to investing, but can also be extended to other financial matters such as the correct level of financial buffers for unforeseen events, adequate saving levels, or insurance coverage given employment in a certain sector, to name a few. As pointed out by Cavezzali and Rigoni (2012, p. 157) "financial intermediaries in household finance can fill the gap between the normative view (what people should do) and the positive view (what people actually do)". However, it should be noted that this can also become a potential double-edged sword, as increasing reliance on advice can also create dependence. Therefore, to promote good financial practices, the investor should also be aware of the reasoning for certain advice.

Learning

This puts forward the next area of potential for robo-advisors, learning. As clients are expected to at least periodically check in on their investment, they can be subjected to various ways in which they can learn more about investing. For example, confronting a client with a different quiz question and subsequent explanation of the answer, would be a potential way in which clients can learn. It should be noted that this is dependent on the willingness of the client to participate. It is not possible to force clients, however nudging them into compliance by keeping effort low can help. Additionally, the portfolio creation services offered by ETFmatic, JustETF, and Swanest can also form a potential way in which clients can learn about risk and return, if they are offered for free, and alongside regular advice. They can form a sort of playground for investors to mess around. They can create various portfolio allocations using various assets, and learn about the impact those decisions have on risk and return.

Conclusion

The aim of this paper was to assess how risk profiling of investors can be changed by robo-advisors. At it stands, currently robo-advisors in general do not change risk profiling. They offer generally the same as what their traditional advisor counterparts offer. Both robo-advisors as well as traditional advisors rely only on questionnaires to elicit risk tolerance levels from their clients. For their assessment of risk tolerance, both make use of risk tolerance, risk capacity, financial knowledge and experience measures, and risk capacity measures. Both make mistakes in their assessment of risk tolerance by including biased instruments. Robo-advisors seem slightly more prone to include more varied risk capacity measures into their questionnaires compared to their traditional counterparts. Additionally, the manner in which robo-advisors and traditional advisors handle the advisory process is also similar. Both offer their clients the opportunity for an informed choice between various portfolio allocations or investment products. While the large majority does not offer or do anything particularly novel, there are two notable exceptions. These two robo-advisors allow their clients to choose multiple portfolio allocations for different goals they might have. This is shown to be a promising way of constructing portfolio allocations, as it allows for better assessments of risk tolerance by clients (Das, Markowitz, Scheid, & Statman, 2010; 2011).

Currently robo-advisors currently set themselves apart predominately because they offer a cheap and fast way for clients to get investment advice that is presented clearly, without having to leave the comfort of a chair. However, it can be argued whether this will be enough for them to stay relevant. Some of the traditional advisor have already shown, that they are also capable of offering their risk profiling questionnaires over the internet. Thus robo-advisors need to keep setting themselves apart in other ways from their traditional counterparts. Robo-advisors can do so by exploring the areas in which their strengths lie more extensively. Using their interactivity they can map more data on their clients, and also track how this data changes over time. Apart from in an investing context, such data can also be of interest for research purposes. New ways of portfolio allocation methodology, such as those based on mental accounting, can be put to work to provide better and more accurate investment advice for those clients. This need not stop there, as robo-advisors can take a more proactive role in their advisory process. Anticipating certain needs that might arise for their clients, and advert their clients' attention on the importance of accommodating such goals in the portfolio allocation. This is also where robo-advisors have the potential to offer more than just investing advice. They can extend their advice to cover various household finance matters, such as promoting adequate saving levels or insurance coverage. Additionally, they have the ability to confront clients with interactive tools that can promote the understanding of financial concepts and investing in a playful way, allowing them to mess around with fake homemade portfolio allocations.

Campbell and Viceira (2001, p. 197), more than a decade ago, prophetically stated: "[o]ne of the most interesting challenges of the 21st Century will be the development of systems, combining the

scientific knowledge of financial economists with information technology and the human expertise of financial planners, to help investors carry out the task of strategic asset allocation". Perhaps robo-advisors in their current form are just in the early phases of tackling these challenges. This is also an interesting extension for future research.

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Appendix:

Table 1						
Expected utility framework measurement iter						
Number:	Items:	Answer categories:				Source:
1	In addition to whatever you own, you have been given $1,000. You are now asked to choose between:	A sure gain of $500	A 50% chance to gain $1,000 and a 50% chance to gain nothing			Grable & Lytton (1999)
2	In addition to whatever you own, you have been given $2,000. You are now asked to choose between:	A sure loss of $500	A 50% chance to lose $1,000 and a 50% chance to lose nothing			Grable & Lytton (1999)
3	You are on a TV game show and can choose one of the following. Which would you take?	$1,000 in cash	A 50% chance at winning $5,000	A 25% chance at winning $10,000	A 5% chance at winning $100,000	Grable & Lytton (1999)
4	Given the best and worst case returns of the four investment choices below, which would you prefer?	$200 gain best case; $0 gain/loss worst case	$800 gain best case; $200 loss worst case	$2,600 gain best case; $800 loss worst case	$4,800 gain best case; $2,400 loss worst case	Grable & Lytton (1999)
5	Your trusted friend and neighbor, an experienced geologist, is putting together a group of investors to fund an exploratory gold mining venture. The venture could pay back 50 to 100 times the investment if successful. If the mine is a bust, the entire investment is worthless. Your friend estimates the chance ofsuccess is only 20%. If you had the money, how much would you invest?	Nothing	One month's salary	Three month's salary	Six month's salary	Grable & Lytton (1999)

6	Suppose that you are the only income earner in the family, and you have a goods job guaranteed to give you your current (family) income for life. You are given the opportunity to take a new and equally good job, with a 50-50 change it will double your aftertax income and a 50-50 chance that it will cut your aftertax income by X%. Would you take the job?	Yes	No			Barsky, Juster, Kimball, and Shapiro (1997)
7	Suppose that you are about to retire and have two choices for a pension. 1. You would have a pension equal to your takehome family income now. 2. There would be a 50-50 chance the pension would double your takehome income and a 50-50 chance that it be X% less than your takehome. You would have no other source of income, and no chance of employment or help from the family, friends, or agencies. Which would you prefer?	Yes	No			Hanna, Gutter, and Fan (2001)

Table 2						
General risk attitude items						
Number:	Items:	Answer categories:				Source:
1	Which of the statements comes closest to the amount of financial risk that you and your (spouse/partner) are willing to take when you save or make investments?	Take substantial financial risks expecting to earn substantial returns	take above average financial risks expecting to earn above average returns	take average financial risks expecting to earn average returns	not willing to take any financial risks	Survey of Consumer Finances (1983)
2	When managing your financial investments, would you describe yourself as someone who looks for:	Very high returns, regardless of a high risk of losing part of your capital	A good return, with reasonable security for your invested capital	A reasonable return, with a good degree of security for your invested capital	Low returns, without any risk of losing your capital	Iezzi (2008)
3	I am willing to take financial risks in order to	7-point Likert scale ranging from:				Keller & Siegrist (2006)
		Strongly disagree			Strongly agree	
4	In money matters, I tend to be willing to take risks	7-point Likert scale ranging from:				Keller & Siegrist (2006)
		Strongly disagree			Strongly agree	
5	In general, how would your best friend describe you as a risk taker?	A real gambler	Willing to take risk after completing adequate research	Cautious	A real risk avoider	Grable & Lytton (1999)
6	Suppose a relative left you an inheritance of $100000, stipulating in the will that you invest all the money in one of the following choices. Which one would you select?	A savings account or money market mutual fund	A mutual fund that owns stocks and bonds	A portfolio of 15 common stocks	Commodities like gold, silver, and oil	Grable & Lytton (1999)
7	If you had to invest $20,000, which of the following investment choices would you find most appealing?	60% in low-risk investments 30% in medium-risk investments 10% in high-risk investments	30% in low-risk investments 40% in medium-risk investments 30% in high-risk investments	10% in low-risk investments 40% in medium-risk investments 50% in high-risk investments		Grable & Lytton (1999)

8	You have just finished saving for a “once-in-a-lifetime” vacation. Three weeks before you plan to leave, you lose your job. You would:	Cancel the vacation	Take a much more modest vacation	Go as scheduled, reasoning that you need the time to prepare for a job search	Extend your vacation, because this might be your last chance to go first-class	Grable & Lytton (1999)
9	If you unexpectedly received $20,000 to invest, what would you do?	Deposit it in a bank account, money market account, or an insured CD	Invest it in safe high quality bonds or bond mutual funds	Invest it in stocks or stock mutual funds		Grable & Lytton (1999)
10	Assume you are going to buy a home in the next few weeks. Your strategy would probably be:	To buy an affordable house where you can make monthly payments comfortably	To stretch a bit financially to buy the house you really want	To buy the most expensive house you can qualify for	To borrow money from friends and relatives so you can qualify for a bigger mortgage	Grable & Lytton (1999)
11	Assume that you are applying for a mortgage. Interest rates have been coming down over the past fewmonths. There’s the possibility that this trend will continue. But some economists are predicting rates to increase. You have the option of locking in your mortgage interest rate or letting it float. If you lock in, you will get the current rate, even if interest rates go up. If the rates go down, you’ll have to settle for the higher locked in rate. You plan to live in the house for at least three years. What would you do?	Definitely lock in the interest rate	Probably lock in the interest rate	Probably let the interest rate float	Definitely let the interest rate float	Grable & Lytton (1999)

Table 3						
Emotional association						
Number:	Items:	Answer categories;				Source:
1	It's hard for me to pass up a bargain (investment	7-point Likert scale ranging from: Always			Never	Yamauchi & Templer (1982)
2	How would you respond to the following statement? "It's hard for me to pass up a bargain."	Very true	Sometimes true	Not at all true		Grable & Lytton (1999)
3	When you think of the word "risk" which of the following words comes to mind first?	Loss	Uncertainty	Opportunity	Thrill	Grable & Lytton (1999)
4	Which situation would make you the happiest?	You win $50,000 in a publisher's contest	You inherit $50,000 from a rich relative	You earn $50,000 by risking $1,000 in the options market	Any of the above—after all, you're happy with the $50,000	Grable & Lytton (1999)
5	Compared to most other people I know, I believe	7-point Likert scale ranging from: Strongly disagree			Strongly agree	Lim & Teo (1997)
6	I often feel anxious and defensive when asked about by personal finances	7-point Likert scale ranging from: Likert scale				Lim & Teo (1997)
7	I worry about my finances (investments) much of the time	7-point Likert scale ranging from: Likert scale				Lim & Teo (1997)
8	Your investments are down by X% in value, what level of anxiety would you feel:	Likert scale				Yook and Everett (2003)

Table 4		
Objective risk tolerance items		
Number:	Items:	Source:
1	Participation in short selling	Cordell (2001)
2	Speculating with options and commodities	Cordell (2001)
3	Level of insurance coverage	Cordell (2001)
4	Ratio of high-risk to low-risk investments	Cordell (2001)
5	Ratio of liabilities to assets (debt ratio)	Cordell (2001)
6	Ratio of liabilities to income	Cordell (2001)
7	Ratio of salary to life insurance	Cordell (2001)
8	Number of voluntary job changes to number of years of work experience	Cordell (2001)
9	Percentage of annual salary spent on recreational gambling	Cordell (2001)
10	Shortness of job tenure	Cordell (2001)

Table 5						
Knowledge & experience						
Number:	Item:	Answer categories:				Source:
1	How many different investment products (e.g. shares, funds, bonds, certificats) did you hold within the last year?	0	1 to 5	6 to 10	More than 10	Nosic & Weber (2010)
2	How do you rate your statistical knowledge?	5-point Likert scale ranging from:				
		Very good			Bad	Nosic & Weber (2010)
3	How do you rate your knowledge about stock	5-point Likert scale ranging from:				
		Very good			Bad	Nosic & Weber (2010)
4	In terms of experience, how comfortable are you investing in stocks or stock mutual funds?	Not at all comfortable	Somewhat comfortable	Very comfortable		Grable & Lytton (1999)

Table 6		
Risk capacity		
Category:	Variable:	Source:
Portfolio goals and constraints:	time horizon	Cordell (2001)
	current income needs	
	capital preservation	
	growth	
	tax minimization	
Income:	amount	Cordell (2001) & Cavezali and Rigoni (2012)
	stability	
Expenses:	fixed versus discretionary	Cordell (2001)
	amount relative to income	
Balance sheet:		Cordell (2001) & Cavezzali and Rigoni (2012)
Assets	diversification	
	asset allocation	
	risk exposure in various assets	
Liabilities	amount	
	time frame	
	structure of debt	
Financial obligations:	family	Cordell (2001) & Cavezzali and Rigoni (2012)
	contractual	
	retirement	

Table 7		
Goal setting		
Name:	Explicit goal setting:	Multiple goal setting:
Betterment	X	
ETFmatic		X
Motif Investing	X	
Nutmeg	X	
Vaamo	X	
WealthFront	X	
Wealthify	X	
Whitebox		X
WiseBanyan	X	
Yomoni	X	

Table 8			
Views regarding advisory process			
Name:	Informed choice:	Goal based portfolio choice:	Portfolio creation:
Betterment	X		
Binck Forward	X		
Easyfolio	X		
Easyvest	X		
ETFmatic	X	X	X
Fiver-a-day	X		
Fundshop	X		
FutureAdvisor	X		
Ginmon	X		
Growney	X		
JustETF			X
MoneyFarm	X		
Motif Investing	X		
Nutmeg	X		
Quirion	X		
Scalable.capital	X		
Stockspot	X		
Swanest			X
Vaamo	X		
Wealth Horizon	X		
WealthFront	X		
Wealthify	X		
Whitebox	X	X	
WiseBanyan	X		
Yomoni	X		

Table 9				
Informed portfolio choice				
Name:	No warning:	Verbal warning:	Constrained choice:	No choice:
Betterment	X	X		
Binck Forward	X			
Easyfolio	X			
Easyvest	X			
ETFmatic		X		
Fiver-a-day			X	
Fundshop	X			
FutureAdvisor	X			
Ginmon	X			
Growney	X			
MoneyFarm	X			
Motif Investing	X			
Nutmeg		X		
Quirion		X		
Scalable.capital			X	
Stockspot	X			
Vaamo			X	
Wealth Horizon			X	
WealthFront		X		
Wealthify	X			
Whitebox	X			
WiseBanyan		X		
Yomoni				X

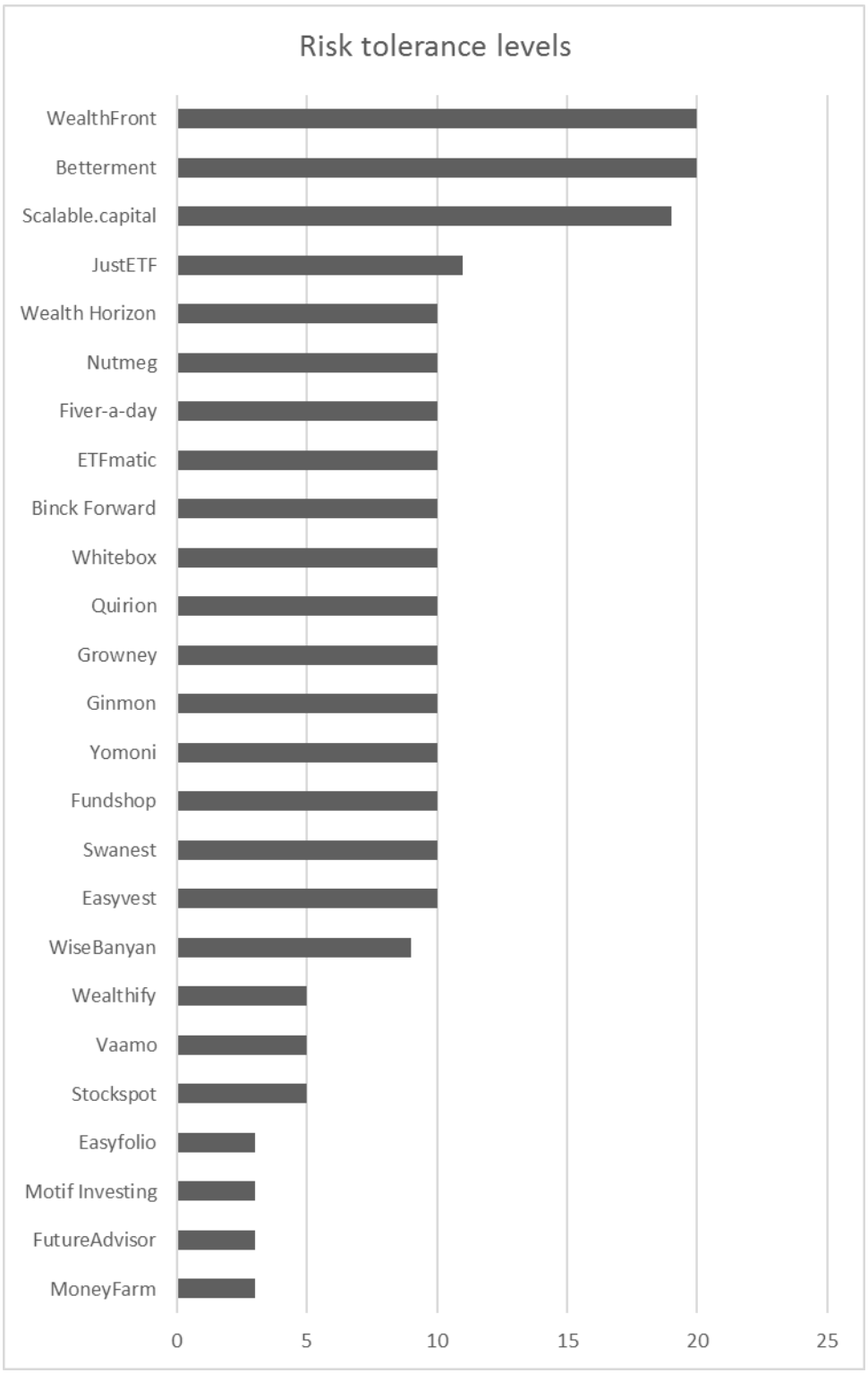

Risk tolerance levels
WealthFront
Betterment
Scalable.capital
JustETF
Wealth Horizon
Nutmeg
Fiver-a-day
ETFmatic
Binck Forward
Whitebox
Quirion
Growney
Ginmon
Yomoni
Fundshop
Swanest
Easyvest
WiseBanyan
Wealthify
Vaamo
Stockspot
Easyfolio
Motif Investing
FutureAdvisor
MoneyFarm
0
5
10
15
20
25

Figure 1

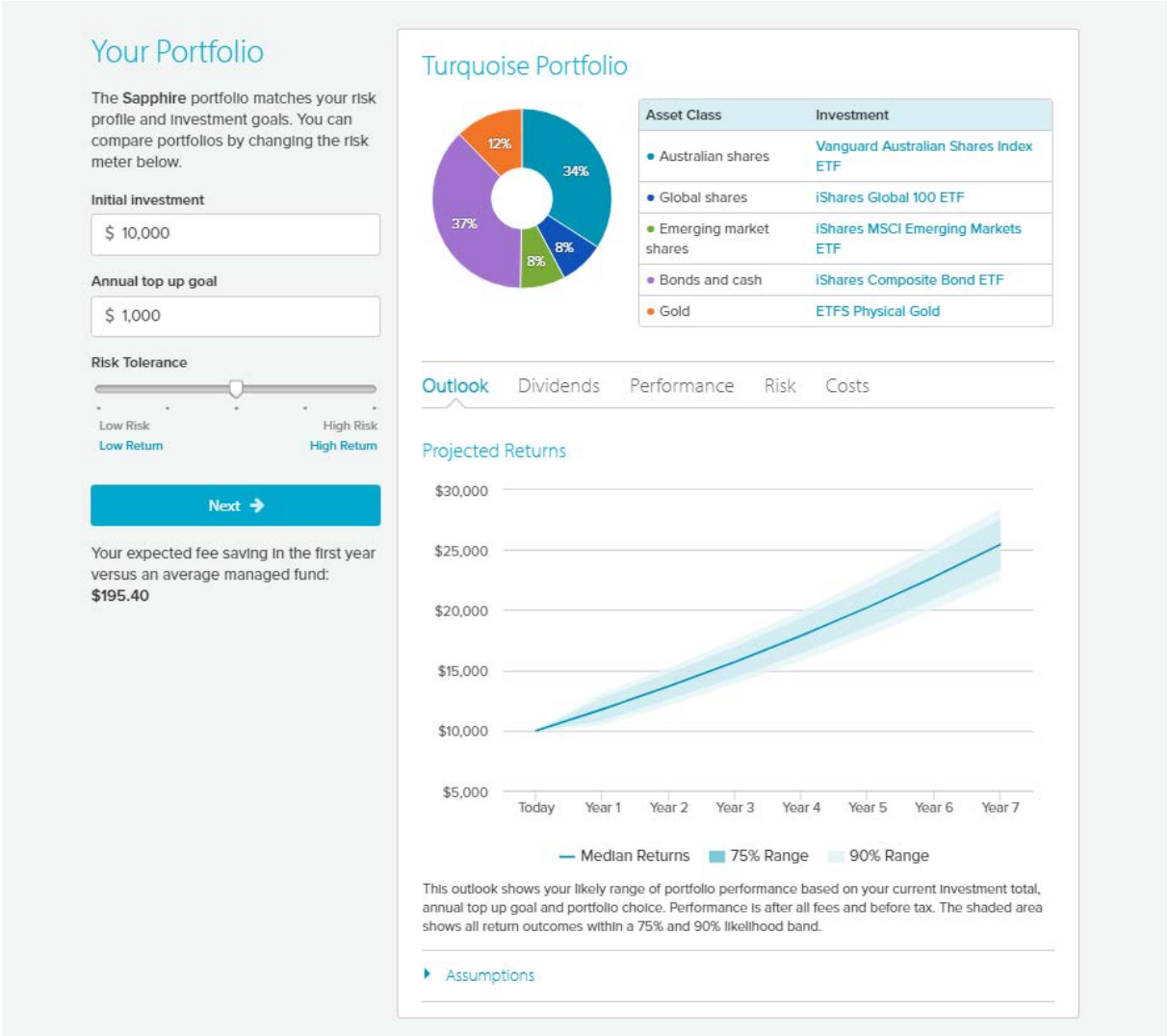

Your Portfolio
The Sapphire portfolio matches your risk profile and investment goals. You can compare portfolios by changing the risk meter below.
Initial investment
$ 10,000
Annual top up goal
$ 1,000
Risk Tolerance
Low Risk
Low Return
High Risk
High Return
Next
Your expected fee saving in the first year versus an average managed fund:
$195.40
Turquoise Portfolio
12%
34%
37%
8%
8%
Asset Class
Investment
Australian shares
Vanguard Australian Shares Index ETF
Global shares
iShares Global 100 ETF
Emerging market shares
iShares MSCI Emerging Markets ETF
Bonds and cash
iShares Composite Bond ETF
Gold
ETFS Physical Gold
Outlook
Dividends
Performance
Risk
Costs
Projected Returns
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
Today
Year 1
Year 2
Year 3
Year 4
Year 5
Year 6
Year 7
Median Returns
75% Range
90% Range
This outlook shows your likely range of portfolio performance based on your current investment total, annual top up goal and portfolio choice. Performance is after all fees and before tax. The shaded area shows all return outcomes within a 75% and 90% likelihood band.
Assumptions

Figure 2

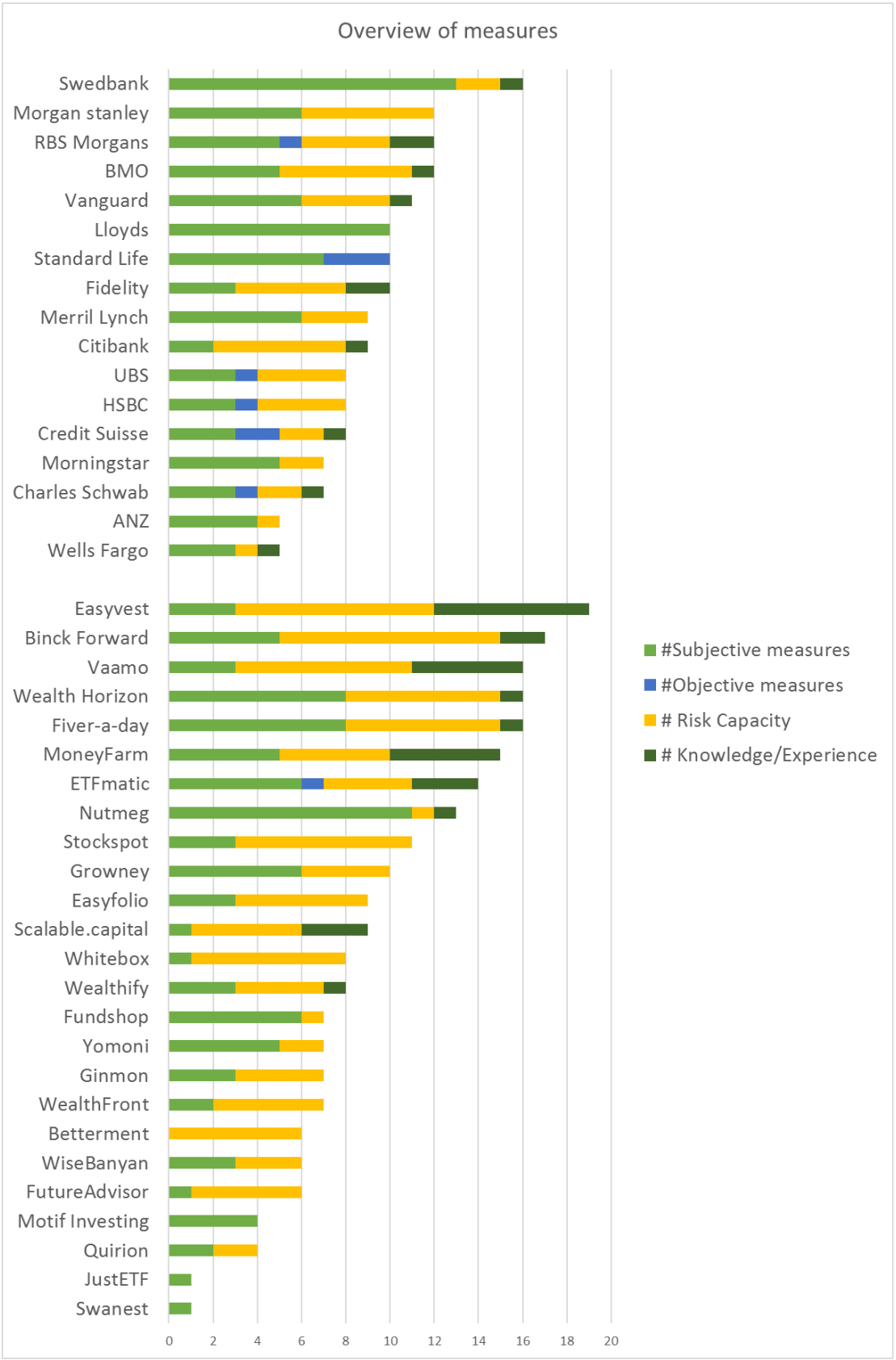
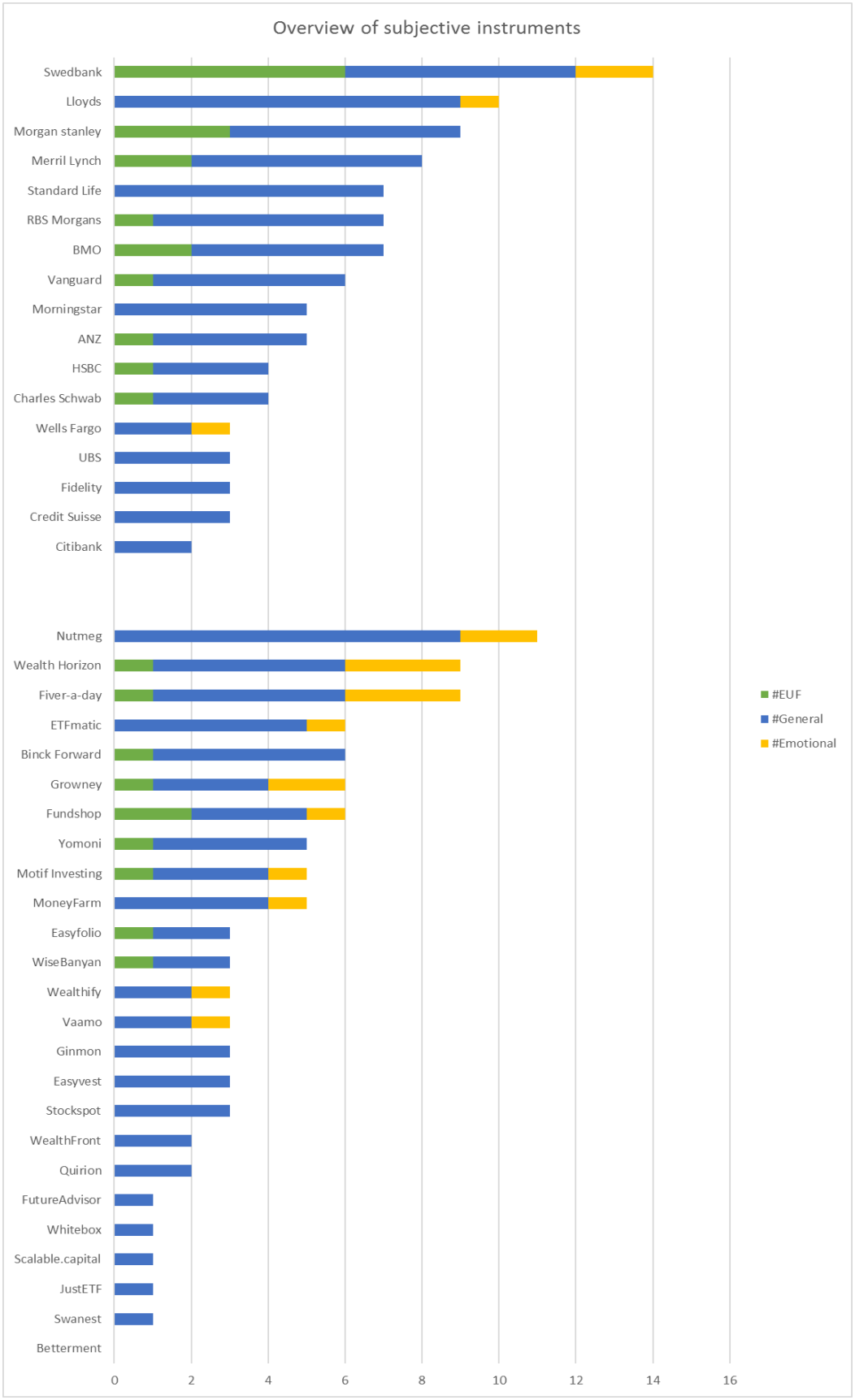

Overview of measures
Swedbank
Morgan stanley
RBS Morgans
BMO
Vanguard
Lloyds
Standard Life
Fidelity
Merril Lynch
Citibank
UBS
HSBC
Credit Suisse
Morningstar
Charles Schwab
ANZ
Wells Fargo
Easyvest
Binck Forward
Vaamo
Wealth Horizon
Fiver-a-day
MoneyFarm
ETFmatic
Nutmeg
Stockspot
Growney
Easyfolio
Scalable.capital
Whitebox
Wealthify
Fundshop
Yomoni
Ginmon
WealthFront
Betterment
WiseBanyan
FutureAdvisor
Motif Investing
Quirion
JustETF
Swanest
0
2
4
6
8
10
12
14
16
18
20
#Subjective measures
#Objective measures
Risk Capacity
Knowledge/Experience

Figure 3


Overview of subjective instruments
Swedbank
Lloyds
Morgan stanley
Merril Lynch
Standard Life
RBS Morgans
BMO
Vanguard
Morningstar
ANZ
HSBC
Charles Schwab
Wells Fargo
UBS
Fidelity
Credit Suisse
Citibank
Nutmeg
Wealth Horizon
Fiver-a-day
ETFmatic
Binck Forward
Growney
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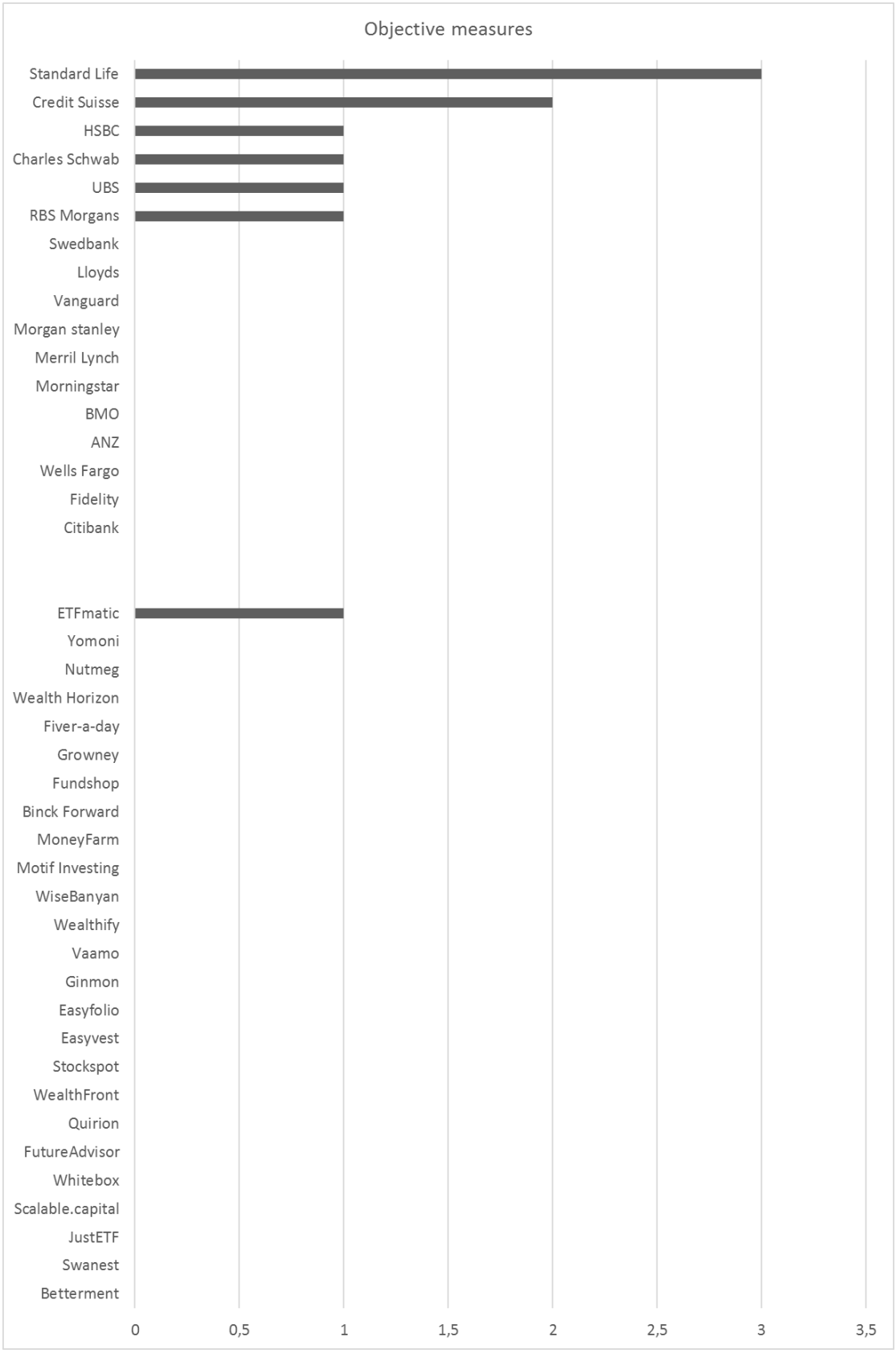
Stockspot
WealthFront
Quirion
FutureAdvisor
Whitebox
Scalable.capital
JustETF
Swanest
Betterment
0
2
4
6
8
10
12
14
16
#EUF
#General
#Emotional

Figure 4


Objective measures
Standard Life
Credit Suisse
HSBC
Charles Schwab
UBS
RBS Morgans
Swedbank
Lloyds
Vanguard
Morgan stanley
Merril Lynch
Morningstar
BMO
ANZ
Wells Fargo
Fidelity
Citibank
ETFmatic
Yomoni
Nutmeg
Wealth Horizon
Fiver-a-day
Growney
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Vaamo
Ginmon
Easyfolio
Easyvest
Stockspot
WealthFront
Quirion
FutureAdvisor
Whitebox
Scalable.capital
JustETF
Swanest
Betterment
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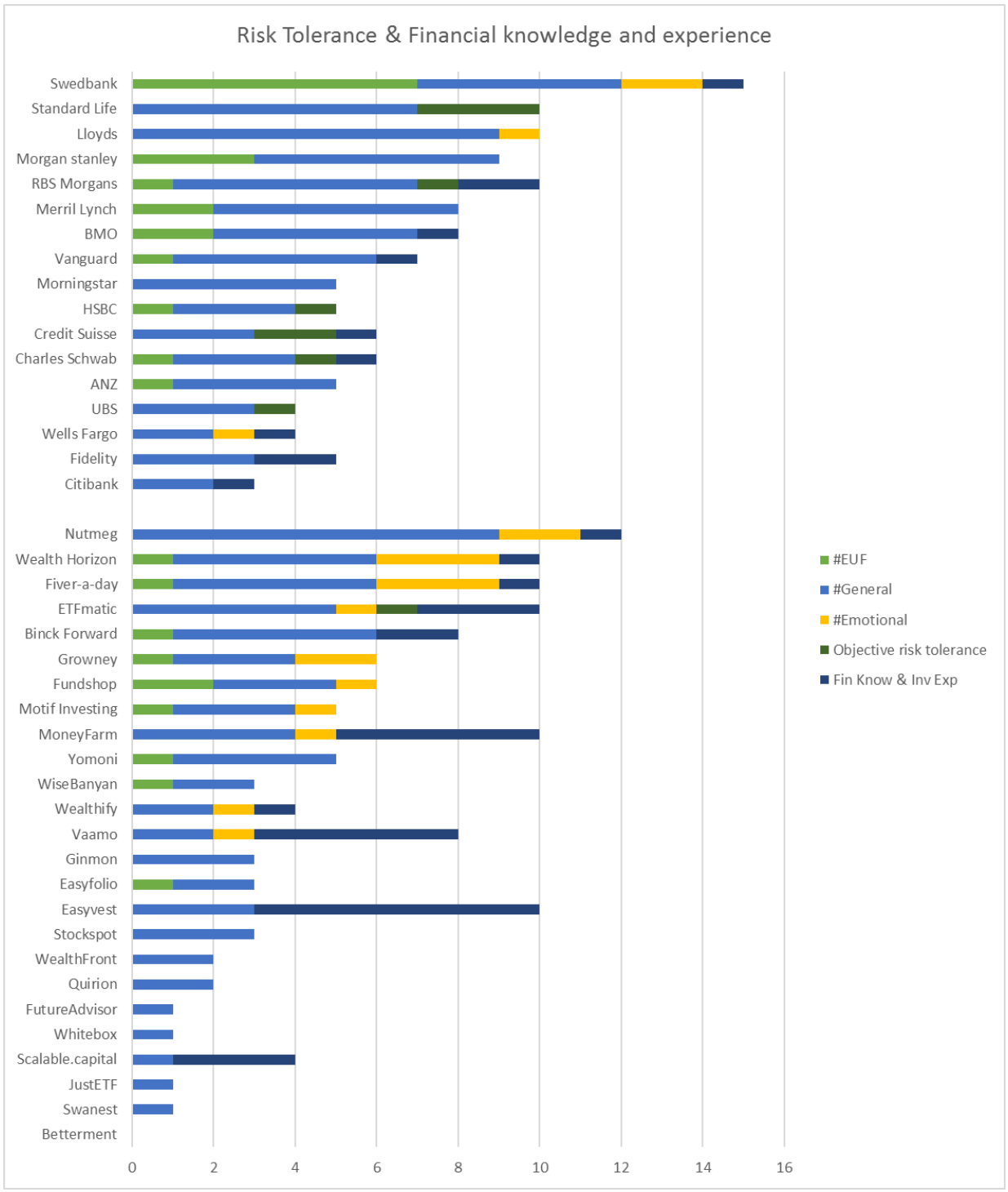
0,5
1
1,5
2
2,5
3
3,5

Figure 5


Risk Tolerance & Financial knowledge and experience
Swedbank
Standard Life
Lloyds
Morgan stanley
RBS Morgans
Merril Lynch
BMO
Vanguard
Morningstar
HSBC
Credit Suisse
Charles Schwab
ANZ
UBS
Wells Fargo
Fidelity
Citibank
Nutmeg
Wealth Horizon
Fiver-a-day
ETFmatic
Binck Forward
Growney
Fundshop
Motif Investing
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Quirion
FutureAdvisor
Whitebox
Scalable.capital
JustETF
Swanest
Betterment
0
2
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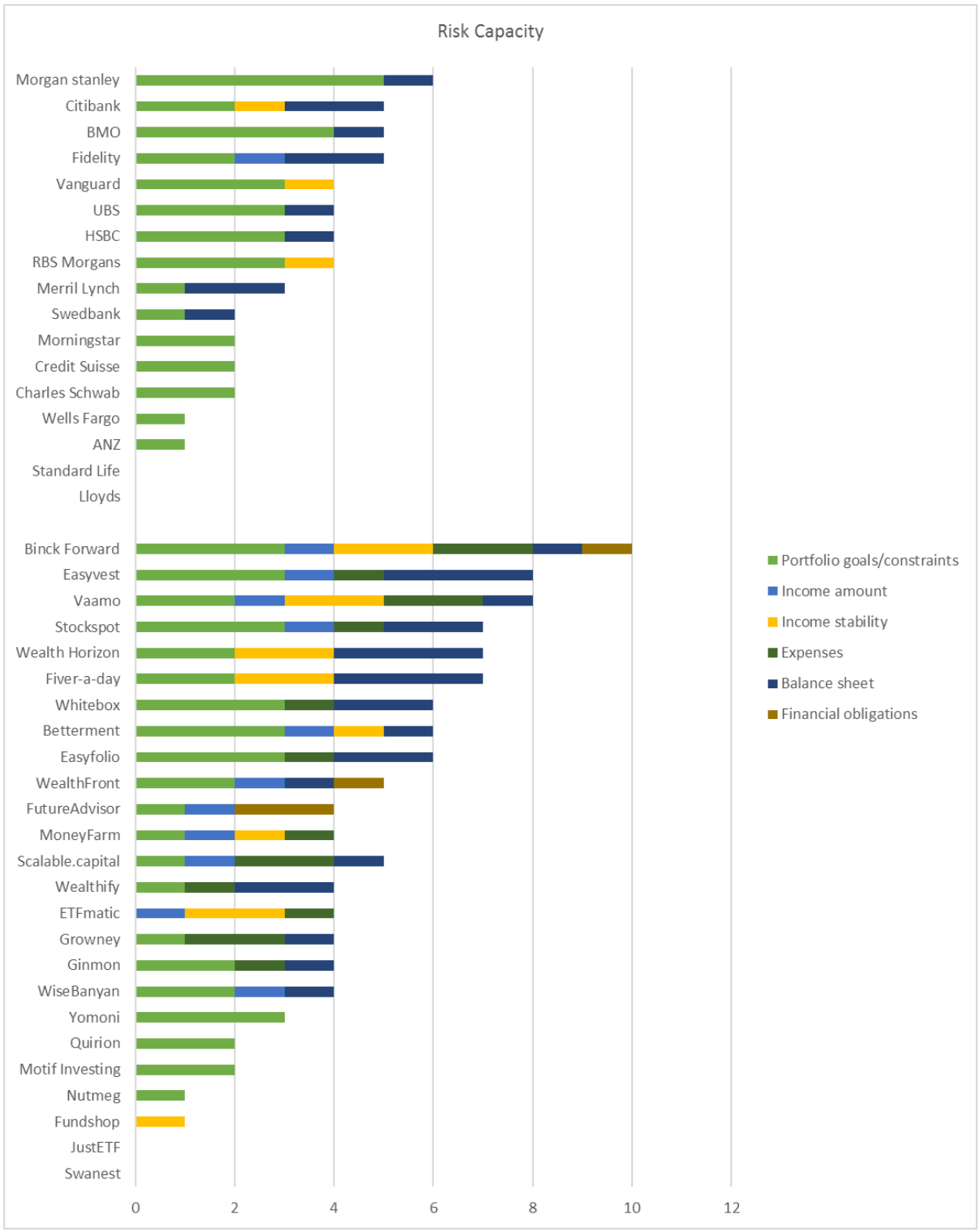
6
8
10
12
14
16
#EUF
#General
#Emotional
Objective risk tolerance
Fin Know & Inv Exp

Figure 6


Risk Capacity
Morgan stanley
Citibank
BMO
Fidelity
Vanguard
UBS
HSBC
RBS Morgans
Merril Lynch
Swedbank
Morningstar
Credit Suisse
Charles Schwab
Wells Fargo
ANZ
Standard Life
Lloyds
Binck Forward
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WiseBanyan
Yomoni
Quirion
Motif Investing
Nutmeg
Fundshop
JustETF
Swanest
0
2
4
6
8
10
12
Portfolio goals/constraints
Income amount
Income stability
Expenses
Balance sheet
Financial obligations

Figure 7