Essays on Investor Preferences

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Ann-Christine Brunen Cologne, January 2021

This thesis consists of the following works:

Brunen, Ann-Christine (2018): Moral Licensing and Socially Responsible Investment Decisions

Brunen, Ann-Christine and Laubach, Oliver (2020): Do Sustainability-Conscious Individuals Prefer Socially Responsible Investments? A Study among the Users of Robo Advice

Laubach, Oliver and Brunen, Ann-Christine (2019): Managing Diversifiable Risk of Institutional Private Equity Investors

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Chapter 1

Introduction

Investor preferences go far beyond financial returns. Standard portfolio theory traditionally requires investors to trade off the risk and return of their investments according to their individual preferences. In the recent past, it seems as though these preferences have been relocating. On the one hand, financial market crises occurring within ever shorter temporal distance, and more volatile markets, have brought portfolio risk further to the fore of investors. On the other hand, sustainability has newly supervened the trade-off between portfolio return and risk. Investors have begun to value sustainability – whether it be for return, risk, or non-financial pursuits. The papers in this thesis are concerned with these two matters that preoccupy institutional and individual investors alike: how they can invest their capital in a sustainable manner, and at an adequate level of risk.

Only the United Nations' 2015 agreement which formulates 17 Sustainable Development Goals (SDGs) to address the social and environmental issues of our time, has abetted sustainable investing. Investments that consider "environmental, social and corporate governance (ESG) criteria to generate long-term competitive financial returns and positive societal impact" (SIF, 2016) have risen above the status of a niche market, and the initial assertion of financial return sacrifices has extensively been challenged over the past years (Friede et al., 2015). Especially during times of financial market downturns, sustainable assets have outperformed their conventional counterparts (Lins et al., 2017, Y. Kim et al., 2014, Nofsinger & Varma, 2014), which has come true again during the latest stock market crash caused by the COVID-19 pandemic (Albuquerque et al., 2020). Even though more and more retail investors prefer to invest in a sustainable manner, institutional investors are hitherto the primary drivers of sustainable investing (Eurosif, 2018). In order to raise an estimated 180 billion euro per year required to meet the 2030 climate targets of the Paris agreement, the EU made a ten-point action plan on financing sustainable growth, setting out how private capital has to be directed towards sustainable investments. It envisages investment firms and insurance distributors to

incorporate sustainability into the investment advice they provide to individual clients (European Commission, 2019).

The first and second paper in this thesis therefore attempt to provide a better understanding of the motives and preferences that encourage socially responsible retail investors. Specifically, the first paper, "Brunen, Ann-Christine (2018): Moral Licensing and Socially Responsible Investment Decisions", contributes to the growing strand of literature investigating non-pecuniary motives of socially responsible retail investors. Related works have discovered stronger altruism (Brodback et al., 2019), feelings of warm glow, and higher environmental awareness (Gutsche & Ziegler, 2019), as well as stronger identification with sustainable investment strategies (Bauer & Smeets, 2015) among sustainable investors, while the role of financial return expectations, is not equivocally resolved (Brodback et al., 2019, Riedl & Smeets, 2017, Døskeland & Pedersen, 2016).

Only Bauer et al. (2020) and Riedl & Smeets (2017) rely on actual choices, investigating how general social preferences relate to socially responsible investment decisions. Most of the previous contributions apply a survey-based approach to capture the motives of socially responsible investors. These, however, might carry some bias due to social desirability and an attitude-behavior gap (Carrington et al., 2014). To overcome these issues, I analyze field data when investigating whether engagement in sustainable behavior elsewhere spills over (*spillover effect*) or substitutes (*crowding out effect*) sustainable investments. To address my question, I use a unique data set covering the consumer spending, charitable giving and investment decisions of 287 German retail investors in one year. I observe inconsistent behavior, as investors' environmentally and socially conscious consumer habits do not spill over to sustainable investment decisions, but show a negative relationship with sustainable equity fund investments. I eliminate that skepticism towards the providers of sustainable funds, whether they really fulfill the sustainability guidelines used for their marketing, drives these results. Instead, the observed inconsistency provides evidence in line with the psychological concept of *moral licensing* (Nisan, 1991, Hollander, 1958), indicating that sustainable consumer habits relieve investors from a guilty conscience about putting financial returns in the first place. The remaining investors might experience moral balance by making up for their less responsible consumer habits with sustainable investments, in the sense of a letter of indulgence. In support of this explanation, the *moral licensing* effect has been documented in the context of green purchasing and charitable giving (U. Gneezy et al. (2014), Mazar & Zhong (2010), Sachdeva et al. (2009), Khan & Dhar (2006) among others). Moreover, in the context of socially responsible investing, Mackenzie & Lewis (1999) confirm that investors, who are torn between their moral principles and financial pursuits, overcome their conflict in a similar way, allocating only a small portion of their portfolio to sustainable investments, while keeping the majority in conventional assets.

The second paper uses a quasi-experimental design to determine the relation between individuals' sustainability awareness in non-investment-related decision making and sustainable investment preferences. Meeting the EU's request for advice on sustainable investments, German robo

advisors have recently started to introduce sustainable investment strategies and to inform their current and prospective customers about sustainable investments on their websites. They provide an interesting setting for the second paper "Brunen, Ann-Christine and Laubach, Oliver (2020): Do Sustainability-Conscious Individuals Prefer Socially Responsible Investments? A Study among the Users of Robo Advice".

Robo advisors offer investment advice and portfolio management on an automated basis, eliciting their clients' risk-return profile based on a set of questions regarding their socio-demographic characteristics, investment purpose, and risk preferences. They commonly invest in passively managed index funds and ETFs in order to provide their services at relatively low cost and a small required minimum investment amount. Thereby, they give access to professional financial advice and wealth management to a broad customer base. Robo advisory services are a fast-growing market to German retail investors: assets under management are expected to rise by 92.8% to 8.068 billion euro in 2020 and the number of customers is presumed to grow by 50.2% to 2.089 million. In 2024, investments are projected to reach 29.86 billion Euro, serving 3.771 million customers (Statista, 2020).

The robo advisory market is rather young and so is the literature dealing with it. We contribute by conducting a study with 448 investors of three German robo advisors. In an up-front lottery, participants are given the opportunity to behave in a sustainable manner; a manner which would be financially costly to them. In a survey, they report their portfolio choice, attitudes, beliefs, and experience with SRI. We find that awareness for sustainability that is detached from investment decisions positively relates to sustainable investment preferences. Investors who make a sustainable choice in the lottery, willing to sacrifice part of their lottery gain, are more likely to have their robo advisor portfolio managed according to a sustainable investment strategy, express a stronger interest in a prospective sustainable investment portfolio by their robo advisor, and are more likely to choose their robo advisor based on its sustainable financial product offer. We conclude that engagement in sustainable behavior elsewhere facilitates the identification with SRI. Additionally, warm glow feelings encourage sustainable investments. In contrast to some previous studies (Bauer et al., 2020, Riedl & Smeets, 2017), however, we note that financial motives play a role to socially responsible investors as well. High expected return encourages sustainable investments, while high perceived risk deters it.

I trace the deviation of the first and second paper's findings back to several aspects. First, the two investor groups, i.e. individual fund investors and the users of robo advisory services, might differ in terms of their investment experience, cost-sensitivity, and their willingness to pay for sustainable investments. Second, the settings of the two papers stand in stark contrast to one another. Robo advisors provide detailed information about the investment strategies they offer their customers during the registration process, thus avoiding insufficient information provision, one of the most important barriers (Bundesverband deutscher Banken, 2018), and as an implication eliminate the excuse for not investing in a socially responsible way. Another

distinctive feature of the second paper is that, rather than calming their conscience by adding a sustainable fund to their conventional core portfolio (Mackenzie & Lewis, 1999), the robo advisor customers are asked to commit to either a sustainable or a conventional investment strategy. At the end of the day, the deviating findings make me optimistic that awareness for sustainability has risen over the past years. It appears that, by now, people consider their impact on a sustainable development for an increasing number of decisions.

With this in mind, the first and second paper contribute to the literature in three ways. First, they contribute to the growing stream of literature exploring the non-pecuniary motives of socially responsible investors. Second, the studies add to the field of environmental psychology, dealing with the spillover and crowding out effects of sustainable actions. Third, we are, to the best of our knowledge, the first to study socially responsible investment preferences among customers of robo advisors, and thereby add to the young stream of robo advice literature. We provide some advice facilitating the development of sound marketing strategies for sustainable financial products, to help unlock more of the hidden retail investor potential for sustainable investments, which also makes the papers relevant for practitioners.

The third paper in this thesis addresses the risk preferences of institutional private equity (PE) investors. It assesses whether institutional investors prefer to work with general partners (GPs) that manage well-diversified funds, and the extent to which models commonly used in PE practice are adequate to accurately capture PE portfolio risk. Venture capital and PE funds are typically established as limited partnerships. Institutional investors, such as pension funds, banks, and endowments, become partners with limited liability, i.e. limited partners (LPs). They endow a fund manager as general partner (GP) with the rights and liability for the fund's management and returns (Cumming & Johan, 2013). The risk of private equity investments is considerably higher, their returns are far more skewed compared to public company investments (Korteweg & Sørensen, 2010, Cochrane, 2005, Gompers & Lerner, 1998) and the success of operation crucially depends on the skill of a few, which makes portfolio risk diversification even more important for this asset class. The risk models commonly used in PE practice, like Value at Risk and Conditional Value at Risk, assume well-diversified LP portfolios. They assign risks based on cumulated cash flows from investments of the same class, thereby neglecting diversifiable risk in their calculation. It is, however, questionable whether this is a valid assumption. In our paper "Laubach, Oliver and Brunen, Ann-Christine (2019): Managing Diversifiable Risk of Institutional Private Equity Investors", we argue that PE portfolio risk models should account for the number of deals that a portfolio comprises. We conclude that the relevance of diversifiable risk is underrated.

We combine three data sources that give us a unique dataset containing data on real LPs, their funds, deals and deal-level cash flows. We obtain large LPs' portfolio compositions and deal characteristics from Preqin, the most comprehensive source of PE investor data, and complement

it with data from Thomson Reuters Eikon, in particular data on PE index returns. Deal returns, which are generally not publicly available, are obtained from an institutional investor.

A random portfolio selection procedure based on the Monte Carlo simulation technique shows that increasing diversification through the number of portfolio companies mitigates idiosyncratic portfolio risk, even in large LP portfolios. Adopting the mixed-effects model developed by Korteweg & Sørensen (2017) to our setting shows that the LPs' ability to diversify their portfolio is unevenly distributed. Additionally, a bootstrap procedure reveals that real portfolio concentrations on certain deals, which are jointly conducted by several funds with the same institutional investor, occur more often than luck would have it. These concentrations generally increase idiosyncratic portfolio risk but yield high returns at the same time.

Our work contributes to the growing literature strand that assesses risk in the PE market. We also add to the sparse literature analyzing LP investments (Cavagnaro et al., 2019, Sensoy et al., 2014, Hochberg & Rauh, 2013). We look at LPs' skill concerning the selection of well-diversified funds here. Our results serve practitioners, indicating that LPs should include idiosyncratic portfolio risk to their reporting.

This thesis comprises one single-author paper and two papers that have emerged in collaboration with my co-author Oliver Laubach. For the paper "Brunen, Ann-Christine (2018): Moral Licensing and Socially Responsible Investment Decisions", a fund provider has made investor data available to me. I have then, automatically and manually, collected additional data on investment characteristics and the observed shop spending. For the paper "Brunen, Ann-Christine and Laubach, Oliver (2020): Do Sustainability-Conscious Individuals Prefer Socially Responsible Investments? A Study among the Users of Robo Advice", I have developed the research idea and contacted three robo advisors whose customers were surveyed for the study. The remainder of the paper has resulted in collaboration. We have jointly determined the survey, implemented it in oTree, conducted the analysis, and have written down the results. Professor Dr. Thomas Hartmann-Wendels and the Institut für Bankwirtschaft und Bankrecht have provided the financial support for this project. Moreover, I am very thankful for the opportunity to use the server of the Cologne Laboratory for Experimental Research for the survey. My co-author, Oliver Laubach, developed the idea for the paper "Laubach, Oliver and Brunen, Ann-Christine (2019): Managing Diversifiable Risk of Institutional Private Equity Investors". He is in touch with the institutional investor that has provided us with the non-public data. We have then jointly worked on this paper. Together, we collected the remaining missing data, compiled the methodology for our analysis, implemented the regressions, and wrote down our results.

The three papers that this Ph.D. thesis comprises are unique in terms of the distinctive datasets they rely on, the multiplicity of research methods they apply, and the investor perspectives they take – institutional and individual – to catch the reader's attention to three crucially important investor matters: sustainability, robo advice, and PE portfolio risk management.

Chapter 2

Moral Licensing and Socially Responsible Investment Decisions*

2.1 Introduction

Socially responsible investing captivates investors and researchers alike. In Europe, between 2013 and 2017, CAGRs of assets managed according to socially responsible investment (SRI) strategies like *ESG*[1] *Integration* and *Sustainability Theme* equaled 22.22% and 26.05% in Europe (Eurosif, 2018), and, on average, exceeded the total investment market growth of 11.17% (Efama, 2018). In particular, retail investors have become an important source of sustainable capital next to institutional investors. During the same period, the market share of socially responsible retail investors in Europe has increased from 3.4% to 30.7%, catching up with the total market share of retail investments (Eurosif, 2016, Efama, 2018).

The mission of SRI strategies is to supplement "the traditional criteria of profitability, liquidity and security for environmental, social and ethical criteria"(Forum Nachhaltige Geldanlagen, 2018). Numerous studies have been dedicated to the question whether the performance of SRI and ESG investments deviates from that of their conventional counterparts,[2] albeit yielding divergent results.[3] Investors at least need to be prepared to pay a premium when choosing to invest in a responsible manner, indicating some non-financial pursuits (Bauer et al. (2020),

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[1]Environment, social, and governance (ESG).

[2]Friede et al. (2015) count 2200 studies in 2015.

[3]Lesser et al. (2016), Belghitar et al. (2014), Bartling et al. (2014), Hong & Kacperczyk (2009), Fabozzi et al. (2008), Renneboog et al. (2008a,b) find that SRI or ESG investing is financially costly while sin stocks generate abnormal returns. Syed (2017), Edmans (2011), Kempf & Osthoff (2007), instead, observe that SRI and social stock screening can yield high abnormal returns. Erragragui & Lagoarde-Segot (2016), Calvo et al. (2015), Mollet & Ziegler (2014), Bauer et al. (2005) come to the conclusion that both asset classes yield a similar performance.

Brodback et al. (2019), Hartzmark & Sussman (2019), Gutsche & Ziegler (2019), Riedl & Smeets (2017), El Ghoul & Karoui (2017), Bauer & Smeets (2015), Renneboog et al. (2008b), among others). In this light, sustainable investors show stronger social preferences (Bauer et al., 2020, Riedl & Smeets, 2017) and higher environmental awareness (Brodback et al., 2019), experience the warm glow of giving (Gutsche & Ziegler, 2019), but may also strive for social esteem (Riedl & Smeets, 2017). They have also shown a willingness to sacrifice part of their financial return in favor of investment in accordance with their non-financial pursuits (Gutsche & Ziegler, 2019, Renneboog et al., 2011, Barreda-Tarrazona et al., 2011).[4]

Since both, responsible consumers[5] and investors, seem to be concerned about the societal impact of their actions, it raises the question if responsible consumers prefer to invest in a sustainable manner. Previous studies noted the occurrence of a spillover as well as a compensatory, moral licensing effect of various types of pro-environmental and pro-social behavior (Chatelain et al. (2018), Juhl et al. (2017), Margetts & Kashima (2017), Carfora et al. (2017), Truelove et al. (2014), Tiefenbeck et al. (2013), Whitmarsh & O'Neill (2010), among others). In terms of sustainable investing, the responses of 415 Spanish savers have revealed that the self-reported degree of socially responsible consumption is positively related to the *intention* to invest in SRI (Palacios-González & Chamorro-Mera, 2018). Among another 1,000 participants of an international survey, those consumers who reported a willingness to punish irresponsible companies also stated that they would take into account companies' social responsibility when deciding which shares to buy or sell (Williams, 2007).[6] Survey responses, however, often suffer from bias due to social desirability (Follows & Jobber, 2000) or an *attitude-behavior gap*. The latter describes the case when people do not suit the action to their word. Consumers, for example, frequently report ethical concerns but seldomly convert them into conscious consumer habits (Joshi & Rahman, 2015, Carrington et al., 2014, Chatzidakis et al., 2007, De Pelsmacker et al., 2005, Carrigan & Attalla, 2001).

In order to rule out any of those biases, I analyze data containing the consumer spending, charitable giving and investment decisions of 287 German retail investors for one year. I populate this data with information gathered from the shops these investors frequent. This provided me with a unique dataset comprising information on both, investors' environmentally as well as socially conscious consumer behavior.[7] In particular, I relied on organic grocery shopping and patronage of small and independent bookstores. In addition, I consider the giving to good

[4]Moreover, Hong & Kostovetsky (2012) find that political orientation can determine fund managers' asset choice. According to their results, democratic mutual fund managers hold smaller portfolio portions in companies that are considered socially irresponsible. Borgers et al. (2015) provide evidence that equity mutual fund managers take their investors' preferences into account, observing a weaker exposure to ethically questionable stocks when the target investor groups are socially conscious and institutional investors.

[5]Ladhari & Tchetgna (2015), Andorfer & Liebe (2013), van Dam & Fischer (2015) and Thøgersen (2011) find that altruistic motivations, identification, and personal values positively encourage organic and fair trade purchases.

[6]Results for Germany are insignificant.

[7]I follow the recommendation by the consumer literature here (Roberts, 1995).

causes. In the following, I use the terms *socially responsible, ethical and conscious consumers* interchangeably.

I observe inconsistent behavior, noting that responsible consumer habits do not spillover to sustainable investment decisions. All measures of pro-social behavior yield a significant and negative relationship with sustainable equity fund investments. Mackenzie & Lewis (1999) observe that investors who are torn between their moral principles and financial pursuits overcome their conflict by allocating only a small portion of their portfolio to SRI, while keeping the majority in conventional assets. It seems like most sustainable investors in my sample allocate their portfolio this way. 75% of them only hold one single sustainable fund. I argue that the observed inconsistent behavior can be traced back to conscious consumers' moral credits, which prevent them from feeling guilty about putting financial returns first. Less responsible consumers may seek moral balance by making up for less responsible consumer habits with sustainable investments, which reminds of a letter of indulgence. In psychology literature, the effect of *moral licensing* describes how an individual's moral decisions are affected by the moral legitimacy of their previous decisions. According to this concept, previous moral decisions allow for some deviation from moral behavior without remorse, as long as the moral and immoral decisions balance (Nisan, 1991, Hollander, 1958).

I discuss and test several alternative explanations of the observed negative relationship. In particular, I account for the possibility of responsible consumers being more skeptical towards the providers of sustainable funds actually meeting the guidelines used for their marketing. For instance, I examine whether responsible consumers screen stocks based on ESG scores themselves.

This article contributes to three strands of literature. First, this paper contributes to the literature investigating the non-financial motivations that drive SRI decisions. Second, the findings of this paper relate to the psychology and marketing literature strand exploring consistent versus compensatory behavior. Khan & Dhar (2006) have proven the relevance of moral licensing in consumer choices. They analyze consecutive consumer decisions and observe that previous virtuous choices can license consumers to choose indulgent products afterwards. Sachdeva et al. (2009) have been able to show that the licensing effect also applies to charitable giving. After describing themselves with positive traits, individuals donated dramatically less indicating that affirming one's moral identity makes people feel free to behave immorally and vice versa. Likewise, U. Gneezy et al. (2014) find that an immoral decision increases an individual's likelihood for a subsequent donation. Mazar & Zhong (2010) show that this effect ranges from consumption to financial decisions. They find that individuals who purchase green products shared less money in an anonymous dictator game and were more willing to behave immorally afterwards in order to win money. Their paper shows that the moral licensing effect spans from consumption to monetary decisions creating room for the assumption that an individual can derive moral balance either through offsetting portfolio decisions or by compensating consumer

and investment choices. The third literature stream this paper contributes to is the barely explored connection between consumption and investment choices.[8] Earlier attempts to analyze a connection between SRI and conscious consumption has been limited to questionnaire responses (Palacios-González & Chamorro-Mera, 2018, Williams, 2007). To the best of my knowledge this is the first study to link real consumer spending to SRI choices rather than merely relying on investors' reported behavior.

This paper aims to add another piece to solve the SRI puzzle. It has implications for practitioners and researchers. The EU's action plan on sustainable finance discusses how to direct private capital towards sustainable investments. It calls on investment firms and insurance distributors to include ESG criteria into the financial advice they give to individual clients. This is a first step to fill the EU's estimated investment gap of 180 billion euro per year to fulfill the 2030 targets that were agreed on in Paris (European Commission, 2019). Understanding socially responsible investors can help to market SRI retail funds more effectively to interested investors and to further increase the retail investor base. The latter has become a second important source of sustainable capital. In particular, understanding socially responsible investors helps to develop a sound marketing strategy for sustainable investment products. At the same time, it points to the adverse effect that encouraging sustainable behavior in one area might have on the achievement of sustainability goals in other areas.

The remainder of this paper is organized as follows. Section 2.2 and 2.3 contain a detailed description of the data and the methodology applied. Section 2.4 explains the variables utilized in this study and provides the summary statistics. Section 2.5 presents the main analysis of this paper, investigating the relationship between consumer and investment preferences. Section 2.6 discusses the potential explanations of my findings. Section 2.7 addresses the limitations of my study. Section 2.8 concludes this paper and evinces a potential direction for future research.

2.2 Data

To address my question, I combine individual investors' portfolio, demographic and consumption data. The data has been provided by a German fund distributor that operates online. It offers discounts that apply in particular to funds. In the whole process, the individual investors make their investment choices without advice from the fund distributor.

I consider Germany an interesting market to study SRI developments. Most of the SRI strategies have experienced growth rates between 21% to 143% in 2017. They gained increasing popularity among retail investors. Still, with 9% in 2017, retail investors' share on that market[9] is relatively

[8] Keloharju et al. (2012) have brought forward the most remarkable work on that field. They find that customer relation increases an investor's likelihood to purchase the company's stock. Bernard et al. (2018) rule out reverse causality to show that customer relation encourages investment.

[9] Compared to institutional investors.

low in comparison to the neighboring countries Austria (24%) and Switzerland (37%), which offers further potential to increase sustainable capital provision (Forum Nachhaltige Geldanlagen, 2018).

2.2.1 Portfolio data

On the securities account level, I observe individual investors' track record on a daily basis from January 1, 2017 to December 31, 2017. I observe every position an investor holds in the portfolio. The respective position is identified by its International Securities Identification Number (ISIN) and carries information on daily prices as well as the quantity and total value the investor holds on a given day. Moreover, I have the investors' full trading history during that year and have additionally been provided with information on the capital decisions made by the funds and companies, i.e. fund distributions, reinvestments, dividends, stock splits, and bonus shares.

For the analysis, additional data was collected. Information on asset names, asset classes and the classification as an equity fund have been collected via Thomson Reuters Datastream and, if not available,[10] via webscraping in Google. Funds have been identified as an SRI if they include words associated with an SRI such as sustainability, responsibility or ESG in their name, since SRI funds would most likely signal their strategy in this manner hoping to attract investors. Investors, in turn, would most likely search for SRI funds or recognize them as such by their name.[11] Furthermore, ESG information on stocks has been retrieved from Thomson Reuters Datastream.

I analyze portfolio data of 287 equity investors (stocks and equity funds). Thereof, 220 investors hold equity funds.

2.2.2 Socio-demographic data

On the socio-demographic level, I observe an investor's gender, age, town, and state as well as the information whether the securities account is managed by a couple. The majority of equity fund investors in this sample is male (63%), while women and couples make up approximately 25% and 12%, respectively. Most of them live in West Germany (90%), with 40% of the investors living in one of the 20 largest cities. The investors are approximately equally distributed across the age brackets 30 to 39 (23%), 40 to 49 (25%) and 50 to 64 (29%). Investors younger than 30 years account for 13%, while investors at the age of 65 or above make up the smallest fraction of this sample (10%). These numbers do not vary much from the ones for equity investors.

[10] Most of the time this were derivatives.

[11] Cooper et al. (2005) show that funds changing their name to capture a new investment trend experience abnormal fund inflows of 28% in the following year without registering performance improvements. Investors seem to go for trend names.

2.2.3 Consumer spending and charitable giving data

This data set is a one-year record of all consumption spending an investor placed with the offsetting bank account. Each record indicates the date, shop, and the amount the consumer spent. I use consumption histories from January 1, 2017 to December 31, 2017 and populate the data with information on the shops' purpose. This data has been collected via webscraping in Google and the results have been evaluated manually. Additionally, outgoing payments have been checked for donations. Furthermore, I checked the nature of the investors' incoming payment, i.e. revenue from income from work, supplements or rental income.

2.3 Methodology

A probit regression is applied to explain an investor's decision to hold an SRI equity fund in 2017 by her consumer habits in the same year. I control for portfolio characteristics in 2017 as well as socio-demographic characteristics. In order to investigate how conscious consumers structure their equity portfolios, I always use two specifications: in the first specification, I call on the full sample of equity investors in order to analyze investment decisions irrespective of an investor's preference for equity funds or stocks. Hereinafter, these regressions will be indicated as regression (1); In the second specification, I use the subsample of investors holding equity funds to account for the fact that, by construction, an *equity fund* holder's probability to invest in an SRI *equity fund* is higher than that of a mere stock owner. In what follows, these regressions will be labeled as regression (2).

I use equity as that allows me to compare investments in funds and stocks. Moreover, the SRI funds in my sample are mainly equity funds which is why I restrict my analysis to this category.[12] For the latter reason I also exclude ETFs from the analysis. Moreover, the fund distributor's favorable conditions do not extend to ETFs, such that the inclusion of ETFs into the analysis would potentially bias the results.

In a separate regression, I examine an equity investor's tendency to hold a high stock portfolio ESG score. I calculate an individual investor's mean aggregate value-weighted stock portfolio ESG score in 2017 as mean value of the investor's portfolio ESG scores during that year, with the ESG score in the respective point of time calculated as

$$ESGScore\,(Pf) = \sum_{i=1}^{n} ESGScore\,(i) \cdot \frac{Stock's\ value\,(i)}{Value\ of\ scored\ stock\ portfolio}\ ,$$

where *ESG Score (i)* is a stock's ESG score as retrieved from Thomson Reuters Datastream, *Stock's value (i)* is the euro value an investor holds in this particular stock position, and *Value*

[12] See also Riedl & Smeets (2017) who restrict their sample to equity funds for the same reason.

of scored stock portfolio is the value of the entire scored stock portfolio the individual investor holds.

2.4 Variables

For an overview of all variables used in this study, I refer the reader to Table 2.6 in the Appendix. Moreover, Table 2.7 in the Appendix reports summary statistics of all variables listed by investor groups and summary statistics comparing the traits of socially responsible and conventional investors.

2.4.1 Dependent variables on SRI

An investor is classified as a socially responsible investor (*SR investor*) if she owned an SRI equity fund in 2017.

On the stock level, an investor is classified as having a *High ESG Score* if she owned a stock portfolio with an ESG score that is above the 75% percentile stock portfolio ESG score observed in this sample.

2.4.2 Independent variables on consumer spending and charitable giving

Webster (1975), among others, provides a broad definition of a socially conscious consumer as "a consumer who takes into account the public consequences of his or her private consumption or who attempts to use his or her purchasing power to bring about social change" (p. 188). Yet, this definition does not provide more clarity on the aspects to consider and how they should be integrated into a reliable measure of responsible consumption. In fact, socially responsible consumer behavior is not as easy to define and measure as it may appear at first sight. What happened is that all attempts to approximate conscious purchase behavior make use of questionnaires that depict attitudes, hypothetical scenarios, and intended behavior but have mostly not even begun measuring actual purchase behavior (Sudbury-Riley & Kohlbacher, 2016). Even scales that do make use of self-reported past behavior are subjected to socially-desirable responses, false self-awareness or lack of better knowledge about responsible consumption. Hence, actual socially responsible consumer behavior remains an abstract concept. To overcome these issues, I measure socially responsible behavior based on actual purchase record data. I assume that one year of consumption history is reliable to characterize an individual's consumer habits.

Summarizing the many facets of responsible consumption, Roberts (1995) requires a scale for responsible consumption to include environmental and social issues, like socially responsible

investing comprises environmental, social and ethical criteria. When talking about environmentally conscious consumer behavior, green consumption is a dominant theme (do Paço et al. (2019), Haws et al. (2014), Lin & Huang (2012), among others). Ethical consumers prefer organic and fair trade products that meet their requirements concerning environmental and animal welfare issues as well as fair working conditions (Ueasangkomsate & Santiteerakul, 2016, Basha et al., 2015, Doran, 2009, Honkanen et al., 2006), and they are willing to pay a premium for these products (Ladhari & Tchetgna, 2015).[13] According to a German consumer survey, most of the consumers stated animal welfare and environmental concerns as *the* or one of the primary reasons for organic purchases, while health and personal well-being are an import yet less frequently stated motivation (BMEL, 2018). I therefore refer to organic supermarket loyalty as first measure of responsible consumption, covering its environmental dimension. More precisely, I quantify an investor's preference for sustainably crafted, organic products in terms of the number of times per year an investor does the grocery shopping at organic supermarkets relative to the number of times she shops for groceries at mainstream supermarkets (factor 1: Organic purchases).[14] Even though purchase record data is only observable on a shop level and not on an item level, making it impossible to include consumers' organic product purchases from mainstream retailers, several arguments lend support to the assumption that conscious consumers will likely prefer organic supermarkets over the mainstream supermarkets' organic product assortment for their household needs. First, trust in mainstream supermarkets' organic store brand quality is low. 68.1% of the German consumers stated that they do not or at least do not convincingly trust the organic quality of mainstream supermarkets' store brands (Statista, 2018). This explains why organic supermarkets' customer base is steadily increasing. 13.24 million out of 81.40 million Germans did their grocery shoppings partially in organic supermarkets (Statista, 2018), making organic supermarket customers no longer an exception.[15] Second, organic supermarkets offer the convenience of a full assortment of organic products for all household necessities. Padel & Foster (2005) describe convenience as an important factor in a customer's decision for the point of sale of organic products. Third, and most important, it represents a more obvious way to express one's personal values, since organic supermarkets completely refrain from offering non-organic products.

Socially conscious consumers will be concerned about their close surrounding. Preferring local products and purchasing in the shop next door relates to the idea of supporting the local economy, protecting local workplaces and supporting one's community. According to Carrigan & Attalla (2001), it is the small and medium enterprises (SMEs) that are crucial for society's transformation towards sustainability. In line with these ideas, Francois-Lecompte & Roberts

[13] According to Statista (2019), with a share of 17% German consumers are the second most willing to pay a price premium for organic food products. In line with that, Liobikienė et al. (2016) observe among the weakest influence of price on green purchase behavior for Germany in their EU study.

[14] Here, conscious product choice is measured in relative rather than absolute terms in order to capture the fraction of conscious purchase behavior instead of the frequency of one's supermarket shoppings.

[15] Perrini et al. (2010) further investigate this lack of trust on the Italian consumer market.

(2006) include a consumer's support of neighborhood shops into their measure of responsible consumption. Taking up this idea, I approximate the extent of a consumer's effort to support small, local businesses with the aggregate amount a consumer spends at small, independent bookstores per year (factor 2: Small bookstores).

The feeling of personal proximity, other-beneficial concerns, and the awareness of being better off than others even encourages pro-social behavior that is detached from any material reward (Schlosser & Levy, 2016, Ein-Gar & Levontin, 2013, Fisher et al., 2008). I consider charitable giving as another channel through which the individual can contribute to tackle social and environmental grievances and consequently include the amount the individual donates per year (factor 3: Charitable giving) into my analysis.

2.4.3 Control variables

Socio-demographic variables

In order to account for investors' socio-demographic differences, I integrate dummy variables for the mean monthly revenue consisting of the income from work, supplements for children and household as well as rental income. The variable *Untold income* is equal to one for the cases where an investor's income is not observable or payments lower than 750 euro[16] are observed. Based on a tercile split, I construct the dummy variables *Low Income* (between 750 and 2,553.17 euro) and *High Income* (above 4,397.97 euro), where *Medium Income* (between 2,553.17 euro and 4,397.97 euro) is the omitted reference group. Furthermore, the dummies *East Germany* and *Urban resident* indicate whether an investor lives in East Germany[17] (one, zero otherwise) and in one of Germany's 20 largest cities in terms of population (one, zero otherwise). The investor's age has been classified into categories *Age: 30-39*, *Age: 40-49*, *Age: 50-64*, *Age:* $\geq$*65*, with *Age:* $<$*30* as omitted reference group.[18] To control for gender differences, I construct the dummy variables *Female* which is equal to one if the investor is a women, and *Couple* which is equal to one if a couple owns the securities account. Male investors are the omitted reference category.

Portfolio variables

On the portfolio level, I control for equity portfolio wealth (*Log total equity value*) as the logarithm of the mean value the investor holds in equity (equity funds, stocks and equity ETFs) in 2017. I account for an investor's portfolio activity with the *Number of trades in equity* observed in 2017. I approximate an individual investor's *Risk appetite* by the average amount an investor holds in derivatives in 2017 as percentage of the total portfolio value. *Fraction held*

[16]This is the German monthly tax-free amount. It is reasonable to assume that an individual will have more than the lower income threshold at their disposal if she is able to allocate money to funds.

[17]All investors living in Berlin are considered as living in West Germany.

[18]I refer to Christiansen et al. (2018) who use the same age brackets.

in funds controls for the average amount invested in equity funds in 2017 as percentage of the investor's equity value (stocks and equity funds).

2.4.4 Descriptives

The sample comprises 220 equity fund investors, 20% of them hold SRI. Table 2.1 compares SR and conventional investors' equity portfolio composition.

Table 2.1: Differences in portfolio compositions of socially responsible and conventional investors

This table contains details on the differences regarding portfolio compositions of SR and conventional equity fund investors. Investors are classified as socially responsible if they hold SRI equity funds in 2017. *# equity funds, # SRI equity funds, # conv. equity funds* refer to the average number of equity funds (i.e. SRI and conventional funds), SRI equity funds, and conventional equity funds that fund investors hold in their portfolio. *Equity fund value, SRI equity fund value, Conv. equity fund value* present the average euro amount fund investors allocate to equity funds, SRI equity funds, and conventional equity funds. *Equity value, Total equity value, Stock value, Portfolio value* describe the average euro amount investors hold in equity funds and stocks, in equity in total (that is stocks, equity funds and equity ETFs), in stocks, and the average euro value of the total portfolio. *% SRI of equity funds*, respectively *% in SRI equity funds* pertains to the average value fraction SRI equity funds make up of investors' entire equity fund portfolio position, resp. the average value fraction investors allocate to equity funds relative to the total equity fund and stock value. *% equity funds* refers to the average value fraction equity funds make up of investors' equity fund and stock value. All statistics refer to mean observations during 2017.

	Mean by investor group		
	All investors	SR investors	Conv. investors
# equity funds	3.44	5.15	3.02
# SRI equity funds	0.20	1.01	.
# conv. equity funds	3.24	4.14	3.02
Equity fund value	22,802	35,638	19,592
SRI equity fund value	1,582	7,912	.
Conv. equity fund value	21,219	27,725	19,592
Equity value	46,194	66,275	41,174
Total equity value	53,975	76,23	48,411
Stock value	23,392	30,637	21,581
Portfolio value	71,586	106,644	62,821
% SRI of equity funds	0.07	0.35	.
% in SRI equity funds	0.05	0.27	.
% equity funds	0.69	0.75	0.68
Investors	220	44	176
% of investors	1.00	0.20	0.80

It shows that the average (and median) socially responsible investor does not hold a complete SRI portfolio but selects one SRI fund complementing the conventional fund portfolio. Table 2.8 and Figure 2.1 in the Appendix further illustrate this finding, showing that 75% of the

socially responsible investors hold one SRI fund at most, compared to 4.1 conventional equity funds. This goes in line with the idea of a core satellite strategy where investors choose a core portfolio based on financial considerations and supplement it with a smaller satellite portfolio that satisfies their non-financial goals (Methling & von Nitzsch, 2019).

Second, in terms of the overall portfolio composition, it appears that conventional investors hold, on average, a less diversified equity fund portfolio compared to socially responsible investors with 3.0 compared to 5.2 funds (median 2.0 versus 4.0 funds) and a lower total portfolio value of 63,000 euro compared to 107,000 euro among socially responsible investors. This relationship also applies to the equity fund value and total equity value (funds and stocks). The mean (median) socially responsible investor has an equity fund portfolio worth 36,000 (13,000) euro, of which SRI accounts for 0.35% (0.23%). In contrast, conventional investors hold equity fund portfolios worth 20,000 (5,000) euro. These findings match with the data of Lapanan (2018) and Riedl & Smeets (2017), who find that SR equity fund investors hold a higher portfolio wealth and a more diversified fund portfolio.

2.5 Are conscious consumers sustainable investors?

This paper aims to understand how conscious consumption and sustainable investing are related, thereby adding another piece to solve the SRI puzzle. Do responsible consumers integrate sustainability considerations into their investment decisions, or do they feel that responsible consumption compensates for non-sustainable investments? How do responsible consumers structure their equity portfolios in terms of sustainability aspects? Investigating the consumer behavior of fund investors will shed light on the connection between responsible consumer and sustainable investment behavior.

Table 2.2 reports the results of this analysis. I examine the connection of an investor's degree of responsibility as consumer and his likelihood to hold SRI. As noted before, regression (1) refers to the full sample specification, regression (2) references to the restricted sample of equity fund investors. Both specifications present the marginal effects of a probit regression in which the dependent variable is a dummy that takes the value of one if an investor holds an SRI equity fund, and zero otherwise.[19] The main explaining variables are the previously described measures of responsible consumption, namely *Organic purchases*, *Small bookstores*, and *Charitable giving*. I control for several individual-level characteristics, in particular the income group the investor belongs to (i.e. *Low*, *High* or *Untold income*, with *Medium income* as omitted reference group), *East Germany* and *Urban resident*, the investor's age bracket (i.e. *30-39*, *40-49*, *50-64* or $\geq$*65*, with $<$*30* as omitted reference group), whether the investor is *Female* or the account is managed

[19] See Riedl & Smeets (2017), who specify their dependent variable in such manner.

by a *Couple*. I also control for several variables related to an investor's portfolio, specifically *Log total equity value*, *Number of trades in equity*, *Risk appetite*, and *Fraction of equity funds*.

The results for both sample specifications, (1) and (2), show that all defined measures of responsible consumption are significantly and negatively related to an investor's likelihood for choosing an SRI fund. An investor who does some grocery shoppings at organic supermarkets expresses a certain degree of concern about environmental and animal welfare issues and is less likely to purchase an SRI fund than a consumer who only frequents mainstream supermarkets.

Table 2.2: Are conscious consumers sustainable investors?

This table presents the marginal effects of two probit regressions. Regression (1) refers to the full sample of investors that are invested in equity (funds or stocks) in 2017. Regression (2) calls on the subsample of equity fund investors. The dependent variable *SR investor* takes the value of one if the investor owns an SRI equity fund in 2017, and zero otherwise. For definitions of the remaining variables, see Table 2.6 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

	(1)	(2)
SR investor	Equity owners	Fund owners
Organic purchases	-0.1116**	-0.1388**
	(0.0552)	(0.0708)
Small bookstores	-0.0010**	-0.0013**
	(0.0005)	(0.0006)
Charitable giving	-0.0003*	-0.0004*
	(0.0002)	(0.0002)
Low income	-0.0880	-0.1103
	(0.0614)	(0.0803)
High income	-0.1069**	-0.1396**
	(0.0537)	(0.0677)
Untold income	-0.0385	-0.0535
	(0.0543)	(0.0704)
East Germany	0.0145	0.0228
	(0.0637)	(0.0837)
Urban resident	0.0253	0.0208
	(0.0416)	(0.0540)
Age: 30-39	-0.0858	-0.1018
	(0.0751)	(0.0972)
Age: 40-49	-0.0338	-0.0516

Continued

Table 2.2: *Continued*

SR investor	(1) Equity owners	(2) Fund owners
	(0.0733)	(0.0963)
Age: 50-64	-0.0189	-0.0363
	(0.0722)	(0.0950)
Age: ≥65	0.0117	0.0157
	(0.0852)	(0.1141)
Female	0.0281	0.0386
	(0.0490)	(0.0649)
Couple	0.0103	0.0237
	(0.0616)	(0.0815)
Log total equity value	0.0372***	0.0448***
	(0.0120)	(0.0160)
Number of trades in equity	0.0006	0.0006
	(0.0005)	(0.0007)
Risk appetite	-0.1744	-0.2424
	(0.2113)	(0.2685)
Fraction of equity funds	0.2447***	0.1980**
	(0.0493)	(0.0802)
Observations	287	220
Pseudo R^2	0.177	0.116

Likewise, investors are less likely to pick an SRI equity fund if they express social concerns through their loyalty to small bookstores. Donating to a charitable organization that addresses environmental or social issues is also negatively associated with an individual's likelihood to invest in an SRI equity fund, yet this finding is only significant at the 10%-level. The effects are economically substantial given that only 20% of the equity fund investors in my sample hold SRI funds. My results indicate that conscious consumers and socially responsible investors are not the same people. Rather, an investor's degree of responsibility as a consumer seems to be negatively related to the likelihood that the investor considers sustainability in investment decisions.

Socio-demographic attributes have little explanatory power in this analysis. Equity fund investors having a high income at their disposal are 10.69 (1) resp. 13.96 (2) percentage points less likely

to invest in SRI than the medium income reference group. Apart from this, SR and conventional investors do not differ significantly in their individual characteristics.

On the portfolio level, control variables turn out to be significant. A higher equity portfolio value comes with a greater likelihood for a socially responsible investment. Trading activity does not significantly affect the likelihood to invest in SRI. Naturally, a higher *fraction of equity funds* promotes the probability that wealth is allocated to SRI. Yet, an investor's risk preference does not significantly influence the likelihood of opting for SRI funds.

When I compare the performance of the sustainable and conventional fund investments that investors earn during the sample period, I first find that SR investors on average generate a higher monthly Sharpe Ratio on their total equity fund portfolio compared to purely conventional investors, with 0.5504 compared to 0.4394 (Panel A). This outperformance can be traced back to selecting *conventional* fund portfolios with a better performance (Panel B), whereas sustainable equity fund portfolios perform slightly weaker than social investors' conventional investments. The difference is not statistically significant, however (Panel C). Table 2.3 reports the results.

I execute additional regressions to check whether the observed negative relation between conscious consumption and socially responsible investing is robust for alternative specifications. The results of these robustness checks can be retrieved from Table 2.9 in the Appendix. Columns (1) and (2) report the results of a regression where equity ETFs are included in the initial analysis, columns (3) and (4) use a consecutive timing. It contains the results of a regression where equity portfolio allocations after the observed consumption period are considered. In particular, an *SR investor* is defined as one that holds an SRI equity fund at least once in January 2018. The observed period for the explaining consumption variables remains unchanged. The results of these variations show that the observed relation of conscious consumption and sustainable investments is robust to the aforementioned specifications.

Furthermore, I can exclude that the observed negative relationship between conscious consumption and responsible investing is driven by income level differences. More precisely, I can exclude that more wealthy individuals are generally more likely to purchase from organic supermarkets or being more generous when it comes to charitable giving while being less interested in social funds, and that the observed negative connection is actually driven by an individual's income level. Table 2.10 in the Appendix reports the coefficients of an OLS regression in which the respective measures of responsible consumer behavior are the dependent variables and income brackets serve as the main explaining variables. The results do not show a significant relationship between an individual's income level and the preference for organic consumerism, small bookstores or her charitable giving behavior.

Table 2.3: Portfolio performance comparison of socially responsible and conventional investors

This table shows the 1-year monthly portfolio performance by investor groups. *Mean return* is the mean of the monthly portfolio returns realized in 2017. *Volatility* is the standard deviation of the monthly portfolio returns realized in 2017. *Sharpe Ratio* refers to the monthly portfolio Sharpe Ratio and is calculated as *Mean return* divided by *Volatility*. Panel A compares the monthly performance that SR and conventional equity fund investors realized on their total equity fund holdings. Panel B is limited to the conventional equity fund portfolio performance of SR versus conventional investors. Panel C compares SR investors' monthly portfolio performance realized on their conventional and SRI equity fund holdings. Monthly portfolio returns during 2017 have been used for calculation. *p*-Values refer to the left-sided t-test.

Panel A. All investors, entire equity fund portfolio			
	Conv. investors	SR investors	p-Value
Mean return	0.0095	0.0098	0.3412
Volatility	0.0236	0.0192	0.9994
Sharpe ratio	0.4394	0.5504	0.0483
Panel B. All investors, conventional equity fund portfolio only			
	Conv. investors	SR investors	p-Value
Mean return	0.0095	0.0123	0.1007
Volatility	0.0236	0.0232	0.5634
Sharpe ratio	0.4394	0.5403	0.0836
Panel C. Socially responsible investors only			
	Conv. equity funds	SR equity funds	p-Value
Mean return	0.0123	0.0091	0.0656
Volatility	0.0232	0.0191	0.0566
Sharpe ratio	0.5403	0.5265	0.4370

To conclude, responsible consumers appear to behave in an inconsistent manner as they do not transfer their sustainable habits from consumption to investment choices. In the following section, I will discuss the potential explanations of this finding.

2.6 Explanations for the contrary relationship between consumer and investor ethics

2.6.1 Moral licensing

According to Lanzini & Thøgersen (2014), green purchases rather spill over if low-cost opportunities turn up, and venturing returns is not exactly a low cost opportunity. Schier et al. (2016)

observe that people often fail to live up to their moral standards as soon as stakes are high. Possibly, money speaks louder to responsible consumers such that responsible actions might tend to crowd out one another. Even those who have high environmental and social awareness might not be prepared to pay for sustainable alternatives at all times. It is for this reason that some investors might be able to draw on moral credits from being responsible consumers allowing them to concentrate on their portfolio returns without feeling guilty about it; the remainder might consider sustainable funds an excellent opportunity to make up for some environmentally or socially unconscious purchases, similar to a letter of indulgence. Such a relationship indicates decreasing marginal utility from sustainable behavior.

The aforementioned concept has often been documented as *moral licensing* (Nisan, 1991, Hollander, 1958) in marketing and psychology literature. According to the *moral licensing theory*, people strive for moral balance yet have a limited morality at their command. This allows them to deviate from moral behavior for as long as a certain moral balance of actions is maintained. Khan & Dhar (2006) provide evidence that moral licensing affects consumer choices. Likewise, it influences the willingness to donate (U. Gneezy et al., 2014) and the donated amount (Sachdeva et al., 2009). U. Gneezy et al. (2014) appositely term this behavior *conscience accounting*. An experiment by Mazar & Zhong (2010) shows that the licensing effect can span from consumption to financial decisions meaning that the choice for green products can allow a person to behave immorally if it is financially-rewarding. According to Mazar et al. (2008), people behave dishonestly exactly to the extent that it is financially beneficial while leaving their positive self-image unscathed.

My paper uses field data to show that moral licensing can affect the willingness to *invest* in a sustainable manner. Mackenzie & Lewis (1999) observe that investors who are torn between their moral principles and financial pursuits behave in a similar way when they decide on their portfolio allocation. Though ethically concerned, these investors are mostly not willing to risk waiving a substantial part of their financial return. They overcome their conflict and maintain their clear conscience by allocating only a small part of their portfolio to SRI while keeping the majority in conventional assets. It reminds of a core satellite strategy where the investor focuses on returns for her core portfolio while pursuing her personal interests, for instance technology or sustainability, with the smaller 'satellite' investment (Methling & von Nitzsch, 2019). It seems like most sustainable investors in my sample allocate their portfolio in such manner. 75% of the sustainable investors in my sample only hold a single sustainable fund (see Table 2.8 in the Appendix), which approximately confirms other studies dealing with sustainable investors.

In the following, I will discuss further potential explanations for the negative relationship between consumer and investor ethics I observe in my research.

2.6.2 Financial motives of sustainable investors

Another explanation might be that my sample of sustainable investors expect a better performance from their social funds rather than caring about the societal impact of their investment. Sustainable fund investments might also serve diversification purposes. CSR has proven to outperform during times of market crisis thus providing a favorable downside-protection to an investor's portfolio (Lins et al., 2017, Y. Kim et al., 2014, Nofsinger & Varma, 2014). Literature provides evidence, however, that financial expectations play less of a role for social investors (Riedl & Smeets, 2017) and that they derive utility from some non-pecuniary attributes of their social investments (Brodback et al., 2019, Rossi et al., 2019, Lapanan, 2018, El Ghoul & Karoui, 2017). This leads me to my next point.

2.6.3 Deviating non-financial motives of sustainable investors and consumers

Responsible consumers and sustainable investors might have different non-financial pursuits. Studies on both consumer and investor ethics postulate fairly similar motives, however. In both cases, environmental awareness and social identification is crucial (see Gutsche & Ziegler (2019), Bauer & Smeets (2015) for SRI, and van Dam & Fischer (2015), Andorfer & Liebe (2013) for responsible consumption). Almost all respondents to a German consumer survey report securing animal welfare and protecting the environment as reason for organic purchases. When making such purchases, they care about these issues even more frequently than about their health and personal well-being (BMEL, 2018); both types of pro-social behavior require some altruistic character traits (see Brodback et al. (2019) for SRI, and Ladhari & Tchetgna (2015), Thøgersen (2011) for responsible consumption); and both actions provide the warm glow of giving (see Gutsche & Ziegler (2019) for SRI, and Dubé et al. (2017) for responsible consumption). While conscious consumption certainly serves as a means to acquire social esteem and status (Gino et al., 2013, Khamis et al., 2012, Griskevicius et al., 2010, Ariely et al., 2009), at first glance, investment choices do not seem to polish up an investor's social image. However, Riedl & Smeets (2017) discovered that sustainable investors like to show off their investments in conversations. Conscious consumers and investors seem to strive for the same here.

2.6.4 Skepticism towards the providers of SRI funds

Possibly, ethically concerned consumers are more skeptical towards the providers of sustainable funds following the principles they use for their marketing. To check whether they choose to refrain from sustainable funds because they doubt those funds actually being socially responsible,[20] I test whether those investors prefer to select stocks that perform well in terms of CSR instead of trusting fund managers' choice. Companies' ESG scores are externally assigned by a rating agency and publicly available to all investors.

Specification (1) and (2) in Table 2.4 report the relationship between an investor's likelihood to hold a stock portfolio with a particularly *High ESG Score* and the extent to which she pays attention to sustainability as consumer as well as to charitable giving. Both specifications show the marginal effects of a probit regression in which the dependent dummy variable *High ESG Score* takes the value of one if the investor holds a stock portfolio whose value-weighted ESG score is among the highest 25% in the sample, and zero otherwise. As I only observe a significant coefficient for high income, I conclude that responsible consumers are neither more nor less skeptical towards the providers of sustainable funds, which they would surrogate by high-ESG stocks.[21]

Table 2.4: Skepticism towards the providers of SRI funds

This table presents the marginal effects of four probit regressions. Odd columns refer to the full sample of investors that are invested in equity (funds or stocks) in 2017. Even columns call on the subsample of equity fund investors. In specification (1) and (2), the dependent variable *High ESG Score* takes the value of one if the investor owns a stock portfolio that scores above the 75% percentile ESG score of the examined sample in 2017, and zero otherwise. In specification (3) and (4), the dependent variable *SR investor* takes the value of one if the investor owns an SRI equity fund in 2017, and zero otherwise. We additionally include *High ESG Score* as independent variable. For definitions of the remaining variables, see Table 2.6 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

	High ESG Score		SR investor	
	(1)	(2)	(3)	(4)
	Equity owners	Fund owners	Equity owners	Fund owners
High ESG Score			0.0716	0.0747
			(0.0571)	(0.0779)
Organic purchases	-0.0057	-0.0074	-0.1114**	-0.1354*
	(0.0466)	(0.0506)	(0.0556)	(0.0704)
Small bookstores	-0.0004	-0.0004	-0.0010**	-0.0013**

Continued

[20] Confer Revelli (2017) on 'greenwashing'.

[21] To check whether these results are robust for a different specification of a high ESG portfolio score, I rerun the regressions defining *High ESG Score* based on the median portfolio ESG score. As Table 2.11 in the Appendix shows, I obtain similar results. Only *charitable giving* shows a significantly positive relation with the target variable.

Table 2.4: *Continued*

	High ESG Score		SR investor	
	(1) Equity owners	(2) Fund owners	(3) Equity owners	(4) Fund owners
	(0.0004)	(0.0004)	(0.0005)	(0.0006)
Charitable giving	-0.0000	-0.0001	-0.0003*	-0.0004*
	(0.0001)	(0.0001)	(0.0002)	(0.0002)
Low income	0.0972	0.1306*	-0.0941	-0.1166
	(0.0612)	(0.0716)	(0.0611)	(0.0802)
High income	0.1483***	0.1836***	-0.1199**	-0.1543**
	(0.0575)	(0.0648)	(0.0544)	(0.0694)
Untold income	0.1142*	0.1519**	-0.0467	-0.0640
	(0.0602)	(0.0657)	(0.0534)	(0.0700)
East Germany	0.0260	0.0252	0.0073	0.0178
	(0.0634)	(0.0681)	(0.0617)	(0.0818)
Urban resident	-0.0296	-0.0624	0.0302	0.0268
	(0.0445)	(0.0464)	(0.0412)	(0.0539)
Age: 30-39	-0.0393	-0.0285	-0.0848	-0.1018
	(0.0766)	(0.0827)	(0.0749)	(0.0970)
Age: 40-49	0.0106	0.0040	-0.0349	-0.0524
	(0.0759)	(0.0780)	(0.0728)	(0.0961)
Age: 50-64	-0.0069	-0.0273	-0.0144	-0.0312
	(0.0737)	(0.0769)	(0.0721)	(0.0950)
Age: $\geq$65	-0.0290	-0.0448	0.0161	0.0197
	(0.0873)	(0.1015)	(0.0862)	(0.1151)
Female	-0.0304	-0.0235	0.0292	0.0405
	(0.0518)	(0.0548)	(0.0489)	(0.0649)
Couple	0.0376	0.0342	0.0082	0.0225
	(0.0654)	(0.0666)	(0.0612)	(0.0811)
Log total equity value	0.0170*	0.0111	0.0370***	0.0446***
	(0.0094)	(0.0116)	(0.0120)	(0.0161)
Number of trades in equity	-0.0003	-0.0004	0.0006	0.0007
	(0.0005)	(0.0005)	(0.0005)	(0.0007)

Continued

Table 2.4: *Continued*

	High ESG Score		SR investor	
	(1) Equity owners	(2) Fund owners	(3) Equity owners	(4) Fund owners
Risk appetite	-0.3149	-0.2359	-0.1684	-0.2385
	(0.2427)	(0.2513)	(0.2114)	(0.2689)
Fraction of equity funds	-0.2202***	-0.2639***	0.2658***	0.2242***
	(0.0467)	(0.0601)	(0.0519)	(0.0827)
Observations	287	220	287	220
Pseudo R^2	0.1438	0.2140	0.1826	0.1193

I additionally test whether ESG stock screening substitutes or complements sustainable fund investments. Specification (3) and (4) present the marginal effects of two probit regressions where *SR investor* is the dependent variable, taking the value of one if an investor holds an SRI equity fund, and zero otherwise. *High ESG Score* has entered the regression as explaining variable. The results show that the decision to invest in an SRI equity fund is not related to an investor's stock portfolio choice. SR fund investments and ESG stock screening neither act as substitutes nor as complements. This is an interesting finding against the background that ESG screening is a popular SRI fund strategy, the fourth most popular in Germany during 2017. The finding holds for both sample specifications, (3) and (4). An explanation for this finding might be that an investor sends an explicit social signal with a sustainable fund investment (Riedl & Smeets, 2017), whereas a stock portfolio's ESG score is less concrete and contributes less to 'do good and talk about it' situations.

In summary, ESG stock screening is not interrelated with SRI choices and some other responsible behavior analyzed here. Neither do conscious consumers have a higher likelihood to directly select company stocks based on their CSR performance nor does a responsible stock portfolio come along with a socially responsible investment. It also does not replace it.

2.6.5 Insufficient information regarding SRI

In the context of the previous argument, a German survey by the Bundesverband deutscher Banken (2018) has uncovered a tremendous investor potential with an interest in SRI. Only 5% of the respondents hold SRI, whereas 14% report to have an interest in this asset type. Insufficient knowledge about SRI has been identified as a crucial barrier to these potentially interested investors (Bundesverband deutscher Banken, 2018, Wins & Zwergel, 2016). Nevertheless, as my

sample investors are customers of the same fund distributor, I consider the potential effect of insufficiently informed sustainable consumers on my results as being rather small.

In order to at least get an indication of whether the responsible consumers in my sample have less experience with funds and rather concentrate on stocks, I test whether the probability of investing in one or the other relates to my measures of responsible behavior. Table 2.5 reports the results of this analysis. It shows the marginal effects of two probit regressions with *Holding funds* as the dependent dummy variable in regression (1), which takes the value of one if an equity investor holds equity funds, and zero otherwise, and, for the purpose of completeness, *Holding stocks* as the dependent dummy variable in regression (3), taking the value of one if the equity investor allocates part of his equity to stocks, and zero otherwise. In both regressions, I investigate the influence of an investor's consumer behavior measured in terms of the three aforementioned factors of sustainable consumption. As in previous versions, I control for various socio-demographic and portfolio characteristics.

In support of my earlier findings, I observe that consumer behavior plays a rather small role in this context. An exception is charitable giving, which negatively relates with fund and positively relates with stock investments, although the coefficient is statistically significant on a 10%-level. I also check whether the portion an investor allocates to one of the asset classes is somehow related to her consumer behavior and get similar results. Specification (2) and (4) show the results of two OLS regressions in which the continuous dependent variable is the equity portfolio share an investor dedicates to equity funds (2), respectively stocks (4), given that she decides to invest in the respective asset class. As in the previous regressions, an investor's consumer behavior has little explanatory power when it comes to portfolio allocation. Only donation amounts are significantly and negatively related to the share of equity funds and positively related to the share of stocks on a 10%-level each.

Apparently, socio-demographic differences tend to play a role when it comes to portfolio allocation. Female investors are 15.90 percentage points more likely to put their money into the hands of a fund manager and have an additional 15.81 percentage points of their equity investments tied to funds. At the same time, they are 23.82 percentage points less likely to invest in stocks. This goes in line with the existing literature on women and stock market participation that finds women to be less self-confident than men when it comes to their investment skills.[22] Moreover, a portfolio managed by a couple is 25.28 percentage points less likely to include stocks, while allocating 24.98 percentage points more of their equity wealth to funds.

[22]Bucher-Koenen et al. (2017) document lower financial literacy among women in an international comparison. Van Rooij et al. (2011) find lower stock market participation among women. Barber & Odean (2001) document the influence of male overconfidence on investment behavior.

Table 2.5: Asset allocation

Odd columns in this table present the marginal effects of two probit regressions. They refer to the full sample of investors that are invested in equity (funds or stocks) in 2017. In column (1), the dependent variable *Holding funds* takes the value of one if the investor owns an equity fund in 2017, and zero otherwise. In column (3), the dependent variable *Holding stocks* takes the value of one if the investor owns stocks in 2017, and zero otherwise. Even columns in this table report the coefficients of two OLS regressions. Column (2) refers to the subsample of equity fund owners, while regression (4) calls on the subsample of stock owners. In column (2), the dependent variable *% equity funds* is the value fraction of the equity (stocks and equity funds) portfolio that the investor allocates to equity funds in 2017. In column (4), the dependent variable *% stocks* is the value fraction of the equity (stocks and equity funds) portfolio that the investor allocates to stocks in 2017. For definitions of the remaining variables, see Table 2.6 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

	(1) Equity owners Holding funds	(2) Equity fund owners % equity funds	(3) Equity owners Holding stocks	(4) Equity stock owners % stocks
Organic purchases	-0.0386	-0.0273	0.0306	0.0390
	(0.0649)	(0.0741)	(0.0907)	(0.0520)
Small bookstores	0.0003	0.0003	-0.0007	-0.0001
	(0.0005)	(0.0004)	(0.0005)	(0.0005)
Charitable giving	-0.0001*	-0.0001*	0.0002*	0.0001**
	(0.0001)	(0.0001)	(0.0001)	(0.0000)
Low income	-0.0747	0.0580	0.0326	0.0197
	(0.0666)	(0.0701)	(0.0725)	(0.0799)
High income	0.0006	0.0657	-0.0036	-0.0383
	(0.0683)	(0.0668)	(0.0705)	(0.0744)
Untold income	-0.0611	-0.0025	0.0828	0.0561
	(0.0693)	(0.0646)	(0.0737)	(0.0786)
East Germany	-0.0763	-0.0564	0.0589	0.0842
	(0.0715)	(0.0802)	(0.0810)	(0.0839)
Urban resident	0.0895*	-0.0201	0.0031	-0.0531
	(0.0503)	(0.0457)	(0.0523)	(0.0569)
Age: 30-39	-0.0938	0.0849	0.0116	0.0553
	(0.0780)	(0.0690)	(0.0807)	(0.0933)
Age: 40-49	0.0646	0.0159	-0.0188	0.0059
	(0.0851)	(0.0714)	(0.0863)	(0.0980)
Age: 50-64	0.0862	0.0238	-0.0409	0.0014

Continued

Table 2.5: *Continued*

	(1) Equity owners Holding funds	(2) Equity fund owners % equity funds	(3) Equity owners Holding stocks	(4) Equity stock owners % stocks
	(0.0831)	(0.0710)	(0.0831)	(0.0909)
Age: ≥65	-0.0471	-0.0948	0.2368**	0.0174
	(0.0917)	(0.1034)	(0.1133)	(0.1053)
Female	0.1590***	0.1581***	-0.2382***	-0.1137
	(0.0583)	(0.0487)	(0.0556)	(0.0710)
Couple	0.1118	0.2498***	-0.2528***	-0.1231
	(0.0765)	(0.0688)	(0.0769)	(0.0965)
Log total equity value	0.0074	-0.0648***	0.0495***	-0.0119
	(0.0114)	(0.0120)	(0.0126)	(0.0120)
Number of trades in equity	0.0025**	-0.0010*	0.0001	-0.0007
	(0.0010)	(0.0006)	(0.0007)	(0.0007)
Risk appetite	0.1073	-0.2519	0.2945	-0.1571
	(0.1960)	(0.1686)	(0.2154)	(0.2330)
Constant		1.2425***		0.8179***
		(0.1171)		(0.1530)
Observations	287	220	287	200
Pseudo R^2	0.110		0.155	
Adjusted R^2		0.219		-0.021

On the portfolio level, I find that higher equity portfolio wealth increases the likelihood for a stock investment, while portfolio activity comes along with a higher probability for fund investments. Even though the latter observation seems counter-intuitive at first sight, it can be explained by investors having specified saving plans on funds, which will regularly execute buy orders.

2.7 Limitations of this study

In this section, I discuss potential limitations of this study and describe how I have attempted to address them.

First of all, my sample is restricted to Germany, raising the question in how far the results are generalizable to other countries. Nevertheless, Germany is a fairly interesting market to study organic consumer behavior. The willingness to pay a price premium for organic products in Germany is among the highest in Europe (Statista, 2019, Liobikienė et al., 2016). With 9.5 billion euro, it is the largest organic food retail sales market in the EU (European Parliament, 2018), accounts for 5.1% of global organic sales and, with 122 euro, shows among the highest levels of per capita consumption (FiBL & IFOAM, 2019). Considering the ongoing growth that the organic product market experiences, it allows for a fair assumption regarding the future developments in other consumer markets.

A second drawback of this study – and of German purchase record data in general – is that German consumers are among the most cash-reliant ones in an international comparison.[23] I address this limitation by using relative purchase frequencies in supermarkets, assuming that each consumer will approximately equally split the number of times he uses his debit card versus cash in the respective supermarket category. Cash is a minor problem when regarding the amount an investor donates during one year, since the donation will most likely be withdrawn from the bank account itself. Cash payments will most probably be a problem for local bookstore purchases. I cannot fully exclude that there are unobserved purchases in this category, but I minimize the chances for error from unobserved transactions relying on several measures for consumer responsibility at the same time. Still, the mean (median) amount of cash withdrawals relative to an investor's income is 5% (2%) in my sample. I am therefore confident that my observations draw a representative picture of the investors' consumer behavior and that unobserved spending in cash are negligible. In fact, those missing observations, if any, run against my findings.

Third, I would like to call attention to some drawbacks of my indicators for sustainable behavior. I do not observe investors' shopping baskets. I therefore do not account for organic products that investors might have purchased at mainstream supermarkets. Furthermore, even though I take for urban residency into consideration, I am not able to directly control organic supermarkets being within an investor's reach. It would, of course, not be sustainable if grocery shoppings caused higher CO2 emissions due to longer drives. Regarding the variable *small bookstores*, it might be the case that I measure literacy rather than awareness for sustainability. Finally, I wish I had obtained even more indicators for the commitment to sustainable behavior. On the one hand, it would be helpful to observe peoples' shopping baskets. On the other hand,

[23] The research of Bagnall et al. (2016) shows that Germany is on position two after Austria with 53% of the total consumption value paid in cash.

it would be interesting to observe other, even non-purchase related dimensions of sustainable consumption, like mobility, energy consumption, recycling, etc.

Regarding my control variables, I could use more information regarding my investors' financial literacy and education. Even though I observe net incomes, I have no information on household size, which would be relevant for the assessment of a household's financial background. What's more, I would like to learn more about my investors' financial expectations about sustainable investments.

I leave this to future research.

2.8 Conclusion

In this paper, I shed light on the relation between consumer and investor ethics. I note that responsible consumers do not convert their awareness for sustainability into sustainable investment decisions. Measuring responsible behavior in terms of organic grocery shopping, purchases at small, independent bookstores and charitable giving yields a significant and negative relationship with sustainable equity fund investments. I trace my findings back to a limited willingness to pay for sustainability. Money seems to speak louder to ethical consumers, as they do not have to feel guilty about focusing on returns due to the moral credits they gained from their sustainable consumer habits. The remainder might seek moral balance by making up for less responsible consumer habits with sustainable investments, similar to purchasing a letter of indulgence. My findings are backed by psychology and marketing literature, where the observed effect is described as *moral licensing*.

I discuss and test several alternative explanations. To eliminate that responsible consumers refrain from SRI due to a lack of trust in SRI funds actually being socially responsible or a mistrust in the fund managers' choices per se, I examine whether responsible consumers screen stocks based on their ESG scores themselves. This is not the case. Furthermore, I test whether responsible consumers are less experienced with funds. My findings rather indicate that female investors tend to put the responsibility for their investment in the hands of a professional fund manager, which is in line with existing literature.

To the best of my knowledge, this is the first study that links real consumption spending to investment choices in order to study the role of conscience in socially responsible investment decisions. I contribute to the younger strand of literature that tries to understand the non-financial pursuits of socially responsible investors. By investigating how a *moral licensing effect* can affect a person's decisions as both consumer and investor, I additionally contribute to the marketing and psychology literature. It would be interesting to study the determinants and magnitude of this effect in a laboratory experiment in further detail. Finally, my research may

emphasize the need to see investors as consumers of investment products. The latter field has barely been explored so far (see Keloharju et al. (2012)).

My findings have implications for practitioners. Since the willingness to pay for sustainable alternatives seems to be limited, appealing to sustainable consumers' conscience to awaken their interest in SRI will likely miss the mark. Instead, it might be promising to emphasize SRI's favorable return prospects. Døskeland & Pedersen (2016) have conducted an interesting natural field experiment in which they once praise sustainable funds as having an important societal impact, and another time as being financially promising. It turned out that the wealth framing was more effective than the moral framing. This seems to be a reasonable strategy to attract conscious consumers to the sustainable investment market. On the other hand, praising SRI as excellent opportunity to compensate for less sustainable consumption choices, like carbon offsetting one's flights, seems to be a sound marketing strategy to the mainstream consumer. Finally, I would like to emphasize that encouraging pro-social behavior in one area might have adverse effects on the achievement of sustainability goals in other areas, particularly in view of the UN SDGs.

2.9 Appendix

Table 2.6: Variable description

Variable	Measure
	Target variable
SR investor	Dummy variable equal to one if the investor holds an SRI equity fund in 2017.
High ESG Score	Dummy variable equal to one if the investor owns a stock portfolio in 2017 with an ESG score that is above the 75% percentile.
	Consumption variables
Organic purchases	Frequency of doing the grocery shopping at organic supermarkets relative to mainstream supermarkets during 2017.
Small bookstores	Total amount spent in small bookshops during 2017 as proxy for the support of small local businesses.
Charitable giving	Total amount donated during 2017.
	Socio-demographic variables
Low Income	Dummy variable equal to one if the investor's observed monthly net income is less than the 33%-percentile of all observed incomes. This is equal to 2,553.17 euro.
High Income	Dummy variable equal to one if the investor's observed monthly net income is higher or equal to the 66%-percentile of all observed incomes. This is equal to 4,397.97 euro.
Untold Income	Dummy variable equal to one if the investor's monthly net income is not observed or lower than 750 euro.
East Germany	Dummy variable equal to one if the investor lives in East Germany.
Urban resident	Dummy variable equal to one if the investor lives in one of Germany's 20 largest cities.
Age: 30-39	Dummy variable equal to one if the investor's age is between 30 and 39.

Continued

Table 2.6: *Continued*

Variable	Measure
Age: 40-49	Dummy variable equal to one if the investor's age is between 40 and 49.
Age: 50-64	Dummy variable equal to one if the investor's age is between 50 and 64.
Age: ≥65	Dummy variable equal to one if the investor's age is 65 or older.
Female	Dummy variable equal to one if the investor is female.
Couple	Dummy variable equal to one if the portfolio is managed by a couple.
	Portfolio variables
Log total equity value	Logarithm of the mean value the investor held in equity (equity funds, stocks and ETFs) during 2017.
Number of trades in equity	Total number of trades the investor executed in equity (equity funds, stocks and ETFs) during 2017.
Risk appetite	The investor's risk appetite is approximated by the mean fraction of derivatives an investor held in his portfolio during 2017.
Fraction held in funds	Fraction of equity (equity funds and stocks) allocated to equity funds during 2017.

Table 2.7: Comparing descriptives of socially responsible and conventional investors

This table contains mean values for the group of SR investors. *Delta* refers to the difference between SR investors and conventional investors. Delta values are reported for the total group of conventional equity investors (N=243) as well as the subsample of conventional equity fund investors (N=176). *p*-Values refer to a two-sided *t*-test with unequal variances. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively. A detailed variable description is available in Table 2.6 in the Appendix.

	SR investors	Conv. investors Equity owners		Conv. investors Fund owners	
	Mean	Delta	p-Value	Delta	p-Value
% in SRI equity funds	0.2654	.	.	.	.
Organic purchases	0.0276	0.0552**	0.0364	0.0529*	0.0769
Small bookstores	9.17	13.11***	0.0065	15.35***	0.0060
Charitable giving	28.28	103.80***	0.0003	96.68***	0.0047
Low income	0.1818	0.0692	0.2916	0.0455	0.4985
High income	0.2045	0.0712	0.2985	0.0909	0.2015
Untold income	0.2727	-0.0464	0.5279	-0.0511	0.4969
East Germany	0.1136	0.0057	0.9141	-0.0114	0.8326
Urban resident	0.4091	-0.0264	0.7466	0.0000	1.0000
Age: 30-39	0.1818	0.0816	0.2160	0.0511	0.4474
Age: 40-49	0.2045	0.0259	0.7012	0.0455	0.5163
Age: 50-64	0.3636	-0.0838	0.2922	-0.0511	0.5316
Age: $\geq$65	0.1136	-0.0231	0.6573	-0.0341	0.5190
Female	0.3182	-0.0754	0.3267	-0.0511	0.5172
Couple	0.1364	-0.0211	0.7083	-0.0170	0.7690
Log total equity value	9.99	-0.77**	0.0129	-0.57*	0.0623
Number of trades in equity	32.07	-6.48	0.3045	-2.67	0.6814
Risk appetite	0.0220	0.0162	0.2303	0.0161	0.2604
Fraction of equity funds	0.7524	-0.2631***	0.0000	-0.0769	0.1598
Observations	44		243		176

Table 2.8: SRI equity fund allocation among sustainable investors

This table presents statistics on the number of SRI equity funds, conventional equity funds, as well as the value fractions socially responsible investors allocate to SRI equity funds relative to their equity (stocks and equity funds) position, and finally the value fractions they allocate to SRI equity funds relative to their equity fund position in 2017.

	p5	p10	p25	p50	p75	p90	p95
# SRI equity funds	0.41	0.69	0.92	1.00	1.00	1.51	1.86
# conv. equity funds	0.00	0.19	1.65	3.22	5.08	8.00	14.92
% in SRI equity funds	0.01	0.01	0.07	0.20	0.33	0.71	0.90
% SRI of equity funds	0.04	0.07	0.13	0.23	0.47	0.97	1.00
Observations	44						

Figure 2.1: Distribution of portfolio portions invested in sustainable equity funds

This histogram shows the distribution of the portion of equity value (funds and stocks) held in SRI equity funds among SR investors in 2017.

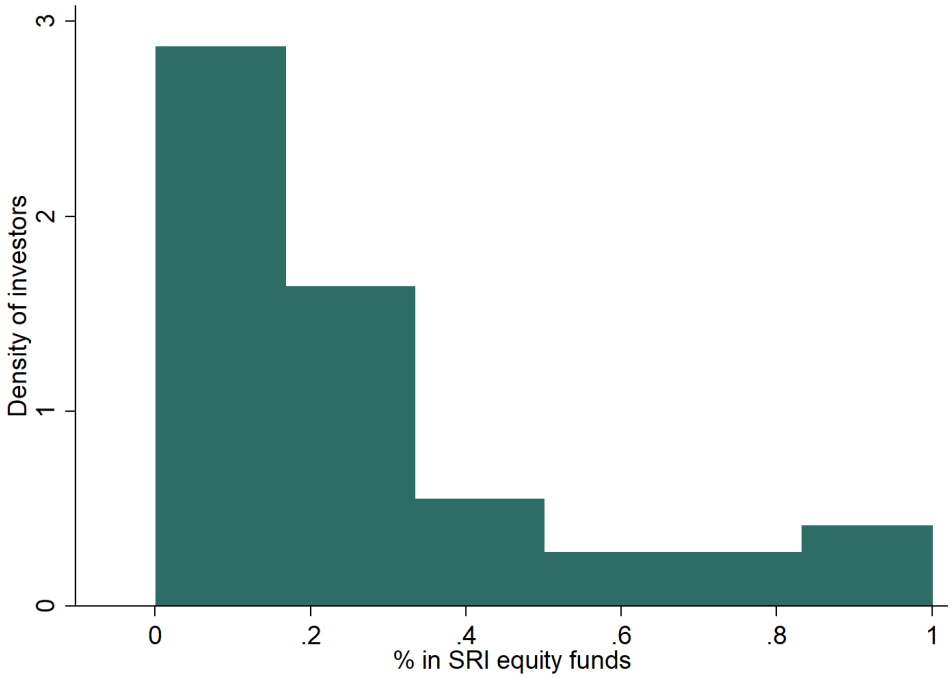

Table 2.9: Robustness tests

This table presents the marginal effects of four probit regressions. Odd columns refer to the full sample of investors that are invested in equity (equity funds, equity ETFs or stocks) in 2017, even columns call on the subsample of equity fund (funds or ETFs) investors. In specifications (1) and (2), the dependent variable *SR investor* takes the value of one if the investor owns an SRI equity fund (fund or ETF) in 2017, and zero otherwise. Here, *Fraction of equity funds* refers to the mean fraction of equity (equity funds, ETFs and stocks) the investor allocates to equity funds (funds and ETFs) in 2017. In specifications (3) and (4), the dependent variable *SR investor* takes the value of one if the investor owns an SRI equity fund in January 2018, and zero otherwise. Here, *Fraction of equity funds* refers to the mean fraction of equity (equity funds and stocks) the investor allocates to equity funds in January 2018. The definitions of the remaining variables have not changed. For definitions of the remaining variables, see Table 2.6 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

	incl. ETFs		timing	
	(1)	(2)	(3)	(4)
SR investor	Equity owners	Fund owners	Equity owners	Fund owners
Organic purchases	-0.1247**	-0.1406**	-0.1040**	-0.1340**
	(0.0520)	(0.0622)	(0.0471)	(0.0625)
Small bookstores	-0.0010**	-0.0012**	-0.0009**	-0.0012**
	(0.0005)	(0.0006)	(0.0004)	(0.0006)
Charitable giving	-0.0004**	-0.0004**	-0.0002**	-0.0003**
	(0.0002)	(0.0002)	(0.0001)	(0.0001)
Low income	-0.0844	-0.0893	-0.1062*	-0.1464*
	(0.0592)	(0.0704)	(0.0602)	(0.0801)
High income	-0.0943*	-0.1072*	-0.0900*	-0.1355**
	(0.0520)	(0.0607)	(0.0542)	(0.0691)
Untold income	-0.0247	-0.0229	-0.0626	-0.0960
	(0.0533)	(0.0630)	(0.0518)	(0.0702)
East Germany	0.0174	0.0189	-0.0838	-0.1085
	(0.0627)	(0.0742)	(0.0681)	(0.0922)
Urban resident	0.0265	0.0256	0.0064	-0.0024
	(0.0404)	(0.0471)	(0.0428)	(0.0558)
Age: 30-39	-0.0723	-0.0781	-0.1259*	-0.1532
	(0.0708)	(0.0826)	(0.0729)	(0.0954)
Age: 40-49	0.0086	0.0134	-0.0587	-0.0829
	(0.0664)	(0.0782)	(0.0719)	(0.0956)
Age: 50-64	0.0137	0.0127	-0.0304	-0.0413
	(0.0667)	(0.0779)	(0.0707)	(0.0941)

Continued

Table 2.9: *Continued*

	incl. ETFs		timing	
	(1)	(2)	(3)	(4)
SR investor	Equity owners	Fund owners	Equity owners	Fund owners
Age: ≥65	0.0185	0.0274	-0.0013	-0.0002
	(0.0798)	(0.0957)	(0.0849)	(0.1149)
Female	0.0534	0.0683	0.0264	0.0301
	(0.0469)	(0.0557)	(0.0483)	(0.0643)
Couple	0.0423	0.0616	0.0541	0.0892
	(0.0618)	(0.0749)	(0.0599)	(0.0822)
Log total equity value	0.0363***	0.0412***	0.0311***	0.0367**
	(0.0117)	(0.0144)	(0.0115)	(0.0157)
Number of trades in equity	0.0006	0.0005	0.0009**	0.0010
	(0.0005)	(0.0006)	(0.0005)	(0.0006)
Risk appetite	-0.1352	-0.1582	-0.0419	-0.1074
	(0.2115)	(0.2440)	(0.2002)	(0.2497)
Fraction of equity funds	0.2027***	0.1558**	0.2462***	0.2021**
	(0.0503)	(0.0721)	(0.0495)	(0.0811)
Observations	307	261	284	214
Pseudo R^2	0.1573	0.1211	0.192	0.124

Table 2.10: Correlations of consumer behavior and income

This table presents the coefficients of three OLS regressions. The regressions refer to the full sample of investors that are invested in equity (funds or stocks) in 2017. The continuous dependent variables are *Organic purchases* in regression (1), *Small bookstores* in regression (2), and *Charitable giving* in regression (3). For definitions of the remaining variables, see Table 2.6 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

	(1) Organic purchases	(2) Bookstores	(3) Charitable giving
Low income	-0.0634	11.6800	-3.8990
	(0.0512)	(11.1412)	(71.2427)
High income	0.0176	-0.6118	22.5563
	(0.0646)	(8.1575)	(74.0320)
Untold income	0.0419	-8.9643	-84.9334
	(0.0650)	(8.2100)	(76.4607)
East Germany	-0.0694*	8.3178	-58.7952
	(0.0357)	(10.8342)	(40.1263)
Urban resident	0.0075	13.3378	32.8032
	(0.0379)	(8.6362)	(40.3320)
Age: 30-39	-0.0049	6.1488	36.1205
	(0.0778)	(8.9028)	(49.8762)
Age: 40-49	-0.0740	11.7762	123.4130*
	(0.0713)	(10.1686)	(68.5997)
Age: 50-64	0.0197	14.3203	101.7964*
	(0.0866)	(9.8033)	(56.5690)
Age: $\geq$65	-0.0540	7.1855	86.4200
	(0.0766)	(12.0061)	(59.9693)
Female	0.0081	19.2529**	-18.2694
	(0.0491)	(9.4640)	(57.6178)
Couple	-0.0705*	21.0190	105.7851
	(0.0409)	(15.8382)	(120.6122)
Log total equity value	-0.0030	0.5013	4.7309
	(0.0096)	(1.7924)	(9.0539)
Number of trades in equity	-0.0004	0.1172	0.0227
	(0.0003)	(0.1405)	(0.6809)

Continued

Table 2.10: *Continued*

	(1) Organic purchases	(2) Bookstores	(3) Charitable giving
Risk appetite	-0.1205	-18.6383	580.5351
	(0.0848)	(12.4024)	(549.8963)
Constant	0.1461	-10.0233	-23.0926
	(0.1511)	(16.7801)	(78.2099)
Observations	287	287	287
Adjusted R^2	-0.017	0.011	0.027

Table 2.11: Skepticism towards the providers of SRI funds (median split)

This table presents the marginal effects of two probit regressions. Regression (1) refers to the full sample of investors that are invested in equity (funds or stocks) in 2017. Regression (2) calls on the subsample of equity fund investors. The dependent variable *High ESG Score* takes the value of one if the investor owns a stock portfolio that scores above the median ESG score of the examined sample in 2017, and zero otherwise. For definitions of the remaining variables, see Table 2.6 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

	(1) Equity owners High ESG Score	(2) Fund owners High ESG Score
Organic purchases	-0.0663	-0.0620
	(0.0582)	(0.0657)
Small bookstores	-0.0004	-0.0003
	(0.0004)	(0.0004)
Charitable giving	0.0001**	0.0002**
	(0.0001)	(0.0001)
Low income	-0.0142	0.0376
	(0.0708)	(0.0779)
High income	0.0937	0.1113*
	(0.0630)	(0.0657)
Untold income	0.1175*	0.1313**
	(0.0621)	(0.0643)
East Germany	0.0047	-0.0103
	(0.0673)	(0.0775)
Urban resident	0.0011	-0.0476
	(0.0496)	(0.0528)
Age: 30-39	-0.0879	-0.0163
	(0.0841)	(0.1013)
Age: 40-49	-0.0497	-0.0420
	(0.0883)	(0.1005)
Age: 50-64	-0.0259	0.0138
	(0.0855)	(0.0970)
Age: $\geq$65	-0.1249	-0.1154
	(0.1007)	(0.1212)
Female	-0.0284	-0.0058

Continued

Table 2.11: *Continued*

	(1) Equity owners High ESG Score	(2) Fund owners High ESG Score
	(0.0617)	(0.0648)
Couple	0.0710	0.0474
	(0.0710)	(0.0795)
Log total equity value	0.0493***	0.0473***
	(0.0125)	(0.0171)
Number of trades in equity	0.0010	0.0003
	(0.0006)	(0.0006)
Risk appetite	-0.3140	-0.3896
	(0.2149)	(0.2524)
Fraction of equity funds	-0.3564***	-0.3801***
	(0.0466)	(0.0628)
Observations	287	220
Pseudo R^2	0.3226	0.2671

Chapter 3

Do Sustainability-Conscious Individuals Prefer Socially Responsible Investments? A Study among the Users of Robo Advice*

3.1 Introduction

In 2015, all UN members agreed to do their bit in pursuing the 17 Sustainable Development Goals (SDGs), which aim to tackle the social and environmental issues of our time. Socially responsible investing (SRI) plays an important role in financing sustainable growth. Investors value sustainability in their investment decisions (Hartzmark & Sussman, 2019) such that we observe an ongoing growth of SRI. From 2016 to 2018, sustainable investing assets have grown by 34% to $30.7 trillion in the five major markets (Europe, USA, Japan, Canada, Australia/New Zealand). Except for Europe that growth has also been accompanied by a surge in market shares (Glocal Sustainable Investment Alliance, 2016).[1] Even in Germany, where sustainable investing has evolved rather slowly, the market share of sustainable investment funds and mandates has surpassed the milestone five percent mark for the very first time towards the end of 2019.

The share of retail investors compared to institutional investors has considerably grown in the past years, e.g. from about 3.4% in 2013 to 30.7% in Europe in 2017. However, the

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[1]The latter is likely to be explained by a change in the definition of SRI.

world will need to step up its efforts in this respects if it wants to meet the SDGs of the UN (Eurosif, 2018). Contributing to the cause, the EU drafted a ten-point action plan on financing sustainable growth. It envisages incorporating sustainability into investment advice to encourage more socially responsible retail investments. In Germany, the share of socially responsible retail investors is particularly low when comparing to the neighboring countries Austria and Switzerland. With 89% of sustainably invested capital coming from institutional investors, sustainable investment[2] growth in Germany is, first and foremost, driven by institutional investors (Forum Nachhaltige Geldanlagen, 2020).

Meeting the EU's request for advice on sustainable investments, German robo advisors have recently started to introduce sustainable investment strategies and to inform their current and prospective customers about sustainable investments on their websites. Robo advisors provide access to financial advice and wealth management to a broad customer base due to low cost and minimum investments. Robo advisory services prove to be a fast-growing market for German retail investors. Assets under management are expected to rise by 92.8% to 8.068 billion euro in 2020. The number of customers is also presumed to grow by such rocketing numbers, i.e. 50.2% to 2.089 million. In 2024, an estimated 3.771 million customers are projected to invest the considerable amount of 29.86 billion euro (Statista, 2020). Robo advisors offer investment advice and portfolio management on an automated basis, mitigating common investment mistakes in terms of diversification, disposition, trend-chasing, and the rank effect (D'Acunto et al., 2019). Robo advisors commonly invest in passively managed index funds and ETFs with low costs. Since only a limited number of ETFs meet sustainability standards, providers of sustainable strategies at least partly fall back to actively managed funds. Yet, these come at higher costs which they then need to spread over their customers.

Recent studies hint at an unlocked potential for sustainable investments among retail investors. They emphasize the need for more information on SRI and for sufficient offers containing sustainable products (Bundesverband deutscher Banken, 2018). Interestingly, actual and potential sustainable investors have turned out to be quite similar. Yet, the latter are deterred from investing in a responsible manner due to an insufficient provision of information on the matter and the lack of actual offers for sustainable financial products by their bank (Wins & Zwergel, 2016). Only one-third of the responding investors in the study by the Bundesverband deutscher Banken has actually heard about sustainable investments. Thereof, only 50% knew what sustainable investment is about. This lack of information might help explain the discrepancy between the 5% who report holding SRI and the 14% who are interested in SRI. When provided with the opportunity to vote, a substantial 67.9% of the members of a Dutch pension fund *favored* more sustainable investments even when their benefits were at stake (Bauer et al., 2020). This gives an idea of the untapped potential for sustainable retail investments.

[2]In the following, we will use the terms *socially responsible*, *sustainable*, *social* and *green investing* interchangeably.

Given the above, we want to find ways to identify these (potentially interested) sustainable investors. In particular, we want to know if it is sustainability-conscious individuals that prefer to invest their money in a sustainable manner. We therefore set out to analyze the insights that can be gained about the preference for sustainable investments from sustainability-aware behavior in other areas. Though it may not be obvious at first sight, sustainable investing does not necessarily result from a person's awareness for sustainability.[3] First, sustainable investing may also be induced by financial motives, or the strive for social prestige (Riedl & Smeets, 2017). Second, skepticism regarding the trustworthiness of the providers of sustainable investments may discourage sustainability-aware individuals from investing their money in a socially responsible manner. Third, the concern for sustainable behavior in a certain area may affect the effort undertaken in other areas. Literature yields divergent findings on how different pro-social and pro-environmental behaviors affect one another. Depending on, among other, the perceived similarity of actions (Margetts & Kashima, 2017, Thøgersen, 2004), manifestation of self-identity (Chatelain et al., 2018, Lacasse, 2016, Whitmarsh & O'Neill, 2010), and the efforts and costs that the initial and subsequent tasks require (Truelove et al., 2014, A. Gneezy et al., 2012, Thøgersen & Crompton, 2009), people either consistently act in a sustainable manner or behave inconsistently in line with the theory of moral licensing. In the former case the sustainable action results in even more responsible engagement in other areas; the latter case leads to a situation in which distinct sustainable actions crowd one another out.

Most of the previous contributions utilize a survey-based approach to capture the drivers and attitudes of socially responsible investors. They have discovered more pronounced altruism (Brodback et al., 2019), feelings of warm glow, and higher environmental awareness (Gutsche & Ziegler, 2019) as well as stronger identification with sustainable investment strategies (Bauer & Smeets, 2015) among sustainable investors. The role of financial return expectations is disputable (Brodback et al., 2019, Riedl & Smeets, 2017, Døskeland & Pedersen, 2016). Since survey responses may suffer from bias due to social desirability and an attitude-behavior gap (Carrington et al., 2014), we look at actual, financially-incentivized choices as the distinguishing feature of our study to capture investors' sustainability awareness. Thus far, there are only a few contributions researching socially responsible investors' motives based on actual choices. While these studies establish stronger general social preferences among socially responsible investors and more engagement in social signaling (Bauer et al., 2020, Riedl & Smeets, 2017), indicating that socially responsible investors tend to be less self-centered in general[4], we look into whether socially responsible investors are more concerned about a sustainable development in particular, addressing "global challenges [...], including poverty, inequality, climate change, environmental degradation, peace and justice" (United Nations, 2020). In what follows, we will refer to such

[3]See also Riedl & Smeets (2017) who explain that other motives than pro-social preferences might drive socially responsible investors.

[4]Social preferences capture a person's concern for the material resources that are allocated to relevant reference agents apart from herself (Fehr & Fischbacher, 2002).

concern for a sustainable development as *sustainability awareness*, *ethical mindfulness*, *social responsibility*[5] or *social and environmental consciousness*.

In line with the notion that environmentally beneficial choices, such as recycling, using public transport, or buying organic food products, reflect a person's environmental concerns and values, and that socially beneficial choices, such as Fair Trade consumption, express equality and social justice values, we infer sustainability awareness as the combination of both from an investor's consumer behavior (van Dam & Fischer, 2015, Ladhari & Tchetgna, 2015, Andorfer & Liebe, 2013, Thøgersen, 2011, Thøgersen & Ölander, 2006).[6] Few studies have explored the relationship between consumption and investments in terms of sustainability preferences. All of them relied on survey responses (Palacios-González & Chamorro-Mera, 2018, Williams, 2007). In order to test how sustainability-conscious engagement relates to investing in socially responsible assets, we apply a two-way approach to capture investors' sustainability awareness. First, we analyze financially-incentivized choices of robo advisory users who are faced with a lottery setting. We asked these investors to choose a voucher for one out of several "fair and ecological" or "mainstream" fashion labels as their preferred price in a lottery. We set the values of the vouchers in a way that a responsible choice would be costly. We use fashion as the distinctive feature as it captures both environmental and social responsibility. The environmental impact of clothing is of particular importance as it accounts for up to 10% of the environmental impact of the EU consumption (European Parliamentary Research Service, 2019). Second, we elicit participants' self-reported awareness of sustainability based on a ten-item consumer scale proposed by Sudbury-Riley & Kohlbacher (2016). The measure is best suitable to the purpose of our study since it is concurrently lean *and* able to capture sustainability in terms of environmental and social responsibility. The latter is oftentimes neglected in consumer responsibility scales. We relate both participants' actual choices and reported actions to their preference for socially responsible investing. To address our question, we survey the customers of three German robo advisors with divergent investment focus. In line with the theory of consistent behavior and spillover effects, we find that sustainability-aware individuals prefer sustainable investments.

First, we study the investment choices of the customers of a robo advisor that offers both conventional and sustainable investment strategies where the latter come at higher costs. We find that engagement in sustainable behavior in the lottery positively relates to the likelihood of having one's portfolio managed according to a sustainable investment strategy. To be precise, the likelihood for a sustainable investment is 24.6% higher for sustainability-conscious individuals. Our finding is robust to several alternative specifications: we introduce additional controls for choosing the particular robo advisor over other digital wealth managers; add interested newsletter subscribers to the sample; redefine the dependent variable as intentionally searching

[5]Please note that the terms social responsibility and social preferences cannot be used interchangeably.

[6]Responsible consumption can additionally be motivated by some hedonic motives (Gino et al., 2013, Khamis et al., 2012, Griskevicius et al., 2010, Ariely et al., 2009).

a robo advisor with a sustainable product offer; and vary our specification of sustainability awareness.

Our results confirm that both responsible consumption and responsible investing are encouraged by strong social preferences. In line with the literature on environmental awareness, women seem to be slightly more concerned about sustainability in general (McCright & Xiao, 2014). Consistent with previous studies on SRI, we identify motives related to social accountability, namely warm glow, identification, trust in SRI, and perceived impact, as crucial drivers of sustainable investments. While these characteristics encourage sustainable investments in general, identification with SRI and the warm glow feeling seem to be particularly pronounced among sustainability-conscious individuals, mediating the effect of sustainable behavior itself. We conclude that engagement in other sustainable activities facilitates the identification with SRI. Moreover, sustainability-conscious individuals communicate a stronger feeling of responsibility for sustainable development, and wish to contribute, by financing a sustainable growth. In contrast, we find that trust, skepticism and knowledge related to sustainable investments generally determine investment decisions. Yet, they do not seem to affect sustainability-conscious individuals in particular. Contradicting the results of some previous contributions (Bauer et al., 2020, Riedl & Smeets, 2017), we find that financial motives also seem to be relevant to socially responsible investors. While high expected returns from SRI encourage such investments, the perception of high risk impedes sustainable investments.

Second, we survey the clients of a conventional robo advisor that plans on launching sustainable investment alternatives for which it requires a better understanding of its current and prospective customers' interest in such products. This allows us to investigate whether sustainability-aware individuals have a particularly strong interest in the launch of sustainable investment strategies by their current robo advisor. We find that participants who care about sustainability express a stronger interest in a sustainable investment offer by their robo advisor than their counterparts do. High return expectations and low risk perception additionally encourage this interest, while low return expectations attenuate the excitement for SRI. Again, female investors express a stronger interest in SRI. In line with the findings of Wins & Zwergel (2016), our results indicate that actual sustainable investors and those who are at least interested in sustainable investments mirror one another in terms of identification and the warm glow they experience from SRI. However, they also differ. First, in our sample, the tendency for social signaling fosters reported interest but not actual investments in SRI, and, second, lower expected returns deter the excitement about a prospective sustainable investment offer. Interestingly, intrigued investors do not seem to perceive increased risk from sustainable investments until they are in the position to actually make the investment decision. While the willingness to sacrifice returns is slightly higher among responsible individuals, they are by far more optimistic regarding the financial returns of sustainable investments.

Third, we investigate whether offering sustainable investment strategies encourages sustainability-conscious individuals to become customers of the particular robo advisor. To make our point, we survey the customers of yet another provider of robo advice. The difference – this robo advisor follows all-out sustainable investment strategies. What we test is whether responsible individuals prefer either a robo advisor that offers both sustainable investments and conventional investments or one that exclusively relies on sustainable investment strategies over a conventional robo advisor. We find that ethically-minded individuals are significantly more likely to invest their money via the 100% "green" robo advisor than via the conventional one. We note that the provision of sustainable investment strategies can, next to performance and costs, be a selling point for a digital wealth manager.

Finally, we address concerns about the generalizability of our findings to investment decisions that go beyond robo advice. We ask participants for the approximate share of SRI in their total securities portfolio. We find that ethically-minded individuals are more likely to hold a considerable share of their total investment portfolio (more than 25%) in SRI. Sustainability-conscious individuals are not only more likely to engage in SRI but also allocate a substantially larger share of their portfolio to this investment class. At the same time, high return expectations encourage a larger exposure to sustainable investments. Additional tests on reverse causality indicate that the direction of the effect that we observe goes from general engagement in sustainable behavior towards investing in a socially responsible manner.

Our contribution to the literature is threefold. First, we contribute to the growing stream of literature exploring the non-pecuniary motives of socially responsible investors (Bauer et al., 2020, Brodback et al., 2019, Hartzmark & Sussman, 2019, Gutsche et al., 2019, Riedl & Smeets, 2017, Bauer & Smeets, 2015, Barreda-Tarrazona et al., 2011, Jansson & Biel, 2011, Pasewark & Riley, 2010, Glac, 2009, McLachlan & Gardner, 2004, Lewis & Webley, 1994) by providing a feature that helps to identify potentially interested investors. Our results are in line with previous studies finding a positive relationship between social investing and engagement in other kinds of pro-social behavior. Riedl & Smeets (2017) find that charitable giving relates to SRI preferences. Hong & Kostovetsky (2012) and Gutsche & Ziegler (2019) observe a positive relationship between a democratic (respectively left-wing) political orientation and the preference for SRI. Palacios-González & Chamorro-Mera (2018) and Williams (2007) note a positive relationship between reported consumer and investor ethics. The distinctive feature of our setting is that investors find themselves faced with an all-or-nothing decision. Rather than calming their conscience by adding a sustainable fund to their conventional core portfolio (Mackenzie & Lewis, 1999), investors are asked to commit to one of the two offered investment strategies. In addition, the robo advisor with the mixed investment offer provides detailed information on both investment strategies to its clients during the sign-up process. As a result, we have a clean setting that allows us to infer why investors have or have not invested their

money in a sustainable manner, since insufficient knowledge or unavailability of sustainable funds do not bias our results.

An additional particularity of our setting is that we are the first to study socially responsible investment preferences among the users of robo advice, which by nature might be a rather cost-sensitive investor group with large heterogeneity concerning their financial literacy. We thereby add to the young stream of literature dealing with robo advice (Brenner & Meyll, 2020, D'Acunto et al., 2019).

Third, we contribute to the field of environmental psychology as we provide evidence in line with a favorable spillover – rather than a crowding out – effect of general sustainable behavior on responsible investment decisions.

From a practitioner's perspective, we aim to help unlock more of the hidden retail investor potential for sustainable investments by providing advice that facilitates the development of sound marketing strategies for sustainable financial products. Since personal switching costs commonly tend to be high (Jones et al., 2007, Yang & Peterson, 2004, Jones et al., 2002, Lee et al., 2001), it is crucial to target potentially interested investors *before* they sign up for a particular financial service provider that does not offer sustainable products. Likewise, making interested existing customers aware of a newly introduced sustainable product could be a promising attempt to increase the sustainable retail investor base. Aimed targeting is of particular importance, since too frequent CRM contact results in inefficiency (M. Kim et al., 2012) or, even worse, discontent.

The remainder of this paper is organized as follows. Section 3.2 describes our setting in detail. In section 3.3, we provide the descriptive statistics of our sample. Since literature on the use of digital financial advice is still scarce, we would also like to provide insights on who the (German) robo advisor clients are. Besides, we unveil the outcome of our lottery. Section 3.4 presents the results of our analysis. Section 3.4.1 is dedicated to our analysis of how sustainability awareness relates to the decision to opt for either a conventional or a sustainable portfolio when managed by a digital financial advisor. We explore the attitudes and sentiments that encourage sustainability-conscious individuals – more than their mainstream counterparts – to invest their money in a socially responsible manner, see section 3.4.2. In section 3.4.3, we analyze whether responsible individuals are more likely to prefer a prospective sustainable investment offer by their robo advisor than their mainstream counterparts. Section 3.4.4 explores whether sustainability-aware individuals are more likely to become customers of a robo advisor that offers sustainable strategies. In section 3.5, we discuss the extent to which our results are generalizable to investments that go beyond robo advice (3.5.1) and validate that the direction of the effect we observe is from general sustainability awareness to sustainable investments (3.5.2). Section 3.6 concludes our study and ends with suggestions how to turn our findings into a sound marketing strategy for sustainable financial products.

3.2 Setup, data, and variables

3.2.1 Setup and data

For our study, we survey clients and newsletter subscribers of three German robo advisors. We are the first to study sustainable investment preferences in the context of robo advice. Our results might deviate from previous studies on socially responsible retail investors to the extent that users of robo advice might be more cost-sensitive and more heterogeneous in terms of financial literacy than general fund investors, who independently manage their portfolios.

Our surveyed service providers' disparate investment focus allows us to address diverse questions. In our first analysis, we study actual investment choices by clients of VisualVest, a robo advisor that offers both conventional and sustainable investment strategies. In this paper, we will refer to this robo advisor as the mixed robo advisor. This robo advisor was the first in Germany to offer a completely sustainable investment alternative next to conventional investment strategies. In the process of signing up for an automatically-managed portfolio, the mixed robo advisor provides information on its conventional and sustainable portfolio and asks its customers to decide between the two options. Due to the hitherto rather small assortment of ETFs meeting sustainability criteria that exist thus far, the robo advisor partly falls back to actively managed sustainable funds which means that sustainable investment strategies come at higher external costs. Past research has shown that the interest in SRI falls down to non-existent sustainable investment offer by the respective financial service provider (Wins & Zwergel, 2016). We use the mixed robo advisor for our first analysis as it provides a clean setting for the analysis of investment choices. Clients are provided with a binary decision between a sustainable and a conventional investment. All investors have the same information on the available investment strategies and have access to the same sustainable assets. They are also customers of the same financial service provider. This should rule out any unobserved effects.

For our second analysis, we study the interest that a financial service provider that has focused on conventional investment strategies thus far might have in including a sustainable investment in his portfolio. In this paper, we will refer to this robo advisor as the conventional robo advisor. We survey the customers and newsletter subscribers of one of the largest German digital wealth managers, growney. It has followed a completely conventional investment strategy up to now but plans to provide its clients with sustainable investment products in the future. The conventional robo was therefore interested in learning about its clients' interest in such products. This setting allows us to compare the attitudes and preferences of actual (mixed robo advisor) and potentially interested (conventional robo advisor) sustainable investors. In follow-up to this study, growney has launched its sustainable investment strategies.

For our third analysis, we study whether ethically-minded individuals are more likely to become customers of a robo advisor that additionally offers sustainable investment alternatives or one that exclusively follows a sustainable investment approach than a robo advisor that completely invests in conventional assets. Therefore, we additionally survey the customers of FiNet Asset Management AG and its robo advisor vividam, which exclusively offers all-out sustainable investment strategies. In this paper, we will refer to this robo advisor as the green robo advisor. This green robo advisor aims to meet its sustainability standards by completely relying on actively managed sustainable funds. This strategy naturally translates into higher costs than is common among robo advisors.

In the following, we will distinguish between customers and interested yet undecided newsletter subscribers for the mixed and conventional robo advisor. The green robo advisor does not have a newsletter service, which means that all our participants are customers of the green robo advisor anyway. We elicited the clients' attitudes, preferences and socio-demographic characteristics in a survey that we set up in oTree (Chen et al., 2016). Whenever reasonable, the survey questions slightly varied between the robo advisors and according to the client status[7].

We have conducted our survey in June 2020. The estimated average response rate across all three robo advisors was 10.2%, even though we are not able to calculate the exact response rate since the invitations for the survey have been sent by the robo advisors themselves.

3.2.2 Independent variables on sustainability awareness

Table 3.11 in the Appendix provides an overview of the relevant variables. Our main variable of interest is sustainability awareness and how it relates to SRI preferences. We therefore consult sustainability-conscious consumption as expression of peoples' involvement with sustainability (Golob et al., 2019, Lee & Cho, 2019, Andorfer & Liebe, 2013, Michaelidou & Hassan, 2008) as it has the most severe impact on the environment among all human activities (Steg & Vlek, 2009). We apply two methods to capture sustainability consciousness.

Financially-incentivized choices

Various studies have reported considerable discrepancies between people's intents and their actual actions (Carrington et al., 2014). We therefore use financially-incentivized choices as indicator of sustainability awareness. As appreciation for their participation, respondents were given the opportunity to take part in a lottery right at the beginning of the survey. They could choose one out of four fashion label vouchers that they would receive if they won the lottery. We choose fashion as a distinctive feature, since it captures both environmental and social responsibility. The environmental impact of clothing is of particular importance as it accounts for up to 10% of the environmental impact of the EU consumption (European Parliamentary

[7] i.e. newsletter subscribers received a slightly different survey than actual clients.

Research Service, 2019). Sustainable fashion labels produce clothes in an eco-friendly manner, on fair working conditions and payment. Few sustainable fashion companies support social projects. To make sure all participants understand the difference between sustainable and mainstream fashion labels, the concept of fair and ecological fashion was explained to them, and the four labels were labeled as fair and ecological or mainstream respectively. Two vouchers referred to the mainstream fashion labels H&M and Zara, worth 100 euro each. The remaining two vouchers referred to the fair and ecological fashion labels Armedangels and Recolution, worth 75 euro each. The average probability of winning across all three robo advisors was 5%.

We provide four choices in order to eliminate any impact that style preferences might have. Additionally, participants could always opt to take part in the survey without receiving a voucher to preclude that indifferent choices bias our results. We make a sustainable choice costly as we want to rule out the possibility of participants only choosing a fair fashion label out of mere curiosity or a desire to try fair fashion simply because it is offered, per se. We also make it costly to avoid them choosing a fair fashion label due to a dislike for the particular mainstream fashion labels we offer in the lottery. To preempt pivotal voting, participants were explicitly made aware that their choice would not affect their chances to win the lottery. To rule out that the order in which the fashion labels were presented would drive our results, we concordantly randomized the sequence of both the vouchers' images and the selection options.

Survey-based measure

Second, we use survey questions capturing sustainability-conscious behavior beyond clothing. Consumer scales tend to concentrate on environmentally-conscious behavior, neglect issues of social responsibility (Larson et al., 2015, Markle, 2013, S.-Y. Kim et al., 2012) and need excessively many items (Yan & She, 2011, Webb et al., 2008, Francois-Lecompte & Roberts, 2006). We use the hands-on scale proposed by Sudbury-Riley & Kohlbacher (2016), which grasps the extent to which a participant engages in ecologically and socially responsible consumption and purchase behavior day by day through a manageable number of questions:

1. "When there is a choice, I always choose the product that contributes to the least amount of environmental damage."
2. "I have switched products for environmental reasons."
3. "If I understand the potential damage to the environment that some products can cause, I do not purchase those products."
4. "I do not buy household products that harm the environment."
5. "Whenever possible, I buy products packaged in reusable or recyclable containers."
6. "I make every effort to buy paper products (toilet paper, tissues, etc.) made from recycled paper."
7. "I will not buy a product if I know that the company that sells it is socially irresponsible."
8. "I do not buy products from companies that I know use sweatshop labor, child labor, or other poor working conditions."

9. "I have paid more for environmentally friendly products when there is a cheaper alternative."
10. "I have paid more for socially responsible products when there is a cheaper alternative."

Participants were asked to indicate how often they consider those issues when making purchases (*never, infrequently, sometimes, often, always*). The questions' sequence varied randomly.

Social preferences

Research on either side – ethically-minded consumption and socially responsible investing – provides evidence that these pro-social actions are often an expression of personal values and social preferences. In order to establish that our indicators of sustainability awareness really capture altruistic rather than self-centered motives, like quality and health concerns of organic consumerism, we additionally determine participants' social preferences. Social preferences have already been shown to predict preferences for sustainable investments (Bauer et al., 2020, Riedl & Smeets, 2017). Instead of having participants pinned in a time-consuming trust game, we use a single question: "How willing are you to give to good causes without expecting anything in return?" This validated measure of social preferences by Falk et al. (2016) is an efficient way to capture social preferences and has only recently been applied by Bauer et al. (2020) in the context of pension fund beneficiaries. We ask participants to rate their agreement with the previous statement on a 7-point Likert scale from *completely unwilling* to *very willing*.

Our results confirm that our measures of responsible consumption relate to general social preferences. As Table 3.1 shows, social preferences significantly and positively relate to making a sustainable choice in the lottery and to a stronger expressed sustainability awareness according to the consumer scale.

Table 3.1: Sustainability awareness and social preferences

This table presents the marginal effects of three probit regressions. We use all customers of the surveyed robo advisors for our analysis. We exclude those investors from the analysis that have opted not to be considered in the lottery. The dependent variable varies across the different specifications. In specification (1), the dependent variable *Sustainable behavior* is a dummy variable equal to one if an investor opts to receive a fair fashion voucher in the lottery, and zero otherwise. In specification (2), the dependent variable *Reported sustainability* is a dummy variable equal to one if the investor's achieved value on the consumer responsibility scale by Sudbury-Riley & Kohlbacher (2016) is greater or equal to the median sample score. In specification (3), the dependent variable *Reported & realized* is a dummy equal to one if an investor simultaneously fulfills both criteria, from specification (1) and (2). The independent variable *Social preferences* indicates the investor's rates her agreement with the question "How willing are you to give to good causes without expecting anything in return?" on a 7-point Likert scale from *completely unwilling* to *completely willing* (see Falk et al. (2016), Bauer et al. (2020)). We include socio-demographic control variables. For definitions of the variables, see Table 3.11 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

	(1) Sustainable behavior	(2) Reported sustainability	(3) Reported & realized
Social preferences	0.0746***	0.123***	0.0867***
	(0.0159)	(0.0140)	(0.0149)
Female	0.187***	0.140***	0.170***
	(0.0468)	(0.0518)	(0.0387)
Age	-0.00166	0.00268	-0.00181
	(0.00168)	(0.00173)	(0.00148)
Highly educated	0.0467	-0.0579	0.0345
	(0.0473)	(0.0490)	(0.0399)
Income up to 1,499 euro	0.0145	-0.0332	0.0276
	(0.0805)	(0.0814)	(0.0704)
Income 3,500 to 6,000 euro	-0.000734	0.0143	0.0313
	(0.0557)	(0.0574)	(0.0484)
Income above 6,000 euro	-0.0708	0.00270	-0.0405
	(0.0856)	(0.0898)	(0.0705)
Income not reported	0.0140	0.0469	-0.0250
	(0.0800)	(0.0806)	(0.0634)
Observations	410	410	410
Pseudo R^2	0.081	0.113	0.138

3.2.3 Variables on sustainable investment preferences

We elicited participants' preferences regarding SRI. We rely on validated questions proposed by previous surveys on the non-pecuniary motives of socially responsible investors. After providing a short explanation of sustainable investments by the Forum Nachhaltige Geldanlagen (FNG), participants were asked to rate their attainments regarding sustainable investments on a 5-point Likert scale from *very weak* to *very good*, with an additional option for those who have never heard of it before.

Afterwards, we elicited investors' monetary motives and those related to social identification and accountability when it comes to sustainable investments. Regarding the former, we surveyed how participants evaluate the return and risk of sustainable as compared to conventional investments (*much lower, a bit lower, equal, a bit higher, much higher*, or *I don't know*), following Riedl & Smeets (2017). They were asked to estimate the share of their total investment portfolio (beyond the investment managed by their robo advisor) that is invested in SRI (*nothing, 1% to 24%, 25% to 50%, 51% to 75%, 76% to 99%, 100%, no answer*).

Clients of the mixed robo advisor were asked to indicate the portfolio option (*the conventional, the sustainable*, or *both*) they had chosen. Newsletter subscribers of the mixed robo advisor were provided with information on these portfolio offers and asked which option (*the conventional, the sustainable*, or *both*) they would prefer.

Clients and newsletter subscribers of the so-far conventional robo advisor were asked to indicate how they rate the likelihood for making use of a prospective sustainable investment offer by that robo advisor on a 7-point Likert scale from *very unlikely* to *very likely*.

We additionally assessed participants' willingness-to-pay for an automatically-managed sustainable portfolio. They were presented with four return scenarios for a conventional portfolio (*2.5%, 5%, 7.5%* and *10% expected annual net return*) and were asked to report the minimum required return in each scenario at which they would prefer a sustainable portfolio with a comparable risk level over the conventional one. A direct survey method serves our purpose well as it keeps our survey lean while providing at least a good indication of the real willingness-to-pay.

We identified participants' attitudes regarding social accountability and identification in the context of sustainable investments by asking them about the extent of agreement with the following statements, on a 7-point Likert scale. The order of the statements randomly varied. We measure identification with SRI based on the 4-item scale proposed and validated by Bauer & Smeets (2015)[8]: "I can identify myself well with socially responsible investments", "Socially responsible investments fit well to me", "I feel attached to socially responsible investments", "I feel good about owning socially responsible mutual funds". Gutsche & Ziegler (2019) combine the latter statement with one appealing to responsibility ("I feel responsible for a sustainable

[8]The scale was initially adapted from Mael & Ashforth (1992) and Homburg et al. (2009).

development and want to contribute by making sustainable investments."), which jointly measure the warm glow investors experience from SRI. Following Brodback et al. (2019), we capture an individual investor's perceived impact with the statement "By investing in SRI every investor can have a positive effect on social and environmental issues." To measure skepticism, respectively trust regarding the providers of sustainable financial products keeping their promises, we provide the statements "I consider sustainable investments a marketing trick that is used to sell more" (Riedl & Smeets, 2017) and "I trust that providers of sustainable funds and ETFs follow the socially responsible guidelines used in their marketing" (Wins & Zwergel, 2016).

3.2.4 Control variables

Robo advisory experience

We posed several questions related to the clients' robo advisory experience. We asked the participants to provide at least one of the following reasons for using or considering robo advice: "objective investment advice", "manages my portfolio on my behalf", "makes better investment decisions than I do", "achieves better diversification than I do", "costs and minimum required investment are lower than those of a personal financial advisor", "some other reason". Participants who selected the latter could also provide a reason in a text field.

Additionally, we asked the participants to select at least one of the following reasons for choosing a particular robo advisor: "low costs", "good service", "sustainable investment strategy", "active investment strategy", "passive investment strategy", "attractive performance", "recommendation (e.g. by the Internet, friends, family, colleagues)", "some other reason". Participants who selected the latter could also provide a reason in a text field.

Customers were asked to indicate the duration that they have been using their robo advisor (*less than 1 month, 1 to 3 months, 4 to 6 months, 7 to 12 months, longer than 12 months*) and to estimate the share of their investment portfolio (*less than 25%, 25% to 50%, 51% to 75%, 76% to 99%, 100%, no answer*) that is managed by their robo advisor. Newsletter subscribers, on the other hand, were asked whether they do currently invest in securities or have done so in the past.

Investment skills

We additionally collected information for our regression controls. We assessed participants' investment proficiency. In line with Bauer et al. (2020), we asked them to rate their investment skills on a 5-point Likert scale from *very poor* to *very good*. As Van Rooij et al. (2011), Graham et al. (2009) and Dorn & Huberman (2005) demonstrate, investors generally have a realistic idea of their own investment skills. We asked how long they have been investing for (*not at all, less than a year, one to three years, three to five years, five to ten years, more than ten years*), how often they deal with investments (*once a day, a week, a month*, or *infrequently*), and

whether their studies or work is related to investments. We explore how investors would describe their attitude towards investment risk on a 7-point Likert scale from *very risk averse* to *very risk tolerant*, a measure validated by Dohmen et al. (2011) and Dorn & Huberman (2005) and applied by Bauer et al. (2020), and how often they talk about investments with others[9]. The latter question is retrieved from Riedl & Smeets (2017) who show that an investors' tendency for social signaling[10] can motivate sustainable fund investments.

Socio-demographic characteristics

Finally, we gathered participants' socio-demographic characteristics. Participants were asked to provide information on their gender, age, financial background in terms of monthly net income (*up to 1,499 euro, 1,500 to 3,499 euro, 3,500 to 6,000 euro, more than 6,000 euro, no answer*), and their highest educational level.

In the following section, we will provide some descriptive statistics on the results of our survey.

3.3 Descriptives

3.3.1 Who uses robo advice?

The strand of literature that deals with robo advice is fairly young (Brenner & Meyll, 2020, D'Acunto et al., 2019), and, to the best of our knowledge, no attention has been paid to the German market so far. We therefore dedicate this section to the descriptive statistics of our robo advisor clients. In the following, we present the statistics for the three robo advisors together and, if appropriate, emphasize peculiarities about a certain robo advisor. The statistics can be retrieved from Table 3.12 in the Appendix. In total, 448 clients[11] of robo advisors completed the survey. Thereof, 159 participants were clients of the mixed, 213 clients of the conventional and 76 clients of the green robo advisor.

With a median age of 43 years, the surveyed robo advisor clients are younger than the general German stock owners[12]. Moreover, robo advice seems to have a greater attraction for men than for women as far as German investors are concerned (25.9% female investors), even when accounting for the lower overall share of female stock investors in Germany. Our findings are in line with those of D'Acunto et al. (2019) for the U.S. market (median age 47, and 71% male investors). Brenner & Meyll (2020) even observe a median age below 35 for U.S. robo clients. Interestingly, they report a balanced use of robo advice across genders. In our sample, the

[9]Measured in terms of participants' agreement with the statement "I often talk about investments with others" on a 7-point Likert scale.

[10]Social signaling is an individual's desire to be seen by others as pro-social individual (see e.g. Ariely et al. (2009)).

[11]Note that newsletter subscribers that are not clients so far are not included in this number.

[12]In 2018, 11.1% of age 14 to 39 and 20.5% of age 40 to 49 owned stocks (Deutsches Aktieninstitut, 2018).

reported median income lies somewhere between 1,500 and 3,499 euro, which supports the importance of robo advisors as door openers for professional financial advice offering services to customers independent from their income.

Education seems to be a crucial barrier to adopting robo advice, however. 60.3% of our clients have a university degree, which is consistent with the positive relation between general stock market participation and education (Van Rooij et al., 2011). Our clients rate their investment experience as average, with a median investment history of 5 to 10 years, and deal with investments on a weekly basis. 22.8% of the clients report their studies were related to investments, and 18.1% have jobs attached to investments. It seems like German robo advisors attract investors regardless of their investment proficiency.

In line with this notion, only 32.4% seek robo advice to improve their investment decisions. Provision of financial advice coming at low cost and a manageable required investment as well as diversification benefits are equally relevant reasons for using a digital wealth manager (47.3% and 35.5%). In sharp contrast to what Brenner & Meyll (2020) find for the U.S. market, the desire for objective financial advice that is more impervious to potential conflicts of interest seems to be less pronounced among German robo users (15.4%). First and foremost, clients want the convenience of delegated portfolio management (73.9%). In line with Brenner & Meyll (2020), we observe a fairly high risk tolerance among the users of robo advice (median is five on a 7-point Likert scale). Our participants have been customers for 7 to 12 months on average (same as median) and allocate 26 to 50% of their total securities portfolio to their robo advisor (median is less than 25%).

We notice several particularities about the respective robo advisors. Customers of the mixed robo are slightly more confident about their investment skills, describing them as being *good*. Diversification benefits are by far more relevant to them than to the remaining robo clients (43.4% versus 35.5% on average). Customers of the green robo, however, seem to be less concerned about service costs and performance when selecting their robo advisor (13% and 5% versus 44.9% and 19% total sample averages), and less frequently report delegated portfolio management as their motivation (21% versus 73.9% on average). Besides, the green robo has a slightly older clientele, with a median age of 51, and a considerably larger female customer base than the remaining two robo advisors (53.9% versus 15.7% and 23.5%).

In summary, and as far as our sample allows for general conclusion about the German robo advisory landscape, investors appreciate the automated financial advice as convenient investment tool that enhances the diversification of their remaining securities portfolio at relatively low cost and a manageable required investment. Many users have moderate investment skills and a median investment history of 5 to 10 years. They are less reliant on objective financial advice but rather benefit from delegating the management of their portfolio.

3.3.2 Does a sustainable attitude coincide with pertinent behavior?

In this section, we would like to present the outcome of our lottery. The result can be retrieved from Table 3.13 in the Appendix. Out of the 541 participants (customers and newsletter subscribers) who completed the survey, 30.7% were willing to give up 25 euro of the maximum return in exchange for a voucher for a fair and organic fashion label as the potential price in our lottery. 61.9% preferred to win a voucher that can be redeemed with a mainstream fashion label. 7.4% opted not to take part in the lottery.

Asking how sustainable the participants consider their own behavior unveils a considerable discrepancy between attitude and actions. 64.7% of the participants report that they *often* or *always* refuse to purchase products from companies practicing questionable working conditions (not reported), which stands in sharp contrast to 30.7% choosing a fair fashion voucher. A disparity between consumers' ethical attitude and their real choices is well-documented (Boulstridge & Carrigan, 2000). In our sample, 47.0% (36.9%) of the participants who claim to not ever (or seldom) purchasing from a company applying questionable working conditions actually decide in favor of the fair fashion voucher. Likewise, only 40.6% of the participants reporting to consume in a responsible manner most of the time (equals median split) choose a fair fashion voucher. The considerable attitude-behavior gap we note emphasizes the need to use financially-incentivized choices for our analysis instead of merely relying on questionnaire answers.

3.4 Do sustainability-conscious individuals prefer socially responsible investments?

In this section, we study how sustainability consciousness and social investment preferences relate to each other. Our main finding is that non-investment-related sustainable behavior allows for some conclusions to be drawn about an investor's preference for sustainable investments as ethically-minded individuals will more likely prefer to invest their money in a sustainable manner. This finding is in favor of the spillover theory on ethical behavior and opposed to a crowding out effect of responsible actions.

In the following sections, we describe, in detail, how we addressed our research question and present the results of our analyses. Each time, we report four specifications of our regression to check the robustness of our results for several definitions of sustainability awareness as our main variable of interest. In what follows, specification (1) always exhibits the results of our main analysis, where a dummy variable indicates if a respondent behaves in a sustainable manner in the lottery. Specification (2) to (4) report our results for alternating measures of sustainability awareness. In specification (2), we rely on participants' answers to the consumer

responsibility scale proposed by Sudbury-Riley & Kohlbacher (2016). A dummy indicates if a respondent's score is equal to or above the median sample score. In specification (3), we use a stricter definition of an ethical mindset, considering only those participants as truly responsible who behave in a responsible manner in the lottery *and* achieve at least the median consumer responsibility score based on their reported sustainability awareness. In specification (4), we rely on the described score as a continuous variable. When we refer to actual choices as our responsibility measure (specifications (1) and (3)), we additionally include a dummy *No choice* for those participants who have opted not to take part in the lottery.

Following previous studies, we include a series of investor- and investment-related characteristics as control variables in our regressions. Specifically, we control for investors' return expectations and risk perception regarding SRI (see for example Riedl & Smeets (2017)). The relevance of financial return expectations for social investment decisions is debatable. Even after more than 2,000 studies there is still no unequivocal conclusion about the performance of ESG and SRI relative to conventional investments (see Friede et al. (2015) for an extensive review). The ambiguous performance evidence is often interpreted as an indication of some non-financial motives driving socially responsible investors (Lapanan, 2018, El Ghoul & Karoui, 2017, Renneboog et al., 2011, Benson & Humphrey, 2008, Bollen, 2007, Webley et al., 2001). Nevertheless, Brodback et al. (2019), for instance, find that financial return expectations can foster sustainable investment decisions. In that sense, Døskeland & Pedersen (2016) show that praising sustainable investments for their chance of yielding a desirable return is even more effective than stressing their societal impact. We, therefore, consider it worth looking at the role of financial return and risk perceptions. This is a particularly captivating circumstance of our setting as robo advisors are transparent about their strategies' past performance on their websites. Current and prospective clients are likely to consider such information when building their financial expectations about SRI. We therefore include one dummy variable each into our regression that indicates whether an investor expects SRI to yield *higher*, respectively *lower returns* compared to conventional investments, and equal or no return estimates operate as omitted reference group. Likewise, we include one dummy variable each that indicates whether an investor expects SRI to yield *higher*, respectively *lower risk* compared to conventional investments, and equal or no risk estimates operate as omitted reference group here.

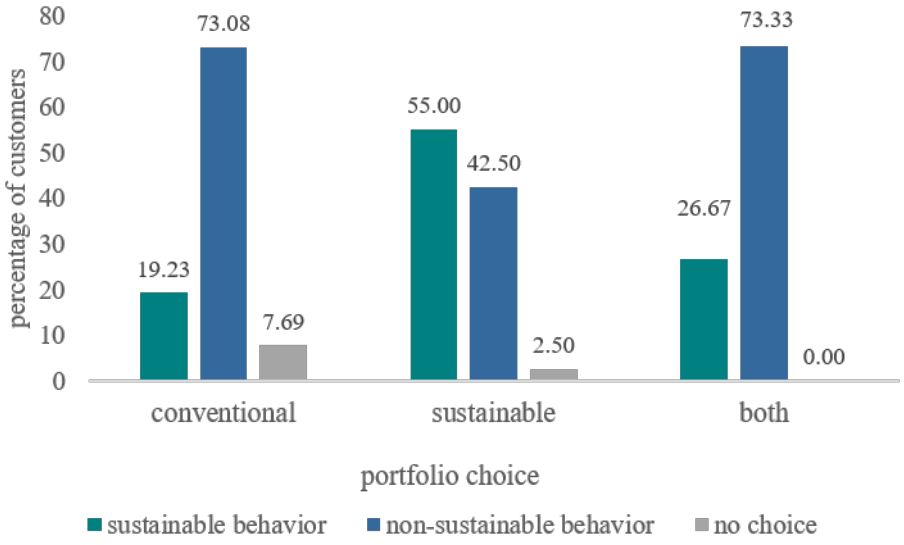
Furthermore, we control for several socio-demographic and investment-related characteristics. In detail, we control for investors' self-rated investment skills, their risk preferences (a higher value refers to more risk-loving participants), gender, age, and a dummy indicating the net income class they come from, with 1,500 to 3,499 euro being the omitted reference group.

3.4.1 Do sustainability-aware individuals select a portfolio managed according to a sustainable investment strategy?

Our first analysis investigates whether individuals engaged in ethical behavior also have a higher likelihood to opt for a sustainable portfolio at their digital wealth manager. We refer to customers of the mixed robo advisor here. A reminder: the mixed robo offers its customers the choice between a sustainable and a conventional portfolio, whereas the former requests from the clients to pay a cost premium. As presented in Figure 3.1, substantially more investors who opt for the sustainable portfolio also behave in a sustainable manner when making the lottery choice. While only 19.23% of the conventional investors prefer the fair and organic alternative (compared to 73.08% mainstream vouchers), sustainable investors opt for it in 55.00% of the cases (compared to 42.50% mainstream vouchers). Investors who have both portfolios are somewhere in between with 26.67% preferring the fair version.

Figure 3.1: Lottery choices by chosen portfolio option

This figure presents the mixed robo advisor customers' lottery choices (*sustainable*, *non-sustainable behavior* or *no choice*). The reported proportions of customers behaving in the respective manner is grouped by their portfolio option (*conventional*, *sustainable* or *both*).



Our regression analysis shows that this relationship is statistically significant. Table 3.2 reports the marginal effects of four probit regressions in which the dependent variable is a dummy that indicates the chosen portfolio (one for a sustainable portfolio, zero otherwise) and the main variable of interest is our respective measure of sustainability awareness. We refer to the sample of actual robo clients only and exclude investors who have both portfolios (15 participants). This provides us with a sample of 144 customers for our first analysis. Our results indicate a significant and positive relationship between sustainability awareness and the preference for a sustainable investment strategy. Ceteris paribus, the marginal effects indicate that, holding all

else equal, participants acting sustainably are 24.58% more likely to engage in SRI. The effect size even increases to 42.58% for individuals who practice what they preach (specification (3)). Next to our main interest, we find that financial return expectations about SRI actually do play a role in our robo advice setting. Clients expecting higher financial returns are more likely to engage in SRI. This finding is in line with what Brodback et al. (2019) find. Perception of high risk, in contrast, deters sustainable investments (see also Gutsche & Ziegler (2019)). The fact that financial considerations play a role here contradicts the findings by Riedl & Smeets (2017), however, and might be traced back to the fact that robo advisor clients are more financially-concerned than general fund investors. In contrast, little can be concluded from our remaining control variables. Gender is the only socio-demographic variable unveiling a significant and positive coefficient in specifications (2) and (4), which indicates a slightly higher preference for SRI among female investors.

Table 3.2: Do sustainability-aware individuals select a portfolio managed according to a sustainable investment strategy?

This table presents the marginal effects of four probit regressions. We use all customers of the mixed robo advisor for our analysis. The dependent variable *Sustainable portfolio* takes the value of one if the investor has a sustainable portfolio at the mixed robo advisor and zero the investor has a conventional portfolio. We exclude customers from the regression that have both portfolios. The different specifications refer to our respective measure of *Sustainability awareness*. In specification (1), the independent variable *Sustainable behavior* is a dummy variable equal to one if an investor opts to receive a fair fashion voucher in the lottery, and zero otherwise. In specification (2), the independent variable *Reported sustainability* is a dummy variable equal to one if the investor's achieved value on the consumer responsibility scale by Sudbury-Riley & Kohlbacher (2016) is greater or equal the median sample score. In specification (3), the independent variable *Reported & realized* is a dummy equal to one if an investor simultaneously fulfills both criteria, from specification (1) and (2). In specification (4), the independent variable *Reported (cts.)* is a continuous variable equal to the value the investor achieves on the consumer responsibility scale by Sudbury-Riley & Kohlbacher (2016). Specifications (1) and (3) additionally control for investors who opt not to be considered in the lottery. For definitions of the remaining variables, see Table 3.11 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

Sustainable portfolio	(1) Sustainable behavior	(2) Reported sustainability	(3) Reported & realized	(4) Reported (cts.)
Sustainability awareness	0.246***	0.217***	0.426***	0.255***
	(0.0622)	(0.0613)	(0.0663)	(0.0637)
No choice	-0.0558		-0.0521	
	(0.139)		(0.131)	
High exp. returns	0.193**	0.180**	0.152*	0.174**
	(0.0778)	(0.0830)	(0.0776)	(0.0779)
Low exp. returns	0.0973	0.0942	0.0966	0.0888

Continued

Table 3.2: *Continued*

Sustainable portfolio	(1) Sustainable behavior	(2) Reported sustainability	(3) Reported & realized	(4) Reported (cts.)
	(0.0786)	(0.0850)	(0.0748)	(0.0824)
High exp. risk	-0.230***	-0.218***	-0.314***	-0.206***
	(0.0759)	(0.0725)	(0.0706)	(0.0713)
Low exp. risk	-0.0384	-0.0307	-0.107	-0.0191
	(0.0817)	(0.0869)	(0.0797)	(0.0837)
Risk preferences	-0.0327	-0.0231	-0.0318	-0.0265
	(0.0286)	(0.0272)	(0.0249)	(0.0289)
Investment skills	-0.0163	-0.0271	-0.00190	-0.0287
	(0.0398)	(0.0428)	(0.0386)	(0.0423)
Female	0.111	0.160*	0.0882	0.172**
	(0.0879)	(0.0847)	(0.0797)	(0.0804)
Age	-0.00250	-0.00340	-0.00144	-0.00319
	(0.00267)	(0.00272)	(0.00230)	(0.00274)
Highly educated	0.0796	0.0868	0.0762	0.0607
	(0.0651)	(0.0680)	(0.0582)	(0.0677)
Income up to 1,499 euro	0.104	0.129	0.114	0.107
	(0.123)	(0.134)	(0.116)	(0.130)
Income 3,500 to 6,000 euro	0.117	0.0930	0.0755	0.0772
	(0.0824)	(0.0897)	(0.0774)	(0.0863)
Income above 6,000 euro	0.131	0.0907	0.0462	0.0623
	(0.140)	(0.134)	(0.134)	(0.137)
Income not reported	0.208	0.136	0.230**	0.145
	(0.139)	(0.142)	(0.117)	(0.145)
Observations	144	144	144	144
Pseudo R^2	0.267	0.244	0.355	0.268

Robustness tests

In the following section, we show that our main finding is robust to several alternative specifications (see Table 3.14 in the Appendix).

First, we variegate our sample. In step one, we include customers to our sample who hold both a sustainable *and* conventional portfolio and consider them as responsible investors in our regression (robustness test 1). In a second step, we add interested newsletter subscribers, who are not yet customers, to our sample. Analogous to our previous analysis of actual clients, we analyze which portfolio the prospective clients *would prefer* in case they became customers of the mixed robo (robustness test 2).[13] In both cases our result that sustainability awareness positively relates to SRI preferences is robust to these changes.

Second, we introduce additional controls to our regression that factor in various motivations for becoming customer of or taking an interest in the mixed robo advisor. To this end, we control for *cost-sensitive* customers as they will likely be unwilling to pay a surcharge for a sustainable portfolio; we control for investors preferring an *active portfolio strategy*. As mentioned before, robo advisors first and foremost rely on passively managed index funds and ETFs. Including actively managed funds into the portfolio is rather unconventional and might somehow affect the investment decision. Investors might appreciate the rare opportunity of an automatically-managed portfolio with a partially-active investment strategy. On the other hand, investors might also believe that active investments cannot beat the market in the long-run and therefore prefer a conventional portfolio regardless of their actual preference for SRI. For this reason, we control for investors preferring a *passive investment strategy*; we control for particularly *performance-sensitive* investors. In contrast to the vast amount of studies dedicated to the performance of actively managed SRI funds (see Friede et al. (2015)), little is known about the performance of sustainable ETFs so far. Moreover, the fact that the robo offers fewer sustainable than conventional investment strategies might come into play here, entailing less feasible variation in the equity-to-bond (i.e. return-to-risk) ratio for sustainable investors. The results of this analysis can be retrieved from Table 3.15 in the Appendix. It shows that the effect size and significance of our main variable of interest remains unaffected and hence lends further support to the notion that ethically-minded individuals pay attention to sustainability when making investment decisions. While the effect of high perceived risk remains unchanged, the coefficient for high return expectations and gender is significant in only three out of four specifications.

Third, we re-define the dependent variable. In this alternate specification, the dependent variable is equal to one if an investor has selected "offering sustainable investment strategies" as one reason for choosing the mixed robo advisor, and zero otherwise. Aside from a re-defined dependent variable, we use the same specifications as in our initial analysis here. Robustness test 3 of Table 3.14 in the Appendix evinces that the coefficients of ethical behavior stay significant. Interestingly enough, perception of high risk is, in contrast to high expected returns, not significant and in most specifications the coefficient sign changes as well. A feasible explanation is that investors do not descry investment risk until ultimately faced with the choice of either

[13] Like actual clients, they can choose between conventional, sustainable, or both portfolios.

consigning their money to SRI – or to conventional assets after all. In addition, robo advisors are transparent about the past performance of their portfolios and let their customers fiddle about with return predictions of the investment strategies. It might occur that investors change their mind at the last minute, investing conventionally despite best intentions.

We find that age is significant and negatively related to searching for a robo advisor with a sustainable product offer. This finding indicates that younger investors more often inform themselves about sustainable investments in the first place and might then purposely base the financial service provider choice on the availability of a sustainable product alternative.

In the next section, we analyze the motives of robo advisor customers to opt for sustainable investments. We distinguish between sustainability-aware individuals and all others.

3.4.2 When do people consistently behave in a sustainable manner?

The concurrent desire for both financial returns and moral benefits or status make socially responsible investing a decision that involves both "*brain and heart*" (Døskeland & Pedersen, 2016). Our results from the previous section suggest that these ambivalent motives hold true for our socially responsible robo clients, too. However, whether or not investors recognize SRI as an opportunity to pursue both aims crucially depends on their manifestation of certain norms, values and beliefs regarding SRI. As such, strong altruism – one facet of social preferences – is a distinctive feature of social investors (Brodback et al., 2019). Strong feelings of warm glow (Gutsche & Ziegler, 2019) provide altruistic investors with the appealed *non-monetary* utility that would even compensate for financial return sacrifices (Brodback et al., 2019). Ultimately, high environmental awareness (Gutsche & Ziegler, 2019) and the ability to personally identify with the concept of SRI is key (Bauer & Smeets, 2015). Next to those unselfish endeavors social prestige can play a role in investment decisions as well (Bauer et al., 2020, Riedl & Smeets, 2017). Regardless of how ethically-minded an investor is – trust in the providers of sustainable funds is indispensable (Wins & Zwergel, 2016), and investors need to perceive a sufficiently large impact coming from their money (Riedl & Smeets, 2017).

We wonder whether some of these features can explain why ethically-minded individuals tend to engage in SRI more frequently. Sustainability-aware individuals might identify with SRI more easily, feel more responsible for a sustainable development or assess a higher impact of the individual than their mainstream counterparts do. Besides, the desire for social prestige might not be equally important for responsible and mainstream individuals. They might also have varying degrees of confidence in the financial performance of sustainable assets. In the following, we analyze how monetary motives, motives related to social accountability and identification (i.e. trust and skepticism, identification, warm glow and the perceived impact of SRI), social prestige, and social preferences matter to our robo clients in general, and to ethically-minded individuals in particular. We additionally analyze the relevance of knowledge about SRI.

Table 3.3: The (non-)pecuniary motives behind responsible investments

This table presents the marginal effects of several probit regressions. We use all customers of the mixed robo advisor for our analysis. The dependent variable *Sustainable portfolio* takes the value of one if the investor has a sustainable portfolio at the mixed robo advisor and zero if the investor has a conventional portfolio. We exclude customers from the regression that have both portfolios. In the various specifications, we include one *Attitude* as independent variable, each, as indicated in the respective column header. *Signaling* indicates the extent to which an investor agrees with the statement "I often talk about investments with others" on a 7-point Likert scale (Riedl & Smeets, 2017). *Signaling* is included into each regression along with the remaining attitudes, as it is not strongly correlated with these attitudes. We additionally report the effect of *signaling* alone in specification (6). *Trust* indicates the extent to which an investor agrees with the statement "I trust that providers of sustainable funds and ETFs follow the socially responsible guidelines used in their marketing" on a 7-point Likert scale (Wins & Zwergel, 2016). *Identification* is the combined score of an investor's extent of agreement with the following statements on a 7-point Likert scale: "I can identify myself well with socially responsible investments", "Socially responsible investments fit well to me", "I feel attached to socially responsible investments", "I feel good about owning socially responsible mutual funds" (Bauer & Smeets, 2015). *Warm glow* is the combined score of an investor's extent of agreement with the following statements on a 7-point Likert scale: "I feel responsible for a sustainable development and want to contribute by making sustainable investments" and "I feel good about owning socially responsible mutual funds" (Gutsche & Ziegler, 2019). *Impact* indicates the extent to which an investor agrees with the statement "By investing in SRI every investor can have a positive effect on social and environmental issues" on a 7-point Likert scale (Brodback et al., 2019). The independent variable *Social preferences* indicates the investor's agreement with the question "How willing are you to give to good causes without expecting anything in return?" on a 7-point Likert scale from *completely unwilling* to *completely willing* (see Falk et al. (2016), Bauer et al. (2020)). *Responsibility* indicates the extent to which an investor agrees with the statement "I feel responsible for a sustainable development and want to contribute by making sustainable investments" on a 7-point Likert scale (Gutsche & Ziegler, 2019). *Feeling good* indicates the extent to which an investor agrees with the statement "I feel good about owning socially responsible mutual funds" on a 7-point Likert scale (Gutsche & Ziegler, 2019). *Skepticism* indicates the extent to which an investor agrees with the statement "I consider sustainable investments a marketing trick that is used to sell more" on a 7-point Likert scale (Riedl & Smeets, 2017). *SRI knowledge* indicates how the investor rates the own knowledge about SRI on a 5-point Likert scale from *very weak* to *very good*In all specifications, the independent variable *Sustainable behavior* is a dummy variable equal to one if an investor opts to receive a fair fashion voucher in the lottery, and zero otherwise. We additionally control for investors who opt not to be considered in the lottery. We use investment-related and socio-demographic controls. For definitions of the remaining variables, see Table 3.11 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

Sustainable portfolio	(1) Trust	(2) Identi-fication	(3) Warm glow	(4) Impact	(5) Social preferences	(6) Signaling	(7) Responsi-bility	(8) Feeling good	(9) Skepticism	(10) SRI knowledge
Sustainable behavior	0.220***	0.121**	0.113**	0.158***	0.215***	0.236***	0.0904*	0.167***	0.227***	0.227***
	(0.0588)	(0.0522)	(0.0499)	(0.0518)	(0.0618)	(0.0605)	(0.0538)	(0.0548)	(0.0553)	(0.0576)
No choice	-0.0368	0.0123	0.0216	-0.0556	-0.0631	-0.0359	0.0430	-0.00463	-0.0403	-0.0562

Continued

Table 3.3: *Continued*

Sustainable portfolio	(1) Trust	(2) Identi-fication	(3) Warm glow	(4) Impact	(5) Social preferences	(6) Signaling	(7) Responsi-bility	(8) Feeling good	(9) Skepticism	(10) SRI knowledge
	(0.137)	(0.0932)	(0.0993)	(0.151)	(0.136)	(0.135)	(0.101)	(0.107)	(0.127)	(0.140)
Signaling	-0.0229	-0.0288	-0.0212	-0.0340*	-0.0325	-0.0310	-0.0216	-0.0213	-0.0360*	-0.0276
	(0.0202)	(0.0181)	(0.0184)	(0.0186)	(0.0217)	(0.0214)	(0.0193)	(0.0177)	(0.0212)	(0.0199)
Attitude	0.0740***	0.140***	0.138***	0.114***	0.0273		0.131***	0.119***	-0.0662***	0.113***
	(0.0232)	(0.0169)	(0.0159)	(0.0179)	(0.0229)		(0.0161)	(0.0179)	(0.0181)	(0.0355)
High exp. returns	0.155**	0.0876	0.0481	0.0938	0.193**	0.199***	0.0581	0.0843	0.178**	0.112
	(0.0739)	(0.0705)	(0.0660)	(0.0655)	(0.0770)	(0.0770)	(0.0682)	(0.0698)	(0.0774)	(0.0791)
Low exp. returns	0.0676	0.0751	0.0348	0.0324	0.0655	0.0691	0.0702	0.0303	0.0736	0.0632
	(0.0744)	(0.0692)	(0.0668)	(0.0669)	(0.0771)	(0.0770)	(0.0718)	(0.0650)	(0.0730)	(0.0747)
High exp. risk	-0.190***	-0.216***	-0.203***	-0.128*	-0.216***	-0.219***	-0.196***	-0.228***	-0.195***	-0.187***
	(0.0713)	(0.0613)	(0.0618)	(0.0653)	(0.0747)	(0.0745)	(0.0614)	(0.0668)	(0.0739)	(0.0709)
Low exp. risk	-0.00205	-0.0829	-0.0457	-0.0436	-0.00729	-0.0259	-0.0213	-0.0722	-0.0390	0.0172
	(0.0755)	(0.0654)	(0.0594)	(0.0717)	(0.0831)	(0.0817)	(0.0641)	(0.0657)	(0.0766)	(0.0793)
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	144	144	144	144	144	144	144	144	144	144
Pseudo R^2	0.276	0.326	0.495	0.512	0.431	0.283	0.506	0.456	0.338	0.325

Table 3.3 reports the marginal effects of several probit regressions in which choosing a *sustainable portfolio* is the binary dependent variable. We stick to our sample of the mixed robo clients who have decided for only one portfolio (i.e. the conventional or the sustainable portfolio). The main variable of interest is the financially-incentivized lottery choice. We add one of the aforementioned values and beliefs at a time as additional independent variable to our regression as they are (by nature) highly correlated. Social signaling, being less strongly intertwined with the remaining concepts, is included in all regressions. Please note that we cannot eliminate that participants' reported attitudes towards sustainable investments might be biased by participants' desire to justify their portfolio choice.

In terms of social accountability and identification, we notice, first of all, that the effect of sustainability awareness does not get superimposed by other values and beliefs regarding SRI. In line with previous literature on social retail investors (Brodback et al., 2019, Gutsche & Ziegler, 2019, Riedl & Smeets, 2017, Wins & Zwergel, 2016, Bauer & Smeets, 2015), we find that trust, identification, warm glow[14], and perceived impact encourage social investments among robo investors as well. Furthermore, an investor's knowledge about SRI positively relates to sustainable investments, while skepticism reveals a negative relation.

In contrast to a sustainable self-concept, social prestige seems to be of secondary importance to our robo clients. In detail, we find a negative yet insignificant coefficient for an investors' tendency to social signaling. This stands in contrast to what Riedl & Smeets (2017) find for fund investors. Presumably, these differences might be caused by at least three issues. First, even though being neighbors, there might be slight cultural differences regarding the candor with which German and Dutch investors talk about their financial situation. Second, mutual fund investors managing their portfolio on their own might have stronger signaling preferences than investors who delegate their portfolio management to a robo advisor. Third, the binary decision might cause the difference. Riedl & Smeets (2017) state that mutual fund investors who strongly strive for social prestige wish to be part of SRI but, if so, are only prepared to allocate a small proportion of their portfolio to it. In our analysis, in contrast, we analyze a binary decision – in favor or against a completely sustainable investment strategy[15] – which obviously requires stronger commitment. In line with this notion, we find that our *sustainable-only* investors score lower on signaling than investors with *both* portfolios (average 3.55 versus 4.6, median 4 versus 5).

Little surprising, social preferences show a positive, but insignificant relationship with SRI preferences when we include sustainability awareness to our regression. We lead this finding back to strong collinearity between the two as social preferences encourage both responsible consumer and investment behavior.

[14]This holds true for both measure components, i.e. sense of responsibility and feeling good about SRI.
[15]with few exceptions having two separate portfolios

We have established that most of the common values and beliefs of social investors equally apply to our robo investors – except for social prestige being less relevant to these investors and financial motives not being extraneous. Next, we investigate whether some of the values and beliefs might help explain sustainable individuals' engagement in SRI. The results of this analysis can be retrieved from Table 3.16 in the Appendix, which presents the effects of several probit regressions. We include interaction terms between acting sustainably, and one of the attitudes regarding SRI at a time, to our regressions here. What we find is that trust respectively skepticism, knowledge about SRI and perceived impact are strong predictors of sustainable investments *per se* but do not affect ethical individuals in particular. Instead, we find significant and positive interaction terms between feelings of identification, respectively warm glow, and sustainability awareness, while the coefficient of sustainable behavior itself turns negative. We conclude that engagement in another eco-friendly and socially responsible behavior crucially facilitates the identification with SRI. Disassembling the effects of warm glow unveils ethical individuals' strong feelings of responsibility for a sustainable development.

In the following section, we analyze whether our previous findings also apply to potentially interested sustainable investors.

3.4.3 Do sustainability-conscious individuals have greater interest in a prospective sustainable investment offer?

According to Wins & Zwergel (2016), investors who do and those who might engage in SRI actually resemble one another. This makes us curious about what sustainable behavior can reveal about an investor's potential interest in SRI. To address our question, we turn to a new sample. The conventional robo advisor provides a suitable setting, since this digital wealth manager has followed a completely conventional investment strategy at the time of the study but has planned to provide its clients with sustainable investment products in the future. The robo was therefore interested in learning about its clients' interest in such products.

Table 3.4: Reported interest in a prospective sustainable investment offer

This table describes the conventional robo clients' reported interest in the launch of a sustainable investment offer by their robo advisor. It reports how the clients rate the likelihood for making use of such a sustainable investment offer by their robo advisor on a 7-point Likert scale from *very unlikely* to *very likely*.

	very unlikely	2	3	4	5	6	very likely
Perc.	5.63	5.16	11.27	18.78	19.72	18.78	20.66
Cum. perc.	5.63	10.79	22.06	40.84	60.56	79.34	100.00
	Mean		Median		Observations		
	4.81		5		213		

In our survey, we asked its clients how they rate the likelihood for making use of such a sustainable investment offer by the conventional robo on a 7-point Likert scale from *very unlikely* to *very likely*. Table 3.4 indicates a large interest in such an alternative product offer. The median reported likelihood is 5 out of 7 that investors will engage in SRI if their conventional robo provides the opportunity. While approximately 20.7% consider it very likely that they will make use of the prospective investment offer, only 5.6% completely refuse to SRI.

We wonder whether responsible individuals have a particularly great desire for a sustainable investment product alternative. Table 3.5 exhibits the results of our analysis. We apply ordered probit regressions in which the dependent variable indicates how investors rate the likelihood for making use of a prospective sustainable product offer by the conventional robo on a 7-point Likert scale (from *very unlikely* to *very likely*). We relate the expressed interest in SRI to participants' concern for sustainability. As before, we use four versions of our main variable of interest (Panel A to D). Marginal effects are reported. Our results indicate a particularly strong interest in SRI among ethical individuals. This finding holds true for all applied measures of sustainability awareness (Panel A to D). Also, female investors express greater interest in a prospective sustainable investment offer.

In fact, we observe various similarities between actual and prospective social investors (see Wins & Zwergel (2016)), as can be concluded from Table 3.17 in the Appendix which reports the marginal effects of several probit regressions in which we include one attitude each as main variable of interest into our regression. Identification, warm glow, trust and perceived impact as well as knowledge about SRI are important determinants of sustainability preferences. Skepticism regarding the reliability of sustainable fund and ETF providers is a crucial obstacle, on the other hand. This time, the effects of social preferences and signaling remain significant, even when we include sustainability awareness into our regression. The latter is little surprising, since investors do not have to back their talk by actions here.

The financial considerations vary between actual and interested social investors, however. Investors who expect lower returns consider it rather unlikely to make use of a sustainable investment offer, as can be retrieved from Table 3.5. Interestingly enough, interested investors seem to be more positive about the risk of this investment class. The perception of low risk goes along with stronger interest in SRI, whereas high risk perception does not play a role here. This result supports our assumption that investors are not too worried about risk when researching into sustainable robo advice, but that this would change once faced with the actual investment decision.

Table 3.5: Do sustainability-conscious individuals have greater interest in a prospective sustainable investment offer?

This table presents the marginal effects of an ordered probit regression. We use all customers of the conventional robo advisor for our analysis. The dependent variable *Interest* indicates how participants rate the likelihood that they will make use of a prospective sustainable financial product offer by the so-far conventional robo advisor on a 7-point Likert scale from *very unlikely* to *very likely*. The columns refer to the respective category of the dependent variable. The different panels refer to our respective measure of *Sustainability awareness*. Panel A and C additionally control for investors who opt not to be considered in the lottery. In Panel B to D, we use the usual investment-related and socio-demographic controls. We additionally use controls for financial expectations about SRI. For definitions of the remaining variables, see Table 3.11 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

Interest	very unlikely	2	3	4	5	6	very likely
Panel A: Results based on sustainable behavior as independent variable							
Sustainable behavior	-0.0570***	-0.0326**	-0.0503***	-0.0423***	0.00314	0.0487***	0.130***
	(0.0206)	(0.0133)	(0.0183)	(0.0149)	(0.00664)	(0.0171)	(0.0397)
No choice	0.0160	0.00915	0.0141	0.0119	-0.000882	-0.0137	-0.0366
	(0.0315)	(0.0178)	(0.0274)	(0.0229)	(0.00251)	(0.0264)	(0.0711)
High exp. returns	-0.0529**	-0.0302**	-0.0466**	-0.0392**	0.00291	0.0452**	0.121**
	(0.0225)	(0.0146)	(0.0209)	(0.0172)	(0.00627)	(0.0192)	(0.0476)
Low exp. returns	0.0476**	0.0272**	0.0420**	0.0353**	-0.00262	-0.0407**	-0.109***
	(0.0190)	(0.0130)	(0.0168)	(0.0138)	(0.00536)	(0.0158)	(0.0404)
High exp. risk	0.0234	0.0134	0.0207	0.0174	-0.00129	-0.0200	-0.0535
	(0.0225)	(0.0117)	(0.0182)	(0.0156)	(0.00284)	(0.0184)	(0.0473)
Low exp. risk	-0.0421**	-0.0241**	-0.0372**	-0.0313**	0.00232	0.0360**	0.0963**
	(0.0194)	(0.0121)	(0.0170)	(0.0135)	(0.00494)	(0.0162)	(0.0397)
Risk preferences	-0.00243	-0.00139	-0.00215	-0.00181	0.000134	0.00208	0.00556

Continued

Table 3.5: *Continued*

Interest	very unlikely	2	3	4	5	6	very likely
	(0.00740)	(0.00433)	(0.00668)	(0.00560)	(0.000490)	(0.00640)	(0.0172)
Investment skills	0.0103	0.00589	0.00908	0.00764	-0.000568	-0.00880	-0.0235
	(0.0104)	(0.00633)	(0.00947)	(0.00812)	(0.00125)	(0.00902)	(0.0243)
Female	-0.0349*	-0.0199*	-0.0308*	-0.0259*	0.00192	0.0298*	0.0797**
	(0.0193)	(0.0115)	(0.0158)	(0.0135)	(0.00412)	(0.0154)	(0.0403)
Age	0.000492	0.000281	0.000434	0.000365	-0.0000271	-0.000420	-0.00112
	(0.000495)	(0.000279)	(0.000438)	(0.000372)	(0.0000582)	(0.000414)	(0.00113)
Highly educated	-0.0122	-0.00698	-0.0108	-0.00907	0.000673	0.0104	0.0279
	(0.0161)	(0.00921)	(0.0140)	(0.0121)	(0.00166)	(0.0138)	(0.0363)
Income up to 1,499 euro	0.0124	0.00752	0.0119	0.0103	-0.000425	-0.0113	-0.0304
	(0.0275)	(0.0161)	(0.0250)	(0.0204)	(0.00316)	(0.0247)	(0.0614)
Income 3,500 to 6,000 euro	0.0136	0.00818	0.0129	0.0111	-0.000570	-0.0123	-0.0328
	(0.0175)	(0.0107)	(0.0168)	(0.0143)	(0.00229)	(0.0164)	(0.0410)
Income above 6,000 euro	-0.0142	-0.00972	-0.0168	-0.0174	-0.00351	0.0133	0.0483
	(0.0201)	(0.0139)	(0.0244)	(0.0265)	(0.00790)	(0.0175)	(0.0742)
Income not reported	0.0691*	0.0343*	0.0472**	0.0298**	-0.0167	-0.0544*	-0.109**
	(0.0411)	(0.0188)	(0.0230)	(0.0128)	(0.0155)	(0.0281)	(0.0450)
Pseudo R^2	0.090						

Continued

Table 3.5: *Continued*

Interest	very unlikely	2	3	4	5	6	very likely
Panel B: Results based on the reported sustainability as independent variable							
Reported sustainability	-0.0582***	-0.0347***	-0.0538***	-0.0449***	0.00274	0.0502***	0.139***
	(0.0200)	(0.0132)	(0.0155)	(0.0124)	(0.00703)	(0.0150)	(0.0344)
Controls	yes	yes	yes	yes	yes	yes	yes
Pseudo R^2	0.0951						
Panel C: Results based on the reported & realized sustainability as independent variable							
Reported & realized	-0.0584**	-0.0334**	-0.0515**	-0.0434**	0.00335	0.0504**	0.133***
	(0.0238)	(0.0157)	(0.0219)	(0.0180)	(0.00706)	(0.0209)	(0.0488)
No choice	0.0210	0.0120	0.0185	0.0155	-0.00120	-0.0181	-0.0476
	(0.0316)	(0.0177)	(0.0272)	(0.0228)	(0.00301)	(0.0265)	(0.0704)
Controls	yes	yes	yes	yes	yes	yes	yes
Pseudo R^2	0.0871						
Panel D: Results based on the reported sustainability (cts.) as independent variable							
Reported (cts.)	-0.0650***	-0.0386***	-0.0616***	-0.0535***	0.000287	0.0580***	0.161***
	(0.0161)	(0.0124)	(0.0144)	(0.0126)	(0.00808)	(0.0130)	(0.0291)
Controls	yes	yes	yes	yes	yes	yes	yes
Pseudo R^2	0.1242						

Continued

Table 3.5: *Continued*

Interest	very unlikely	2	3	4	5	6	very likely
Observations	213						

We are interested in how much return investors require to consider investing sustainably. We therefore presented clients with four hypothetical return scenarios for an automatically-managed conventional portfolio (2.5%, 5%, 7.5% and 10% net return p.a.) and asked for the respective minimum return that would make them favor a sustainable investment strategy instead – given that both have the same risk. We then calculate the average return that each client was willing to sacrifice. Negative values are set to zero. Table 3.6 displays the results of four OLS regressions in which the average reported return sacrifice in percentage points is the continuous dependent variable. As before, specifications (1) to (4) relate to alternating specifications of our main variable of interest. We observe a slightly higher willingness-to-pay among responsible individuals, even though our results are significant on a 10%-level (specification (1) and (3)) and hold true for only three out of four specifications. We additionally report the regression results for each return scenario separately in Table 3.18 in the Appendix. The coefficients for sustainability-awareness are positive, yet most of the time not or only weakly significant on a 10%-level, and increase with the underlying reference return for the conventional portfolio, i.e. the higher the reference return the larger the sustainability-aware individuals' willingness to sacrifice part of their financial return in order to invest in a socially responsible manner. One striking feature is that participants' reported sustainability, when defined as continuous variable, significantly and positively relates to their willingness to sacrifice return in all scenarios and on a 1% confidence level. The divergent results might be traced back to an attitude-behavior gap.

When we look at expected returns, we observe that ethically-minded individuals seem to be more optimistic about the returns of social investments rather than requiring lower returns. In that sense, Table 3.19 in the Appendix exhibits the marginal effects of four ordered probit regressions in which the dependent variable indicates how an investor assesses the return opportunities of SRI relative to conventional investments on a 5-point Likert scale from *much lower* to *much higher*. We exclude investors from our regression who report insufficient knowledge on the topic. Our results indicate higher expected returns from SRI among conscious individuals, even though there is weaker significance for our lottery-based measure (Panel A).

Recapping our findings from this section, we note a stronger excitement about the prospective sustainable investment product among sustainable individuals as compared to their mainstream counterparts. However, this excitement does not indubitably translate into a higher willingness to sacrifice returns.

Table 3.6: Willingness to sacrifice financial returns

This table presents the results of four OLS regressions. We use all customers of the conventional robo advisor for our analysis. The dependent variable *Return sacrifice* indicates how many percentage points of the annual net return for a conventional robo advisor portfolio an investor is willing to forego in order to invest in a sustainable portfolio with similar risk instead. The return sacrifice is calculated as average of four return scenarios for the conventional portfolio (2.5%, 5%, 7.5%, 10%). The different regression specifications refer to our respective measure of *Sustainability awareness*. We use the usual investment-related and socio-demographic controls. For definitions of the remaining variables, see Table 3.11 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

Return sacrifice	(1) Sustainable behavior	(2) Reported sustainability	(3) Reported & realized	(4) Reported (cts.)
Sustainability awareness	0.293*	0.111	0.278*	0.223***
	(0.159)	(0.116)	(0.157)	(0.0777)
No choice	0.273		0.243	
	(0.240)		(0.236)	
Controls	yes	yes	yes	yes
Observations	213	213	213	213
Adjusted R^2	-0.003	-0.020	-0.010	0.008

3.4.4 Do ethically-minded individuals choose their robo advisor based on its sustainable investment offer?

Ultimately, we ask ourselves whether offering sustainable investment strategies encourages sustainability-conscious individuals to become customers of the particular robo advisor. Adding the clients of yet another provider of robo advice that follows an all-out sustainable investment strategy to our remaining investor sample creates an exhilarating setting for our question. The robo advisor's strategy schedules exclusively investing in actively managed funds that meet the robo's sustainability standards. In doing so, the robo advisor has a unique feature on the German market and potentially appeals to sustainability-aware individuals in other ways than robo advisors who offer both conventional and sustainable investments do.

We assess whether sustainability-conscious individuals prefer a robo advisor that additionally, respectively one that exclusively offers sustainable investment strategies over a conventional robo advisor. Table 3.7 reports the relative-risk ratios of four multinomial logit regressions in which the dependent variable indicates the respective robo advisor (mixed, conventional or green). We report probabilities relative to being customer of the conventional robo advisor. As before, the various specifications refer to variations of our main variable of interest.

Table 3.7: Do sustainability-aware individuals prefer robo advisors with a green investment offer?

This table presents the relative-risk ratios of four multinomial logit regressions. We use all customers of all three robo advisors for our analysis. The dependent variable takes on three values for the robo advisors mixed, green and conventional. Odd columns refer to customers of the mixed robo advisor, even columns refer to customers of the green robo advisor. The baseline group are customers of the conventional robo advisor. The different specifications refer to our respective measure of *Sustainability awareness*. We include additional controls for an investor's motives of becoming customer of the respective robo advisor: *Low cost* is a dummy variable equal to one if a participant prefers the robo advisor for its low cost, zero otherwise; *Performance* is a dummy variable equal to one if a participant prefers the robo advisor due to the favorable risk-return-profile of its strategies, zero otherwise; *Active strategy* is a dummy variable equal to one if a participant prefers the robo advisor for offering active investment strategies, zero otherwise; *Passive strategy* is a dummy variable equal to one if a participant prefers the robo advisor for offering passive investment strategies, zero otherwise; *Recommendation* is a dummy variable equal to one if a participant's preference for the robo advisor is based on the recommendation by a friend, colleague, family member, etc., zero otherwise; *Good service* is a dummy variable equal to one if a participant prefers the robo advisor for its good service quality, zero otherwise; *Other reason* is a dummy variable equal to one if a participant prefers the robo advisor for some other reason that has not been listed, zero otherwise. For definitions of the remaining variables, see Table 3.11 in the Appendix. Transformed robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

	Sustainable behavior		Reported sustainability		Realized & reported		Reported (cts.)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Robo advisor	Mixed	Green	Mixed	Green	Mixed	Green	Mixed	Green
Sustainability awareness	1.408	3.394***	1.049	1.642	1.092	2.826**	1.191	1.768
	(0.371)	(1.250)	(0.247)	(0.546)	(0.331)	(1.145)	(0.331)	(1.145)
No choice	0.657	2.798**			0.607	2.325*		
	(0.289)	(1.443)			(0.265)	(1.170)		
Low cost	0.556**	0.204***	0.556**	0.230***	0.562**	0.213***	0.557**	0.238***
	(0.137)	(0.0954)	(0.136)	(0.107)	(0.138)	(0.101)	(0.136)	(0.110)
Performance	0.474**	0.197**	0.482**	0.195***	0.475**	0.196**	0.481**	0.198***
	(0.144)	(0.130)	(0.144)	(0.121)	(0.143)	(0.128)	(0.144)	(0.123)
Active strategy	3.480***	11.19***	3.340***	10.07***	3.399**	10.36***	3.345***	10.14***

Continued

Table 3.7: *Continued*

	Sustainable behavior		Reported sustainability		Realized & reported		Reported (cts.)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Robo advisor	Mixed	Green	Mixed	Green	Mixed	Green	Mixed	Green
	(1.634)	(7.242)	(1.552)	(6.374)	(1.615)	(6.739)	(1.547)	(6.429)
Passive strategy	0.200***	0.291	0.198***	0.343	0.204***	0.303	0.198***	0.337
	(0.106)	(0.300)	(0.107)	(0.346)	(0.109)	(0.316)	(0.107)	(0.336)
Recommendation	0.412***	0.800	0.427***	0.868	0.425***	0.837	0.427***	0.863
	(0.106)	(0.321)	(0.108)	(0.361)	(0.108)	(0.340)	(0.108)	(0.357)
Good service	0.635	0.769	0.645	0.692	0.642	0.759	0.647	0.672
	(0.182)	(0.414)	(0.184)	(0.343)	(0.184)	(0.402)	(0.184)	(0.329)
Other reason	0.502**	0.522	0.508**	0.596	0.516**	0.568	0.511**	0.575
	(0.164)	(0.278)	(0.165)	(0.311)	(0.167)	(0.297)	(0.167)	(0.302)
High exp. returns	0.960	1.557	0.953	1.493	0.969	1.401	0.940	1.479
	(0.294)	(0.672)	(0.291)	(0.625)	(0.296)	(0.592)	(0.286)	(0.622)
Low exp. returns	0.956	0.583	0.946	0.532	0.951	0.534	0.969	0.554
	(0.269)	(0.246)	(0.266)	(0.214)	(0.267)	(0.221)	(0.274)	(0.224)
High exp. risk	1.524	0.584	1.508	0.589	1.522	0.578	1.535	0.640
	(0.461)	(0.248)	(0.458)	(0.243)	(0.462)	(0.247)	(0.467)	(0.265)
Low exp. risk	0.974	1.117	0.983	1.059	0.989	1.148	0.980	1.072
	(0.262)	(0.425)	(0.263)	(0.392)	(0.264)	(0.435)	(0.262)	(0.404)

Continued

Table 3.7: *Continued*

	Sustainable behavior		Reported sustainability		Realized & reported		Reported (cts.)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Robo advisor	Mixed	Green	Mixed	Green	Mixed	Green	Mixed	Green
Risk preferences	0.895	0.736*	0.895	0.765*	0.895	0.748*	0.886	0.746*
	(0.102)	(0.117)	(0.101)	(0.119)	(0.101)	(0.118)	(0.102)	(0.119)
Investment skills	1.506***	0.700	1.515***	0.685*	1.508***	0.695	1.518***	0.688*
	(0.226)	(0.160)	(0.225)	(0.149)	(0.226)	(0.155)	(0.227)	(0.150)
Female	0.489**	2.028*	0.524**	2.243**	0.512**	2.126**	0.512**	2.142**
	(0.142)	(0.769)	(0.153)	(0.825)	(0.150)	(0.797)	(0.149)	(0.804)
Age	0.993	1.023*	0.991	1.019	0.993	1.022*	0.991	1.017
	(0.00875)	(0.0132)	(0.00878)	(0.0128)	(0.00875)	(0.0129)	(0.00875)	(0.0129)
Highly educated	0.978	1.343	0.974	1.397	0.991	1.326	0.959	1.294
	(0.242)	(0.510)	(0.240)	(0.511)	(0.245)	(0.496)	(0.237)	(0.480)
Income up to 1,499 euro	1.154	0.772	1.154	0.916	1.159	0.781	1.163	0.950
	(0.492)	(0.595)	(0.492)	(0.643)	(0.494)	(0.548)	(0.498)	(0.696)
Income 3,500 to 6,000 euro	0.974	1.449	0.959	1.391	0.967	1.411	0.963	1.433
	(0.282)	(0.601)	(0.275)	(0.568)	(0.278)	(0.584)	(0.276)	(0.583)
Income above 6,000 euro	0.606	2.419	0.591	2.237	0.602	2.319	0.593	2.349
	(0.282)	(1.501)	(0.282)	(1.361)	(0.284)	(1.425)	(0.281)	(1.427)
Income not reported	0.609	0.694	0.614	0.773	0.618	0.780	0.610	0.829

Continued

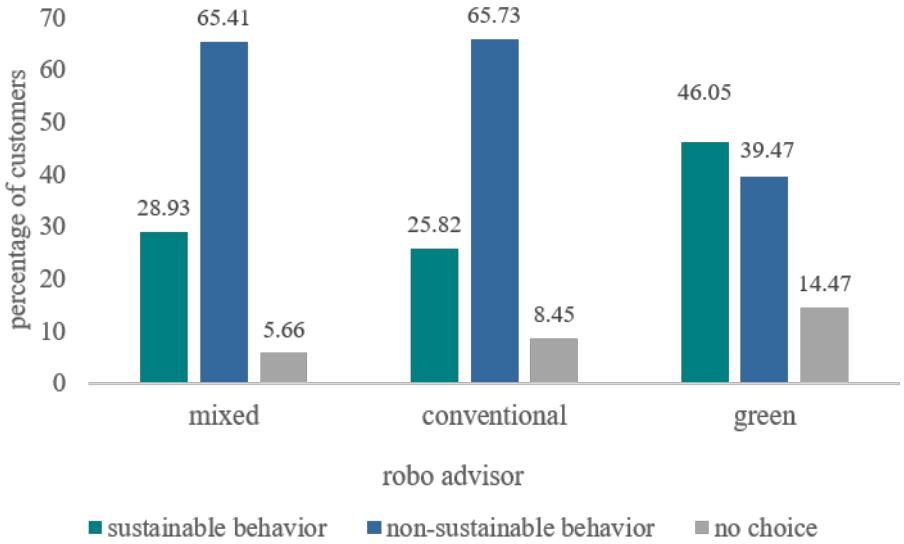
Table 3.7: *Continued*

	Sustainable behavior		Reported sustainability		Realized & reported		Reported (cts.)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Robo advisor	Mixed	Green	Mixed	Green	Mixed	Green	Mixed	Green
	(0.235)	(0.448)	(0.239)	(0.480)	(0.240)	(0.491)	(0.236)	(0.510)
Observations	448		448		448		448	
Pseudo R^2	0.216		0.202		0.212		0.203	

We include additional controls for various motivations of becoming customer of the particular robo advisor to our regular regression specification. In detail, we control for *cost* and *performance* concerns, the preference for an *active* versus *passive* investment strategy, appreciation of *service* quality, *recommendation* by e.g. a friend, family, colleagues, the Internet, or some *other reason*. We expect the preference for an active versus passive investment strategy to play a crucial role for the choice of the respective automated financial advisor. A reminder: Due to the limited choice of socially responsible ETFs, the mixed robo advisor partly and the green robo advisor completely rely on actively managed funds that meet their sustainability requirements. The conventional robo advisor, however, is completely invested in passively managed index funds or ETFs. This is common practice for robo advisors to maintain low service costs.

We find that investors behaving in a sustainable manner are more likely to have a portfolio at the all-out green compared to the conventional robo advisor (columns (2) and (6)), whereas reported sustainability awareness (columns (4) and (8)) is little informative. Also, sustainability awareness positively relates to a larger portfolio share managed by the all-out green robo advisor. Similar to Bauer & Smeets (2015) who survey clients' identification and the reported portfolio share allocated to the only two sustainable banks in the Netherlands, we observe a tendency to more responsible lottery choices the larger the reported portfolio share at the green robo is (see Table 3.20 in the Appendix).

Figure 3.2: Lottery choices by robo advisor



This figure presents the lottery choices (*sustainable*, *non-sustainable behavior* or *no choice*) of all customers. The reported proportions of customers behaving in the respective manner are grouped by the respective robo advisor (*mixed*, *conventional* or *green*).

In contrast, investors of the mixed and the conventional robo advisor are little different regarding their sustainability awareness at first glance. As Figure 3.2 displays, the percentage of participants acting sustainably does not vary much between the two robo advisors. This is due

to the fact that conventional investors still prevail at the mixed robo. Nevertheless, considerably more *sustainable* investors of the mixed robo advisor (compare Figure 3.1) act sustainably than clients of the conventional robo do.

We note that offering sustainable investment strategies is a selling point to sustainability-aware individuals when deciding upon a particular robo advisor. Table 3.8 reports the marginal effects of four probit regressions in which the dependent variable is equal to one if an investor has selected "offering sustainable investment strategies" (*SRI strategy*) as one reason for choosing their robo advisor, and zero otherwise. As before, the various specifications refer to variations of our main variable of interest (columns (1) to (4)). We find that sustainability-aware individuals are more likely to choose their robo advisor based on its sustainable investment offer. An interesting side finding is that the clients of the conventional robo advisor appreciate low cost and favorable performance more than the clients of the remaining two wealth managers (see Table 3.7).

Table 3.8: Do ethically-minded individuals choose their robo advisor based on its sustainable investment offer?

This table presents the marginal effects of four probit regressions. We use all customers of all three robo advisors for our analysis. The dependent variable *SRI strategy* takes the value of one if the investor has chosen the robo advisor for offering sustainable investment strategies, and zero otherwise. The different specifications refer to our respective measure of *Sustainability awareness*. We use the usual investment-related and socio-demographic controls. For definitions of the remaining variables, see Table 3.11 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

SRI strategy	(1) Sustainable behavior	(2) Reported sustainability	(3) Reported & realized	(4) Reported (cts.)
Sustainability awareness	0.108**	0.109***	0.123***	0.113***
	(0.0422)	(0.0389)	(0.0471)	(0.0313)
No choice	0.0269		0.0202	
	(0.0710)		(0.0701)	
High exp. returns	0.103**	0.0898*	0.0923*	0.0871*
	(0.0490)	(0.0487)	(0.0496)	(0.0486)
Low exp. returns	-0.0894*	-0.0831*	-0.0906*	-0.0801
	(0.0490)	(0.0494)	(0.0488)	(0.0492)
High exp. risk	0.00181	0.00434	-0.00123	0.0111
	(0.0513)	(0.0512)	(0.0511)	(0.0514)
Low exp. risk	0.0413	0.0352	0.0431	0.0350
	(0.0461)	(0.0468)	(0.0463)	(0.0462)

Continued

Table 3.8: *Continued*

SRI strategy	(1) Sustainable behavior	(2) Reported sustainability	(3) Reported & realized	(4) Reported (cts.)
Controls	yes	yes	yes	yes
Observations	448	448	448	448
Pseudo R^2	0.196	0.182	0.189	0.191

3.5 Validating our results

3.5.1 Generalizability

We concede that we potentially miss substantial information on our investors' portfolios as we have only analyzed the part that is managed by the robo advisor (25 to 50% on average) so far. To address this concern, we check in how far our robo investment results are valid for investors' total portfolio, and how the results deviate. We therefore test whether ethically-minded individuals are more likely to allocate a (considerable) fraction of their securities portfolio (including investments outside the robo advisor) to sustainable investments. We rely on survey responses for the portfolio allocations, for which previous studies have recognized a good correlation with actual investment decisions (e.g., Van Rooij et al. (2011), Dorn & Huberman (2005)). Table 3.9 reports the marginal effects of four probit regressions in which the dependent variable is equal to one if an investor reports a substantial sustainable portfolio share of at least 25%, and zero otherwise. We include our usual investment-related and socio-demographic control variables. We refer to the survey responses of all investors here, i.e. actual clients and newsletter subscribers who report to have a securities portfolio. The regression results confirm our previous finding that sustainable individuals have a stronger preference for SRI. Also, expectations of high returns or low risk prove to encourage sustainable investments. Female and less experienced investors seem to favor sustainable investments more than the rest does. Moreover, we find a positive relation with education but only for three specifications and on a 10%-significance level.

Table 3.9: Are sustainability-conscious individuals more likely to invest in a sustainable manner?

This table presents the marginal effects of four probit regressions. We use all investors, i.e. actual clients and newsletter subscribers that report to have a securities portfolio. The dependent variable *SRI* is equal to one if an investor has allocated a considerable share of the total securities portfolio (at least 25%) to SRI. The different specifications refer to our respective measure of *Sustainability awareness*. For definitions of the remaining variables, see Table 3.11 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

SRI	(1) Sustainable behavior	(2) Reported sustainability	(3) Reported & realized	(4) Reported (cts.)
Sustainability awareness	0.106***	0.102***	0.101**	0.154***
	(0.0392)	(0.0373)	(0.0438)	(0.0307)
No choice	-0.174**		-0.186**	
	(0.0829)		(0.0825)	
High exp. returns	0.257***	0.240***	0.250***	0.226***
	(0.0448)	(0.0452)	(0.0448)	(0.0449)
Low exp. returns	0.0478	0.0489	0.0462	0.0596
	(0.0483)	(0.0493)	(0.0482)	(0.0486)
High exp. risk	-0.0154	-0.0220	-0.0214	-0.0120
	(0.0494)	(0.0495)	(0.0494)	(0.0491)
Low exp. risk	0.101**	0.0956**	0.0999**	0.0983**
	(0.0427)	(0.0436)	(0.0428)	(0.0429)
Risk preferences	0.0230	0.0222	0.0226	0.0155
	(0.0168)	(0.0169)	(0.0168)	(0.0168)
Investment skills	-0.0475**	-0.0476**	-0.0475**	-0.0476**
	(0.0229)	(0.0233)	(0.0231)	(0.0226)
Female	0.186***	0.200***	0.185***	0.178***
	(0.0429)	(0.0426)	(0.0434)	(0.0417)
Age	-0.00107	-0.00181	-0.00106	-0.00205
	(0.00141)	(0.00141)	(0.00141)	(0.00139)
Highly educated	0.0688*	0.0649*	0.0691*	0.0562
	(0.0384)	(0.0388)	(0.0384)	(0.0379)
Income up to 1,499 euro	0.0645	0.0669	0.0617	0.0826
	(0.0725)	(0.0749)	(0.0724)	(0.0750)

Continued

Table 3.9: *Continued*

SRI	(1) Sustainable behavior	(2) Reported sustainability	(3) Reported & realized	(4) Reported (cts.)
Income 3,500 to 6,000 euro	0.0272	0.0286	0.0237	0.0265
	(0.0456)	(0.0461)	(0.0459)	(0.0448)
Income above 6,000 euro	0.0187	0.0171	0.0176	0.0145
	(0.0755)	(0.0772)	(0.0760)	(0.0761)
Income not reported	0.000363	-0.00847	0.00422	-0.0105
	(0.0671)	(0.0677)	(0.0673)	(0.0671)
Observations	477	477	477	477
Pseudo R^2	0.167	0.155	0.163	0.183

The survey responses furthermore enable us to study how much of their portfolio investors allocate to SRI. Table 3.21 in the Appendix presents the marginal effects of four ordered probit regressions in which the dependent variable indicates the size of an investor's sustainable portfolio share given that the investor reports to hold sustainable investments at all (*between 1 and 24%, 25 and 50%, 51 and 75%, 76 and 99%,* or *100%* of the total securities portfolio). Our results indicate that sustainable individuals do not only have a higher likelihood to engage in SRI, but also allocate a substantially larger share of their portfolio to SRI. Marginal effects show that ethically-minded individuals are 18.1 percentage points more likely to hold more than a minority share of their total portfolio (at least 25%) in SRI. We note that the effect of sustainability awareness is comparable to the magnitude of financial motivations. By way of comparison: Expecting higher financial returns from SRI than from conventional investments increases the likelihood for a large stake in SRI by 22.1 percentage points. More experienced investors avoid portfolio concentration, allocating a smaller portfolio share to SRI. Female investors tend to invest a larger share of their portfolio in a socially responsible manner.

Recapping the previous findings, we are confident about the generalizability of our results to investment decisions that go beyond robo advice. However, we would like to emphasize that the study has been conducted in the midst of the COVID-19 pandemic which might, in one way or another, have affected investors' concern for sustainability.

3.5.2 Reverse causality

We have not undeniably set out the effect-direction of the positive correlation between ethical mindfulness and SRI preferences so far. The findings by Keloharju et al. (2012) give reason to assume that consumer brand choices tend to have an impact on investment decisions but not vice versa. Nevertheless, we address the issue of reverse causality in several ways.

As a first test, we investigate how sustainability awareness and social investment preferences of hereto conventional investors relate to each other. If it was for the responsible investments that encourage general sustainable behavior, then we should not be able to observe a systematic relation between the expressed interest in SRI and the sustainable behavior among hereto conventional investors. To make our point, we look at the investors of the conventional robo advisor again. This time, we restrict our sample to investors who report to have no more than a negligible share of their total securities portfolio (less than 25%) dedicated to SRI. We conduct ordered probit regressions in which the reported interest in SRI is the dependent variable, and the various measures of sustainability awareness function as independent variable. Table 3.22 in the Appendix displays the results of this analysis. Marginal effects are reported. In support of the effect being directed from general ethical mindfulness towards sustainable investment preferences, we find a significant and positive relationship between sustainability awareness and hereto conventional investors' preference for a prospective sustainable investment offer by their robo advisor.

The same is true when we look at these investors' identification with SRI, which has been documented to be a good predictor of sustainable investing (Bauer & Smeets, 2015). Table 3.10 reports the results of several OLS regressions in which the continuous dependent variable is the investor's combined identification score. Odd columns show that conventional investors who engage in sustainable behavior identify significantly stronger with SRI. Our results even remain unchanged when we increase our sample to all (mostly) conventional investors taking part in our survey (regardless of the affiliated robo advisor and client status), as can be retrieved from the even columns. These findings provide us with confidence that we correctly presumed the effect-direction.

As a second attempt to address causality concerns, we investigate whether sustainable investors' extent of ethical mindfulness variegates with the period they have been invested in a sustainable manner. The idea is if SRI encouraged general sustainable behavior among its investors, then the behavior of clients who recently became affiliated with the green robo should distinguish from those with a longer customer history. In line with this notion, we find that the portion of sustainability-aware individuals does not systematically vary with the duration of customer relation (see Figure 3.3 in the Appendix).

Table 3.10: Testing for reverse causality with identification as dependent variable

This table presents the results of six OLS regressions. We use investors who report SRI comprises at most a negligible portion of their entire securities investment portfolio (less than 25%) for our analysis. Odd columns refer to customers of the conventional robo advisor, even columns refer to customers and newsletter subscribers of all three robo advisors who report to have a securities portfolio. The dependent variable *Identification* is the combined score of an investor's extent of agreement with the following statements on a 7-point Likert scale: "I can identify myself well with socially responsible investments", "Socially responsible investments fit well to me", "I feel attached to socially responsible investments", "I feel good about owning socially responsible mutual funds". The different specifications refer to our respective measure of *Sustainability awareness*. Specifications (1) and (2) as well (5) and (6) additionally control for investors who opt not to be considered in the lottery. We use the usual investment-related and socio-demographic controls. We additionally use controls for financial expectations about SRI. For definitions of the remaining variables, see Table 3.11 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

	Sustainable behavior		Reported sustainability		Realized & reported	
	(1)	(2)	(3)	(4)	(5)	(6)
Identification	Conv.	All	Conv.	All	Conv.	All
Sustainability awareness	0.865***	0.689***	1.016***	0.997***	1.145***	1.117***
	(0.261)	(0.188)	(0.241)	(0.161)	(0.310)	(0.215)
No choice	-0.253	-0.583*			-0.291	-0.598*
	(0.496)	(0.323)			(0.480)	(0.320)
Controls	yes	yes	yes	yes	yes	yes
Constant	4.742***	3.831***	4.860***	3.861***	4.664***	3.798***
	(0.715)	(0.535)	(0.709)	(0.529)	(0.717)	(0.522)
Observations	145	286	145	286	145	286
Adjusted R^2	0.140	0.166	0.182	0.214	0.156	0.192

Finally, we elicit sustainability awareness and SRI preferences of financially-literate subjects that have not yet participated in the stock market as their behavior cannot be affected by sustainable investments. We survey 91 undergraduate business students from the University and, matching our previous results, note a stronger reported preference for SRI among students who make a sustainable choice in the lottery.[16]

We are therefore confident that reserve causality is not an issue here.

[16]Please note that lottery prices were lower for this survey. We raffled one voucher, worth 35 euro versus 25 euro.

3.6 Conclusion

SRI is praised as great opportunity for investors to invest their money in accordance with their personal values. We study whether ethically-minded individuals seize this opportunity when faced with an all-or-nothing decision between a conventional and a sustainable portfolio managed by a digital financial advisor. We find evidence that engagement in sustainable behavior elsewhere spills over to investment decisions. Investors who behaved in a sustainable manner were approximately 25% more likely to make use of a sustainable investment offer at their robo advisor – even though sustainability comes at higher costs both times. We note that engagement in another sustainable behavior facilitates the identification with SRI, which is a crucial determinant of adopting this alternative investment strategy. What's more, responsible individuals express a stronger feeling of responsibility for a sustainable development and wish to contribute by financing a sustainable growth. The favorable spillover – rather than crowding out – effect of responsible behavior can help to accelerate the achievement of the UN SDGs.

We use a new setting for our SRI study, surveying customers of three German robo advisors. Digital financial advice has only recently established, and so has the literature dealing with it. We are therefore keen about the particularities of (German) investors engaging in robo advice. In line with U.S. studies, we find that robo advisory services attract younger investors. German investors are different in terms of their motivations for adopting robo advice, however. Rather than hoping for unbiased financial advice, they appreciate the convenience of an automatically-managed portfolio that provides considerable diversification effects to their remaining investments at low costs.

We prove that the correlation between sustainability awareness and preference for sustainable robo advisory services is generalizable to SRI decisions that go beyond robo advice. In terms of marketing sustainable investment products, our results suggest that approaching responsible individuals is an effective means to increase the sustainable retail customer base. Advertisements for an (automatically-managed) sustainable portfolio would be best placed in online stores selling ethical consumer products. Due to commonly high personal switching costs, it is crucial to target potentially interested investors *before* they sign up for a particular financial service provider that eventually does not offer sustainable products. We note a substantial interest in sustainable robo advisory services, and that providing such investment strategies can, next to performance and costs, be a selling point for a digital wealth manager.

Even though we find that investors who engage in ethical behavior have a greater appetite for SRI than their mainstream counterparts, our setting leaves room for further investigation. For instance, one could devote time to the question whether SRI has potential to attract ethically-minded individuals who would otherwise have stayed out of the investment market.

3.7 Appendix

Table 3.11: Variable description

Variable	Measure
	Sustainability awareness, main variable of interest
Sustainable behavior	Dummy variable equal to one if a participant opts to receive a fair fashion voucher in the lottery worth 75 euro, and zero if the participant opts to receive a mainstream fashion voucher worth 100 euro, or not to take part in the lottery.
No choice	Dummy variable equal to one if an individual opts not to take part in the lottery.
Reported sustainability	Dummy variable equal to one if the participant's achieved value on the consumer responsibility scale by Sudbury-Riley & Kohlbacher (2016) is greater or equal to the median sample score, zero otherwise.
Reported & realized	Dummy variable equal to one if a participant opts to receive a fair fashion voucher in the lottery worth 75 euro, concurrently with achieving a value on the consumer responsibility scale by Sudbury-Riley & Kohlbacher (2016) that is greater or equal to the median sample score; zero otherwise.
Reported (cts.)	Continuous variable equal to the value the investor achieves on the consumer responsibility scale by Sudbury-Riley & Kohlbacher (2016). Cronbach's alpha is 0.8833.
	Attitudes regarding sustainable investments *Continuous variables, participants report their agreement with the following statements on a 7-point Likert scale from fully disagree to fully agree*
Impact	"By investing in SRI every investor can have a positive effect on social and environmental issues", retrieved from Brodback et al. (2019).

Continued

Table 3.11: *Continued*

Variable	Measure
Warm glow	Combined score comprising the statements "It makes me feel good to make sustainable investments" and "I feel responsible for a sustainable development and want to contribute by making sustainable investments", retrieved from Gutsche & Ziegler (2019). Cronbach's alpha is 0.8537.
Responsibility	"I feel responsible for a sustainable development and want to contribute by making sustainable investments", retrieved from Gutsche & Ziegler (2019).
Feeling good	"I feel good about owning socially responsible mutual funds" retrieved from Gutsche & Ziegler (2019).
Identification	Combined score comprising the statements "I can identify myself well with socially responsible investments", "I feel good about owning socially responsible mutual funds", "Socially responsible investments fit well to me" and "I feel attached to socially responsible investments", retrieved from Bauer & Smeets (2015). Cronbach's alpha is 0.9370.
Trust	"I trust that providers of sustainable funds and ETFs follow the socially responsible guidelines used in their marketing", retrieved from Wins & Zwergel (2016).
Skepticism	"I consider sustainable investments a marketing trick that is used to sell more", retrieved from Riedl & Smeets (2017).
SRI knowledge	Continuous variable indicating how participants rate their attainments regarding sustainable investments on a 5-point Likert scale from *very weak* to *very good*, with an additional option for those who have never heard of it before.
	Other independent variables *Continuous variables*
Social preferences	Continuous variable indicating participants' agreement with a validated measure by Falk et al. (2016) ("How willing are you to give to good causes without expecting anything in return?") on a 7-point Likert scale from *completely unwilling* to *very willing*.

Continued

Table 3.11: *Continued*

Variable	Measure
Signaling	Participants report their agreement with the statement "I often talk about investments with others", retrieved from Riedl & Smeets (2017), on a 7-point Likert scale from *fully disagree* to *fully agree*.
	Financial controls
	Dummy variables, retrieved from Riedl & Smeets (2017)
High exp. returns	Dummy variable equal to one if an investor expects the financial returns of sustainable investments to be a bit higher or much higher compared to conventional investments.
Low exp. returns	Dummy variable equal to one if an investor expects the financial returns of sustainable investments to be a bit lower or much lower compared to conventional investments.
High exp. risk	Dummy variable equal to one if an investor expects the financial risk of sustainable investments to be a bit higher or much higher compared to conventional investments.
Low exp. risk	Dummy variable equal to one if an investor expects the financial risk of sustainable investments to be a bit lower or much lower compared to conventional investments.
	Investment-related controls
	Continuous variables, retrieved from Bauer et al. (2020)
Investment skills	Continuous variable indicating how participants rate their investment skills on a 5-point Likert scale from *very poor* to *very good*.
Risk preferences	Continuous variable indicating how participants rate their risk tolerance regarding financial investments on a 7-point Likert scale, from *very risk averse* to *very risk tolerant*.
	Socio-demographic controls
Female	Dummy variable indicating whether a participant is female.
Age	continuous variable indicating a participant's age.
Highly educated	Dummy variable equal to one if a participant indicates to have a university degree.

Continued

Table 3.11: *Continued*

Variable	Measure
Income	Dummy variable for the respective monthly net income bracket (up to 1,499 euro, 3,500 to 6,000 euro, above 6,000 euro, not reported), with 1,500 to 3,499 euro as omitted reference group.

Table 3.12: Summary statistics

This table reports the aggregate summary statistics for customers of the three robo advisors.

	count	mean	median	sd
Female	448	0.259		
Age	448	43.904	43.0	14.469
Highly educated	448	0.603		
Income group	403			
up to 1,499 euro		0.099		
1,500 to 3,499 euro		0.511		
3,500 to 6,000 euro		0.290		
above 6,000 euro		0.099		
Risk preferences	448	4.699	5.0	1.358
Investment skills	448	3.266	3.0	1.014
Years of experience	448	3 to 5	5 to 10	
Freq. dealing with investments	448	weekly	weekly	
Investment-related job	448	0.181		
Studied investments	448	0.228		
Robo portfolio share %	438	26% to 50%	less than 25%	
Months of customer relation	448	7 to 12	7 to 12	
Using robo advice for				
autom. pf mgmt.	448	0.739		
better inv. decisions	448	0.324		
low cost & investment	448	0.473		
objective advice	448	0.154		
diversification	448	0.355		
other reason	448	0.085		
Choosing their robo for				
low cost	448	0.449		
performance	448	0.190		
active strategy	448	0.094		
passive strategy	448	0.074		
good service	448	0.208		
recommendation	448	0.484		
other reason	448	0.163		

Table 3.13: Financially-incentivized choices and reported habits

This table displays the proportion of each voucher category participants opted for in the lottery. Panel A reports statistics on the entire participant sample that completely filled in the questionnaire. Panel B splits participants into groups of *high* and *low consumer responsibility* (median split) according to the value they achieved on the consumer responsibility scale by Sudbury-Riley & Kohlbacher (2016). Panel C splits participants into groups of *never or seldom purchasing from companies practicing questionable working conditions (in particular fashion companies)*, and *might purchase from companies practicing questionable working conditions*, according to their answer to question 8 of the Sudbury-Riley & Kohlbacher (2016) survey. Panel D splits participants into groups of *never purchasing from companies practicing questionable working conditions (in particular fashion companies)*, and *might purchase from companies practicing questionable working conditions*, according to their answer to question 8 of the Sudbury-Riley & Kohlbacher (2016) survey.

Behavior	Sustainable	Non-sustainable	No choice
Panel A: Voucher choice	0.307	0.619	0.074
Panel B: Sustainable behavior by reported consumer responsibility			
Low consumer responsibility	0.198	0.729	0.074
High consumer responsibility	0.406	0.519	0.074
Panel C: Sustainable behavior by reported handling of unfair companies			
Might purchase from unfair companies	0.194	0.723	0.084
Never or seldom purchase from unfair companies	0.369	0.563	0.069
Panel D: Sustainable behavior by reported handling of unfair companies			
Might purchase from unfair companies	0.277	0.644	0.079
Never purchase from unfair companies	0.470	0.482	0.048

Table 3.14: Do sustainability-aware individuals select a portfolio managed according to a sustainable investment strategy? Robustness tests

This table presents the marginal effects of several probit regressions. For robustness test 1, we use all customers of the mixed robo advisor for our analysis. Customers choosing both portfolios are included into the regressions. For robustness test 2, we use all customers and newsletter subscribers of the mixed robo advisor for our analysis. In both tests, participants preferring both portfolios are included into the regressions. The dependent variable *Sustainable portfolio* takes the value of one if the participant prefers a sustainable portfolio at the robo advisor, and zero otherwise. For robustness test 3, we use all customers of the mixed robo advisor. We use an alternative definition of the dependent variable. *SRI strategy* takes the value of one if the investor has chosen the robo advisor for offering sustainable investment strategies, and zero otherwise. We exclude customers from the regression that have both portfolios. For all three robustness tests, the different specifications refer to our respective measure of *Sustainability awareness*. For definitions of the remaining variables, see Table 3.11 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

	Robustness test 1 Sustainable portfolio				Robustness test 2 Sustainable portfolio				Robustness test 3 SRI strategy			
	Sust. behavior	Reported sustain.	Reported & realized	Reported (cts.)	Sust. behavior	Reported sustain.	Reported & realized	Reported (cts.)	Sust. behavior	Reported sustain.	Reported & realized	Reported (cts.)
Sustain. awareness	0.220***	0.221***	0.449***	0.171**	0.263***	0.242***	0.478***	0.168***	0.189***	0.169**	0.269***	0.245***
	(0.0683)	(0.0620)	(0.0776)	(0.0710)	(0.0649)	(0.0570)	(0.0765)	(0.0577)	(0.0721)	(0.0657)	(0.0849)	(0.0602)
No choice	-0.160		-0.139		-0.189		-0.180		-0.132		-0.136	
	(0.170)		(0.162)		(0.150)		(0.138)		(0.148)		(0.145)	
High exp. returns	0.225***	0.226***	0.184**	0.239***	0.182**	0.169**	0.134*	0.175**	0.210**	0.190**	0.190**	0.158*
	(0.0855)	(0.0863)	(0.0850)	(0.0875)	(0.0784)	(0.0791)	(0.0769)	(0.0809)	(0.0859)	(0.0887)	(0.0868)	(0.0837)
Low exp. returns	0.145*	0.141	0.146*	0.153*	0.0513	0.0619	0.0561	0.0706	-0.0326	-0.0395	-0.0359	-0.0624
	(0.0852)	(0.0862)	(0.0804)	(0.0873)	(0.0791)	(0.0795)	(0.0735)	(0.0807)	(0.0851)	(0.0894)	(0.0853)	(0.0881)
High exp. risk	-0.233***	-0.217***	-0.326***	-0.207***	-0.240***	-0.215***	-0.317***	-0.208***	0.0353	0.0348	-0.00241	0.0720
	(0.0764)	(0.0742)	(0.0748)	(0.0760)	(0.0740)	(0.0755)	(0.0707)	(0.0772)	(0.0850)	(0.0853)	(0.0846)	(0.0860)
Low exp. risk	-0.00284	-0.0145	-0.0727	-0.000721	0.0281	0.0428	-0.0117	0.0659	-0.0405	-0.0225	-0.0693	-0.0160

Continued

Table 3.14: *Continued*

	Robustness test 1 Sustainable portfolio				Robustness test 2 Sustainable portfolio				Robustness test 3 SRI strategy			
	Sust. behavior	Reported sustain.	Reported & realized	Reported (cts.)	Sust. behavior	Reported sustain.	Reported & realized	Reported (cts.)	Sust. behavior	Reported sustain.	Reported & realized	Reported (cts.)
	(0.0873)	(0.0898)	(0.0841)	(0.0883)	(0.0780)	(0.0785)	(0.0742)	(0.0793)	(0.0894)	(0.0917)	(0.0908)	(0.0867)
Risk preferences	-0.0219	-0.0114	-0.0236	-0.0128	-0.0258	-0.0269	-0.0293	-0.0329	0.00482	0.0120	0.00653	0.00885
	(0.0312)	(0.0302)	(0.0283)	(0.0312)	(0.0289)	(0.0287)	(0.0267)	(0.0299)	(0.0296)	(0.0296)	(0.0285)	(0.0291)
Investment skills	0.00465	-0.00763	0.0243	-0.0118	-0.0135	-0.0192	0.00658	-0.0311	-0.0176	-0.0295	-0.0110	-0.0357
	(0.0419)	(0.0419)	(0.0400)	(0.0422)	(0.0408)	(0.0407)	(0.0389)	(0.0412)	(0.0437)	(0.0449)	(0.0431)	(0.0429)
Female	0.179*	0.213**	0.150*	0.236***	0.192**	0.205**	0.156*	0.221***	0.183*	0.216**	0.170*	0.212**
	(0.0957)	(0.0906)	(0.0897)	(0.0912)	(0.0889)	(0.0844)	(0.0845)	(0.0852)	(0.0983)	(0.0927)	(0.0987)	(0.0853)
Age	-0.00141	-0.00187	-0.000540	-0.00186	0.00382	0.00212	0.00435*	0.00279	-0.00551**	-0.00578**	-0.00476*	-0.00605**
	(0.0029)	(0.00297)	(0.00270)	(0.00299)	(0.00248)	(0.00245)	(0.00230)	(0.00245)	(0.00262)	(0.00261)	(0.00257)	(0.00260)
Highly educated	0.0835	0.103	0.0701	0.0824	0.0962	0.102	0.0849	0.0905	-0.0274	-0.0135	-0.0251	-0.0253
	(0.0697)	(0.0704)	(0.0660)	(0.0710)	(0.0668)	(0.0660)	(0.0632)	(0.0674)	(0.0721)	(0.0733)	(0.0709)	(0.0750)
Income												
up to 1,499 euro	0.0678	0.102	0.0756	0.0768	0.0253	0.0687	0.0396	0.0487	0.100	0.115	0.112	0.104
	(0.133)	(0.141)	(0.127)	(0.141)	(0.127)	(0.128)	(0.128)	(0.127)	(0.126)	(0.133)	(0.128)	(0.124)
3,500 to 6,000 euro	0.130	0.0989	0.0820	0.114	0.111	0.112	0.0709	0.125	0.0574	0.0318	0.0276	0.00645
	(0.0877)	(0.0926)	(0.0834)	(0.0932)	(0.0794)	(0.0823)	(0.0747)	(0.0838)	(0.0911)	(0.0951)	(0.0903)	(0.0915)
above 6,000 euro	0.0592	0.00377	-0.0141	0.00628	0.0617	0.107	0.0547	0.0917	-0.149	-0.165	-0.168	-0.195**

Continued

Table 3.14: *Continued*

	Robustness test 1 Sustainable portfolio				Robustness test 2 Sustainable portfolio				Robustness test 3 SRI strategy			
	Sust. behavior	Reported sustain.	Reported & realized	Reported (cts.)	Sust. behavior	Reported sustain.	Reported & realized	Reported (cts.)	Sust. behavior	Reported sustain.	Reported & realized	Reported (cts.)
	(0.153)	(0.136)	(0.151)	(0.146)	(0.133)	(0.127)	(0.136)	(0.128)	(0.116)	(0.105)	(0.110)	(0.0951)
not reported	0.195	0.125	0.203*	0.159	0.0685	0.0232	0.0951	0.0398	0.119	0.0488	0.132	0.0390
	(0.133)	(0.138)	(0.119)	(0.140)	(0.113)	(0.111)	(0.100)	(0.112)	(0.147)	(0.131)	(0.137)	(0.132)
Observations	159	159	159	159	194	194	194	194	144	144	144	144
Pseudo R^2	0.202	0.199	0.276	0.182	0.185	0.176	0.252	0.159	0.186	0.174	0.197	0.211

Table 3.15: Do sustainability-aware individuals select a portfolio managed according to a sustainable investment strategy? Additional controls

This table presents the marginal effects of four probit regressions. We use all customers and newsletter subscribers of the mixed robo advisor for our analysis. Customers or newsletter subscribers preferring both portfolios are included into the regressions. The dependent variable *Sustainable portfolio* takes the value of one if the participant prefers a sustainable portfolio, and zero otherwise. The different specifications refer to our respective measure of *Sustainability awareness*. We include additional controls: *Low cost* is a dummy variable equal to one if a participant prefers the robo advisor for its low cost, zero otherwise; *Performance* is a dummy variable equal to one if a participant prefers the robo advisor due to the favorable risk-return-profile of its strategies, zero otherwise; *Active strategy* is a dummy variable equal to one if a participant prefers the robo advisor for offering active investment strategies, zero otherwise; *Passive strategy* is a dummy variable equal to one if a participant prefers the robo advisor for offering passive investment strategies, zero otherwise. For definitions of the remaining variables, see Table 3.11 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

Sustainable portfolio	(1) Sustainable behavior	(2) Reported sustainability	(3) Reported & realized	(4) Reported (cts.)
Sustainability awareness	0.254***	0.240***	0.501***	0.164***
	(0.0639)	(0.0560)	(0.0791)	(0.0567)
No choice	-0.201		-0.205	
	(0.147)		(0.136)	
Low cost	-0.0519	-0.0684	-0.0874	-0.0652
	(0.0655)	(0.0640)	(0.0625)	(0.0658)
Performance	-0.134	-0.110	-0.0997	-0.101
	(0.0900)	(0.0880)	(0.0866)	(0.0907)
Active strategy	-0.0797	-0.146	-0.106	-0.144
	(0.103)	(0.103)	(0.0971)	(0.104)
Passive strategy	-0.0265	0.0205	-0.186	0.0393
	(0.165)	(0.163)	(0.180)	(0.171)
High exp. returns	0.156*	0.145*	0.0990	0.153*
	(0.0806)	(0.0802)	(0.0791)	(0.0826)
Low exp. returns	0.0340	0.0557	0.0428	0.0640
	(0.0801)	(0.0790)	(0.0754)	(0.0805)
High exp. risk	-0.232***	-0.205***	-0.308***	-0.198***
	(0.0739)	(0.0758)	(0.0717)	(0.0761)
Low exp. risk	0.0168	0.0344	-0.0256	0.0568
	(0.0765)	(0.0776)	(0.0724)	(0.0785)
Risk preferences	-0.0160	-0.0148	-0.0199	-0.0208

Continued

Table 3.15: *Continued*

Sustainable portfolio	(1) Sustainable behavior	(2) Reported sustainability	(3) Reported & realized	(4) Reported (cts.)
	(0.0300)	(0.0299)	(0.0270)	(0.0311)
Investment skills	-0.0173	-0.0257	0.00659	-0.0371
	(0.0409)	(0.0410)	(0.0388)	(0.0415)
Female	0.168*	0.182**	0.119	0.200**
	(0.0928)	(0.0874)	(0.0900)	(0.0881)
Age	0.00360	0.00222	0.00408*	0.00289
	(0.00242)	(0.00240)	(0.00221)	(0.00241)
Highly educated	0.102	0.116*	0.0968	0.103
	(0.0649)	(0.0655)	(0.0619)	(0.0663)
Income up to 1,499 euro	0.0245	0.0777	0.0585	0.0575
	(0.128)	(0.127)	(0.129)	(0.128)
Income 3,500 to 6,000 euro	0.121	0.113	0.0889	0.126
	(0.0796)	(0.0821)	(0.0765)	(0.0838)
Income above 6,000 euro	0.0402	0.0694	0.0656	0.0526
	(0.133)	(0.129)	(0.126)	(0.129)
Income not reported	0.0678	0.0426	0.104	0.0586
	(0.116)	(0.108)	(0.100)	(0.111)
Observations	194	194	194	194
Pseudo R^2	0.200	0.195	0.275	0.176

Table 3.16: When do people consistently behave in a sustainable manner?

This table presents the effects of several probit regressions. We use all customers of the mixed robo advisor for our analysis. The dependent variable *Sustainable portfolio* takes the value of one if the investor has a sustainable portfolio at the mixed robo advisor and zero if the investor has a conventional portfolio. We exclude customers from the regression that have both portfolios. In the various specifications, we include one *Attitude* as independent variable and one interaction term between *Sustainable behavior* and *Attitude*, each. In all specifications, the independent variable *Sustainable behavior* is a dummy variable equal to one if an investor opts to receive a fair fashion voucher in the lottery, and zero otherwise. We additionally control for investors who opt not to be considered in the lottery. We use the usual investment-related and socio-demographic controls. We additionally use controls for financial expectations about SRI. For definitions of the remaining variables, see Table 3.11 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

Sustainable portfolio	(1) Trust	(2) Identi-fication	(3) Warm glow	(4) Impact	(5) Social preferences	(6) Signaling	(7) Responsi-bility	(8) Feeling good	(9) Skepticism	(10) SRI knowledge
Sustainable behavior	1.067	-3.443*	-2.988*	1.008	-0.170	1.383**	-3.883**	-0.600	0.526	-0.164
	(1.234)	(1.972)	(1.773)	(1.280)	(1.172)	(0.698)	(1.815)	(1.348)	(0.598)	(0.836)
No choice	-0.165	0.0285	0.150	-0.302	-0.155	-0.167	0.219	-0.0302	-0.218	-0.193
	(0.615)	(0.575)	(0.600)	(0.816)	(0.579)	(0.559)	(0.648)	(0.571)	(0.610)	(0.634)
Signaling	-0.103	-0.186*	-0.142	-0.183*	-0.139	-0.102	-0.139	-0.124	-0.167	-0.128
	(0.0906)	(0.108)	(0.112)	(0.0995)	(0.0934)	(0.0993)	(0.122)	(0.0970)	(0.102)	(0.0936)
Attitude	0.338***	0.684***	0.685***	0.627***	0.0343		0.656***	0.558***	-0.391***	0.351*
	(0.129)	(0.160)	(0.157)	(0.165)	(0.111)		(0.147)	(0.151)	(0.119)	(0.181)
Sustainable behavior	-0.0168	0.797**	0.685**	-0.0286	0.223	-0.101	0.830***	0.279	0.197	0.417
× attitude	(0.248)	(0.362)	(0.311)	(0.227)	(0.222)	(0.153)	(0.318)	(0.234)	(0.190)	(0.265)
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Constant	-0.141	-1.353	-2.581**	-2.525*	-2.319*	-0.0205	-2.556*	-2.029	1.100	0.287

Continued

Table 3.16: *Continued*

Sustainable portfolio	(1) Trust	(2) Identi-fication	(3) Warm glow	(4) Impact	(5) Social preferences	(6) Signaling	(7) Responsi-bility	(8) Feeling good	(9) Skepticism	(10) SRI knowledge
	(0.892)	(1.204)	(1.152)	(1.301)	(1.185)	(0.996)	(1.394)	(1.262)	(0.987)	(0.934)
Observations	144	144	144	144	144	144	144	144	144	144
Pseudo R^2	0.326	0.522	0.535	0.431	0.290	0.278	0.542	0.461	0.344	0.338

Table 3.17: What encourages interest in a prospective SRI offer?

Note: This table presents the marginal effects of several ordered probit regressions. We use all customers of the conventional robo advisor for our analysis. The dependent variable *Interest* indicates how participants rate the likelihood that they will make use of a prospective sustainable financial product offer by the so-far conventional robo advisor on a 7-point Likert scale from *very unlikely* to *very likely*. In the various specifications, we include one non-pecuniary motive for responsible investing, each. In all specifications, the independent variable *Sustainable behavior* is a dummy variable equal to one if an investor opts to receive a fair fashion voucher in the lottery, and zero otherwise. We additionally control for investors who opt not to be considered in the lottery. We use the usual investment-related and socio-demographic controls. We additionally use controls for financial expectations about SRI. For definitions of the remaining variables, see Table 3.11 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

Interest	very unlikely	2	3	4	5	6	very likely
Panel A: Results based on trust as independent variable							
Sustainable behavior	-0.0455**	-0.0261**	-0.0385**	-0.0341**	0.00137	0.0385**	0.104***
	(0.0180)	(0.0124)	(0.0158)	(0.0136)	(0.00526)	(0.0157)	(0.0377)
No choice	-0.0218	-0.0125	-0.0185	-0.0164	0.000658	0.0185	0.0500
	(0.0288)	(0.0170)	(0.0246)	(0.0221)	(0.00260)	(0.0250)	(0.0659)
Signaling	-0.0107*	-0.00613	-0.00903*	-0.00801*	0.000322	0.00904*	0.0245*
	(0.00645)	(0.00394)	(0.00538)	(0.00486)	(0.00124)	(0.00542)	(0.0141)
Trust	-0.0269***	-0.0154***	-0.0228***	-0.0202***	0.000811	0.0228***	0.0617***
	(0.00782)	(0.00500)	(0.00588)	(0.00541)	(0.00304)	(0.00591)	(0.0135)
Controls	yes	yes	yes	yes	yes	yes	yes
Pseudo R^2	0.128						
Panel B: Results based on identification as independent variable							
Sustainable behavior	-0.00310	-0.00162	-0.00296	-0.00295	-0.000226	0.00240	0.00845

Continued

Table 3.17: *Continued*

Interest	very unlikely	2	3	4	5	6	very likely
	(0.0127)	(0.00672)	(0.0123)	(0.0122)	(0.000965)	(0.00990)	(0.0349)
No choice	-0.00359	-0.00187	-0.00342	-0.00341	-0.000262	0.00278	0.00977
	(0.0197)	(0.0103)	(0.0187)	(0.0188)	(0.00148)	(0.0153)	(0.0536)
Signaling	-0.00619	-0.00322	-0.00591	-0.00589	-0.000452	0.00480	0.0169
	(0.00484)	(0.00255)	(0.00451)	(0.00442)	(0.000767)	(0.00383)	(0.0125)
Identification	-0.0475***	-0.0247***	-0.0454***	-0.0451***	-0.00347	0.0368***	0.129***
	(0.00810)	(0.00665)	(0.00791)	(0.00714)	(0.00561)	(0.00655)	(0.0148)
Controls	yes	yes	yes	yes	yes	yes	yes
Pseudo R^2	0.248						
Panel C: Results based on warm glow as independent variable							
Sustainable behavior	-0.00375	-0.00187	-0.00314	-0.00333	-0.000541	0.00281	0.00982
	(0.0133)	(0.00669)	(0.0112)	(0.0119)	(0.00192)	(0.0100)	(0.0348)
No choice	0.00339	0.00169	0.00284	0.00301	0.000489	-0.00254	-0.00887
	(0.0213)	(0.0106)	(0.0179)	(0.0189)	(0.00312)	(0.0160)	(0.0559)
Signaling	-0.00692	-0.00345	-0.00579	-0.00613	-0.000998	0.00519	0.0181
	(0.00546)	(0.00272)	(0.00442)	(0.00465)	(0.00108)	(0.00416)	(0.0135)
Warm glow	-0.0446***	-0.0222***	-0.0374***	-0.0396***	-0.00644	0.0335***	0.117***
	(0.00778)	(0.00622)	(0.00667)	(0.00620)	(0.00561)	(0.00616)	(0.0141)

Continued

Table 3.17: *Continued*

Interest	very unlikely	2	3	4	5	6	very likely
Controls	yes	yes	yes	yes	yes	yes	yes
Pseudo R^2	0.237						
Panel D: Results based on impact as independent variable							
Sustainable behavior	-0.0352**	-0.0214**	-0.0344**	-0.0297**	0.00101	0.0310**	0.0887**
	(0.0150)	(0.0106)	(0.0157)	(0.0130)	(0.00436)	(0.0139)	(0.0353)
No choice	-0.0124	-0.00754	-0.0121	-0.0105	0.000355	0.0109	0.0313
	(0.0259)	(0.0161)	(0.0256)	(0.0224)	(0.00165)	(0.0233)	(0.0658)
Signaling	-0.00870	-0.00529	-0.00851	-0.00734	0.000249	0.00766	0.0219
	(0.00578)	(0.00351)	(0.00534)	(0.00472)	(0.00107)	(0.00501)	(0.0135)
Impact	-0.0289***	-0.0176***	-0.0283***	-0.0244***	0.000828	0.0255***	0.0729***
	(0.00648)	(0.00547)	(0.00595)	(0.00522)	(0.00349)	(0.00496)	(0.0118)
Controls	yes	yes	yes	yes	yes	yes	yes
Pseudo R^2	0.153						
Panel E: Results based on social preferences as independent variable							
Sustainable behavior	-0.0455**	-0.0265**	-0.0415**	-0.0357**	0.00277	0.0402**	0.106***
	(0.0193)	(0.0122)	(0.0178)	(0.0149)	(0.00560)	(0.0169)	(0.0399)
No choice	0.00964	0.00561	0.00878	0.00755	-0.000585	-0.00850	-0.0225
	(0.0299)	(0.0173)	(0.0271)	(0.0231)	(0.00213)	(0.0260)	(0.0693)

Continued

Table 3.17: *Continued*

Interest	very unlikely	2	3	4	5	6	very likely
Signaling	-0.0125*	-0.00727*	-0.0114**	-0.00979**	0.000759	0.0110**	0.0292**
	(0.00673)	(0.00408)	(0.00558)	(0.00477)	(0.00158)	(0.00554)	(0.0137)
Social preferences	-0.0147***	-0.00853**	-0.0134***	-0.0115**	0.000890	0.0129***	0.0342***
	(0.00561)	(0.00382)	(0.00504)	(0.00452)	(0.00171)	(0.00484)	(0.0122)
Controls	yes	yes	yes	yes	yes	yes	yes
Pseudo R^2	0.103						
Panel F: Results based on signaling as independent variable							
Sustainable behavior	-0.0585***	-0.0342**	-0.0530***	-0.0449***	0.00365	0.0508***	0.136***
	(0.0201)	(0.0134)	(0.0181)	(0.0148)	(0.00710)	(0.0170)	(0.0379)
No choice	0.0117	0.00683	0.0106	0.00897	-0.000729	-0.0101	-0.0272
	(0.0314)	(0.0182)	(0.0282)	(0.0238)	(0.00241)	(0.0269)	(0.0725)
Signaling	-0.0147**	-0.00860**	-0.0133**	-0.0113**	0.000918	0.0128**	0.0342**
	(0.00699)	(0.00438)	(0.00574)	(0.00489)	(0.00181)	(0.00563)	(0.0141)
Controls	yes	yes	yes	yes	yes	yes	yes
Pseudo R^2	0.099						
Panel G: Results based on responsibility as independent variable							
Sustainable behavior	-0.00312	-0.00147	-0.00231	-0.00237	-0.000395	0.00203	0.00763
	(0.0135)	(0.00643)	(0.0101)	(0.0103)	(0.00173)	(0.00884)	(0.0332)

Continued

Table 3.17: *Continued*

Interest	very unlikely	2	3	4	5	6	very likely
No choice	-0.00712	-0.00335	-0.00527	-0.00541	-0.000902	0.00465	0.0174
	(0.0226)	(0.0107)	(0.0166)	(0.0171)	(0.00301)	(0.0147)	(0.0551)
Signaling	-0.00783	-0.00368	-0.00579	-0.00594	-0.000991	0.00510	0.0191
	(0.00556)	(0.00265)	(0.00402)	(0.00408)	(0.00105)	(0.00374)	(0.0129)
Responsibility	-0.0473***	-0.0222***	-0.0350***	-0.0359***	-0.00599	0.0308***	0.116***
	(0.00799)	(0.00636)	(0.00643)	(0.00560)	(0.00468)	(0.00594)	(0.0125)
Controls	yes	yes	yes	yes	yes	yes	yes
Pseudo R^2	0.249						
Panel H: Results based on feeling good about SRI as independent variable							
Sustainable behavior	-0.0188	-0.0108	-0.0179	-0.0163	-0.00125	0.0155	0.0494
	(0.0144)	(0.00855)	(0.0140)	(0.0127)	(0.00239)	(0.0122)	(0.0371)
No choice	0.0125	0.00714	0.0119	0.0108	0.000828	-0.0103	-0.0328
	(0.0228)	(0.0130)	(0.0218)	(0.0195)	(0.00226)	(0.0186)	(0.0599)
Signaling	-0.00826	-0.00473	-0.00787	-0.00715	-0.000548	0.00683	0.0217
	(0.00577)	(0.00329)	(0.00515)	(0.00476)	(0.00104)	(0.00470)	(0.0140)
Feeling good	-0.0313***	-0.0179***	-0.0298***	-0.0271***	-0.00207	0.0258***	0.0822***
	(0.00663)	(0.00531)	(0.00574)	(0.00483)	(0.00395)	(0.00489)	(0.0121)
Controls	yes	yes	yes	yes	yes	yes	yes

Continued

Table 3.17: *Continued*

Interest	very unlikely	2	3	4	5	6	very likely
Pseudo R^2	0.180						
Panel I: Results based on skepticism as independent variable							
Sustainable behavior	-0.0597***	-0.0342**	-0.0526***	-0.0453***	0.00254	0.0516***	0.138***
	(0.0201)	(0.0136)	(0.0178)	(0.0148)	(0.00712)	(0.0170)	(0.0381)
No choice	-0.000910	-0.000521	-0.000801	-0.000690	0.0000386	0.000785	0.00210
	(0.0305)	(0.0175)	(0.0269)	(0.0232)	(0.00129)	(0.0264)	(0.0704)
Signaling	-0.0152**	-0.00869**	-0.0134**	-0.0115**	0.000645	0.0131**	0.0350**
	(0.00689)	(0.00428)	(0.00550)	(0.00485)	(0.00182)	(0.00557)	(0.0137)
Skepticism	0.0144**	0.00825**	0.0127***	0.0109**	-0.000611	-0.0124***	-0.0332***
	(0.00573)	(0.00337)	(0.00486)	(0.00429)	(0.00165)	(0.00440)	(0.0120)
Controls	yes	yes	yes	yes	yes	yes	yes
Pseudo R^2	0.101						
Panel J: Results based on SRI knowledge as independent variable							
Sustainable behavior	-0.0575***	-0.0340**	-0.0521***	-0.0444***	0.00319	0.0506***	0.134***
	(0.0194)	(0.0133)	(0.0179)	(0.0148)	(0.00697)	(0.0169)	(0.0375)
No choice	0.00417	0.00247	0.00378	0.00322	-0.000232	-0.00367	-0.00974
	(0.0309)	(0.0182)	(0.0279)	(0.0237)	(0.00180)	(0.0270)	(0.0719)
Signaling	-0.0131**	-0.00778*	-0.0119**	-0.0102**	0.000730	0.0116**	0.0307**

Continued

Table 3.17: *Continued*

Interest	very unlikely	2	3	4	5	6	very likely
	(0.00662)	(0.00418)	(0.00553)	(0.00476)	(0.00162)	(0.00549)	(0.0137)
SRI knowledge	-0.0173**	-0.0102**	-0.0156**	-0.0133**	0.000959	0.0152**	0.0403**
	(0.00825)	(0.00506)	(0.00676)	(0.00620)	(0.00204)	(0.00664)	(0.0175)
Controls	yes	yes	yes	yes	yes	yes	yes
Pseudo R^2	0.099						
Observations	213						

Table 3.18: Willingness to sacrifice returns separately for each return scenario

This table presents the results of four OLS regressions. We use all customers of the conventional robo advisor for our analysis. The dependent variable *Return sacrifice* indicates how many percentage points of the annual net return for a conventional robo advisor portfolio an investor is willing to forego in order to invest in a sustainable portfolio with similar risk instead. The different specifications report the return sacrifice separately for each of the four return scenarios for the conventional portfolio (2.5%, 5%, 7.5%, 10%). The different panels refer to our respective measure of *Sustainability awareness*. Panel A and C additionally control for investors who opt not to be considered in the lottery. In all panels, we use the usual investment-related and socio-demographic controls. For definitions of the remaining variables, see Table 3.11 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

	Return scenario for the conventional portfolio			
	(1)	(2)	(3)	(4)
Return sacrifice	2.5%	5%	7.5%	10%
Panel A: Results based on sustainable behavior as independent variable				
Sustainable behavior	0.0980	0.243*	0.298	0.491*
	(0.0643)	(0.127)	(0.197)	(0.278)
No choice	0.173*	0.360*	0.218	0.329
	(0.101)	(0.194)	(0.298)	(0.448)
Controls	yes	yes	yes	yes
Adjusted R^2	-0.008	-0.003	-0.010	0.014
Panel B: Results based on the reported sustainability as independent variable				
Reported sustainability	0.0162	0.110	0.129	0.302
	(0.0469)	(0.0920)	(0.147)	(0.213)
Controls	yes	yes	yes	yes
Adjusted R^2	-0.034	-0.031	-0.017	0.009
Panel C: Results based on the reported & realized sustainability as independent variable				
Reported & realized sustainability	0.0909	0.205	0.294	0.509*
	(0.0650)	(0.126)	(0.192)	(0.283)
No choice	0.163	0.331*	0.190	0.287
	(0.0997)	(0.191)	(0.293)	(0.439)
Controls	yes	yes	yes	yes
Adjusted R^2	-0.014	-0.015	-0.014	0.010
Panel D: Results based on the reported sustainability (cts.) as independent variable				

Continued

Table 3.18: *Continued*

	Return scenario for the conventional portfolio			
	(1)	(2)	(3)	(4)
Return sacrifice	2.5%	5%	7.5%	10%
Reported sustainability (cts.)	0.0584*	0.190***	0.219**	0.416***
	(0.0344)	(0.0590)	(0.109)	(0.149)
Controls	yes	yes	yes	yes
Adjusted R^2	-0.020	0.000	-0.001	0.031
Observations	213	213	213	213

Table 3.19: Financial return expectations of sustainability-aware investors

Note: This table presents the marginal effects of four ordered probit regressions. We use all customers of the conventional robo advisor for our analysis. The dependent variable *Expected return* indicates the return the investor expects from sustainable as compared to conventional investments (*much lower, a bit lower, equal, a bit higher*, or *much higher*). We exclude those customers that report to have no particular expectation about the performance of sustainable investments. The different panels refer to our respective measure of *Sustainability awareness*. Panel A and C additionally control for investors who opt not to be considered in the lottery. In all panels, we use the usual investment-related and socio-demographic controls. For definitions of the remaining variables, see Table 3.11 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

Expected return	much lower	a bit lower	equal	a bit higher	much higher
Panel A: Results based on sustainable behavior as independent variable					
Sustainable behavior	-0.0253	-0.0752*	0.0137	0.0591*	0.0276
	(0.0167)	(0.0452)	(0.0101)	(0.0359)	(0.0173)
No choice	-0.0220	-0.0654	0.0119	0.0514	0.0240
	(0.0279)	(0.0837)	(0.0156)	(0.0661)	(0.0305)
Controls	yes	yes	yes	yes	yes
Pseudo R^2	0.039				
Panel B: Results based on the reported sustainability as independent variable					
Reported sustainability	-0.0392**	-0.127***	0.0105	0.0693***	0.0267**
	(0.0159)	(0.0430)	(0.00849)	(0.0247)	(0.0118)
Controls	yes	yes	yes	yes	yes
Pseudo R^2	0.059				
Panel C: Results based on the reported & realized sustainability as independent variable					

Continued

Table 3.19: *Continued*

Expected return	much lower	a bit lower	equal	a bit higher	much higher
Reported & realized sustainability	-0.0440**	-0.130***	0.0239*	0.103***	0.0474**
	(0.0205)	(0.0460)	(0.0130)	(0.0379)	(0.0192)
No choice	-0.0231	-0.0682	0.0125	0.0538	0.0249
Controls	yes	yes	yes	yes	yes
	(0.0282)	(0.0838)	(0.0157)	(0.0664)	(0.0305)
Pseudo R^2	0.044				
Panel D: Results based on the reported sustainability (cts.) as independent variable					
Reported sustainability (cts.)	-0.0268**	-0.0893***	0.00728	0.0482**	0.0187**
	(0.0124)	(0.0331)	(0.00614)	(0.0192)	(0.00895)
Controls	yes	yes	yes	yes	yes
Pseudo R^2	0.062				
Observations	197				

Table 3.20: Sustainability awareness and portfolio share managed by the green robo advisor

This table reports the portion of green robo customers behaving in a sustainable manner in the lottery, relative to the share of their securities portfolio that is managed by the green robo advisor.

Portfolio portion	less than 25%	25 to 50%	51 to 75%	76 to 99%	100%	no answer
Investor portion	0.406	0.563	0.400	0.600	0.625	0.200
Mean			0.461			
Observations			76			

Table 3.21: Do sustainability-conscious individuals allocate a larger share of their portfolio to SRI?

This table presents the marginal effects of four ordered probit regressions. We use all investors that report to have SRI in their portfolio. The dependent variable *SRI share* indicates the size of the sustainable portfolio share relative to an investor's total securities portfolio. The different panels refer to the respective criteria according to which we consider an individual to be sustainability-conscious. In panel B to D, we use the usual investment-related and socio-demographic controls. We additionally use controls for financial expectations about SRI. For definitions of the remaining variables, see Table 3.11 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

SRI share	1 to 24%	25 to 50%	51 to 75%	76 to 99%	100%
Panel A: Results based on sustainable behavior as independent variable					
Sustainable behavior	-0.181***	0.0494***	0.0396***	0.0441***	0.0475***
	(0.0431)	(0.0123)	(0.0116)	(0.0130)	(0.0152)
No choice	0.103	-0.0282	-0.0226	-0.0252	-0.0272
	(0.110)	(0.0308)	(0.0247)	(0.0260)	(0.0299)
High exp. returns	-0.221***	0.0603***	0.0484***	0.0538***	0.0581***
	(0.0526)	(0.0162)	(0.0145)	(0.0172)	(0.0157)
Low exp. returns	-0.102*	0.0280*	0.0224	0.0249	0.0269
	(0.0610)	(0.0166)	(0.0141)	(0.0157)	(0.0167)
High exp. risk	0.0312	-0.00854	-0.00685	-0.00762	-0.00822
	(0.0566)	(0.0153)	(0.0126)	(0.0140)	(0.0150)
Low exp. risk	-0.0446	0.0122	0.00978	0.0109	0.0117
	(0.0490)	(0.0136)	(0.0107)	(0.0119)	(0.0133)
Risk preferences	-0.0286	0.00783	0.00628	0.00698	0.00754
	(0.0214)	(0.00598)	(0.00477)	(0.00522)	(0.00591)
Investment skills	0.122***	-0.0333***	-0.0267***	-0.0297***	-0.0321***
	(0.0284)	(0.00825)	(0.00749)	(0.00855)	(0.0102)
Female	-0.131***	0.0359***	0.0288**	0.0321**	0.0346**
	(0.0479)	(0.0138)	(0.0113)	(0.0135)	(0.0139)
Age	0.00158	-0.000433	-0.000347	-0.000386	-0.000417
	(0.00162)	(0.000446)	(0.000358)	(0.000412)	(0.000427)
Highly educated	-0.0684	0.0187	0.0150	0.0167	0.0180
	(0.0449)	(0.0125)	(0.0103)	(0.0114)	(0.0120)
Income up to 1,499 euro	-0.0861	0.0198	0.0184	0.0220	0.0259
	(0.0878)	(0.0177)	(0.0189)	(0.0228)	(0.0298)
Income 3,500 to 6,000 euro	0.0141	-0.00400	-0.00315	-0.00344	-0.00354
	(0.0489)	(0.0139)	(0.0109)	(0.0119)	(0.0123)

Continued

Table 3.21: *Continued*

SRI share	1 to 24%	25 to 50%	51 to 75%	76 to 99%	100%
Income above 6,000 euro	0.0519	-0.0157	-0.0117	-0.0123	-0.0121
	(0.0806)	(0.0260)	(0.0183)	(0.0189)	(0.0178)
Income not reported	-0.0286	0.00747	0.00629	0.00713	0.00775
	(0.0850)	(0.0212)	(0.0186)	(0.0214)	(0.0238)
Pseudo R^2	0.107				
Panel B: Results based on the reported sustainability as independent variable					
Reported sustainability	-0.124***	0.0339**	0.0273**	0.0300**	0.0324**
	(0.0475)	(0.0133)	(0.0115)	(0.0128)	(0.0140)
Controls	yes	yes	yes	yes	yes
Pseudo R^2	0.092				
Panel C: Results based on the reported & realized sustainability as independent variable					
Reported & realized	-0.182***	0.0502***	0.0401***	0.0443***	0.0476***
	(0.0500)	(0.0145)	(0.0128)	(0.0144)	(0.0163)
No choice	0.122	-0.0336	-0.0268	-0.0296	-0.0319
	(0.110)	(0.0312)	(0.0250)	(0.0258)	(0.0300)
Controls	yes	yes	yes	yes	yes
Pseudo R^2	0.104				
Panel D: Results based on the reported sustainability (cts.) as independent variable					
Reported (cts.)	-0.192***	0.0516***	0.0429***	0.0474***	0.0499***
	(0.0369)	(0.0113)	(0.0107)	(0.0124)	(0.0141)
Controls	yes	yes	yes	yes	yes
Pseudo R^2	0.115				
Observations	353				

Table 3.22: Testing for reverse causality

This table presents the marginal effects of four ordered probit regressions. We use all customers of the conventional robo advisor for our analysis that have a securities portfolio and report that SRI comprises at most a negligible portion of their entire securities investment portfolio (less than 25%). The dependent variable *Interest* indicates how participants rate the likelihood that they will make use of a prospective sustainable financial product offer by the so-far conventional robo advisor on a 7-point Likert scale from *very unlikely* to *very likely*. The different panels refer to the respective criteria according to which we consider an individual to be sustainability-conscious. We use the usual investment-related and socio-demographic controls. We additionally use controls for financial expectations about SRI. For definitions of the remaining variables, see Table 3.11 in the Appendix. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

Interest	very unlikely	2	3	4	5	6	very likely
Panel A: Results based on sustainable behavior as independent variable							
Sustainable behavior	-0.0598**	-0.0326*	-0.0408**	-0.0254*	0.0152	0.0496**	0.0939**
	(0.0297)	(0.0172)	(0.0202)	(0.0132)	(0.00978)	(0.0242)	(0.0425)
No choice	0.0329	0.0179	0.0224	0.0139	-0.00833	-0.0273	-0.0516
	(0.0472)	(0.0254)	(0.0317)	(0.0196)	(0.0124)	(0.0376)	(0.0732)
Controls	yes	yes	yes	yes	yes	yes	yes
Pseudo R^2	0.060						
Panel B: Results based on the reported sustainability as independent variable							
Reported sustainability	-0.0701**	-0.0402**	-0.0506***	-0.0306**	0.0192*	0.0585***	0.114***
	(0.0291)	(0.0182)	(0.0189)	(0.0121)	(0.0114)	(0.0225)	(0.0378)
Controls	yes	yes	yes	yes	yes	yes	yes
Pseudo R^2	0.0649						
Panel C: Results based on the reported & realized sustainability as independent variable							

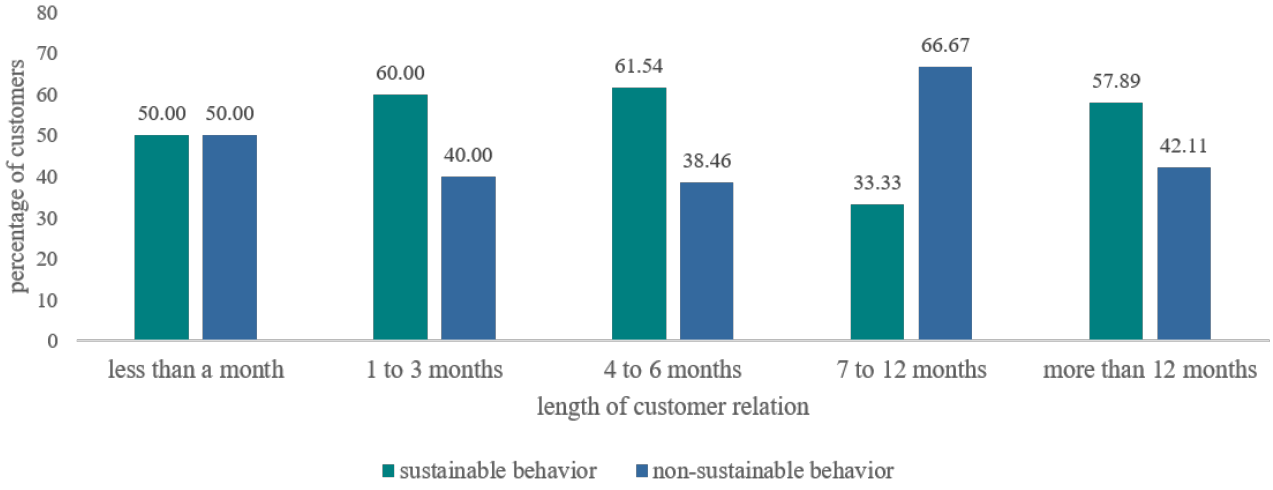
Continued

Table 3.22: *Continued*

Interest	very unlikely	2	3	4	5	6	very likely
Reported & realized	-0.0761**	-0.0411*	-0.0512*	-0.0319*	0.0196	0.0633**	0.118**
	(0.0379)	(0.0224)	(0.0262)	(0.0175)	(0.0128)	(0.0319)	(0.0545)
No choice	0.0364	0.0197	0.0245	0.0153	-0.00936	-0.0303	-0.0562
	(0.0472)	(0.0250)	(0.0312)	(0.0193)	(0.0126)	(0.0375)	(0.0718)
Controls	yes	yes	yes	yes	yes	yes	yes
Pseudo R^2	0.0612						
Panel D: Results based on the reported sustainability (cts.) as independent variable							
Reported (cts.)	-0.0852***	-0.0489***	-0.0640***	-0.0412***	0.0200*	0.0728***	0.146***
	(0.0221)	(0.0169)	(0.0180)	(0.0140)	(0.0105)	(0.0187)	(0.0345)
Controls	yes	yes	yes	yes	yes	yes	yes
Pseudo R^2	0.1003						
Observations	145						

Figure 3.3: Lottery choices by length of customer relation

This figure presents the portion of customers behaving in a sustainable respectively non-sustainable manner in the lottery, out of all customers of the green robo advisor. Customers who opted not to take part in the lottery where excluded. The proportions are grouped by the duration of customer relationship with their robo advisor.



Chapter 4

Managing Diversifiable Risk of Institutional Private Equity Investors*

4.1 Introduction

In private equity (PE), risk diversification is even more important as if investing in public equity. The risk of these assets is way higher, returns are far more skewed (Korteweg & Sørensen, 2010, Cochrane, 2005, Gompers & Lerner, 1998) and strongly depend on the skill of a few. Against this background, it is astonishing that research has paid such little attention to optimal portfolio diversification and risk management in PE so far.

Risk models commonly used in practice, like Value at Risk and Conditional Value at Risk[1], exclusively measure the exposure to market risk. As limited partners' portfolios are assumed to be well-diversified, idiosyncratic risk is neglected. It is questionable, however, whether this assumption is valid, and the number of deals should not be taken into account, especially since PE returns behave in a different manner than public market returns. Assessing the relevance of diversifiable risk is the goal of this paper.

First, we ask whether diversification has a significant economic effect in a typical limited partner (LP) portfolio. We take a random portfolio selection procedure as a basis that disregards any diversification considerations and selection biases to test if and how strongly diversification affects idiosyncratic portfolio risk. To measure diversification correctly, we need to account for syndicated deals[2]. As those deals make up a tremendous part of the investment universe, it is feasible that a syndicate is shared by two or more funds within a particular LP's portfolio. We infer that the potential number of investment doubling[3] in a large LP portfolio is not

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[1]The European Private Equity and Venture Capital Association (EVCA) recommends the Value at Risk (VaR) as industry standard to measure an investor's risk exposure.

[2]Deals that are jointly conducted by several general partners.

[3]The difference between the assumed and the actual number of total deals in a portfolio.

negligible. In what follows, we will refer to them as investment overlaps. While these investment overlaps do not affect an LP's exposure to market risk, they might significantly increase idiosyncratic risk even in a portfolio with a high number of deals. We find that diversification mitigates idiosyncratic portfolio risk even in large LP portfolios. Especially for buyout portfolios, the proportion of syndicates in a portfolio favorably affects risk, while random deal overlaps significantly increase idiosyncratic risk. These effects are economically significant. For buyout investments, the idiosyncratic risk is reduced by 4.24 percentage points per standard deviation increase in diversification. Syndicates correspond to a reduction by 14.77 percentage points, whereas overlaps lead to an increase by 6.66 percentage points. For an investment portfolio of 100 billion USD this equates a deviation by 0.34 (1.19, -0.53) billion USD per year.

Second, looking at a sample of real LPs, we ask whether certain investors have an exceedingly high diversification skill. Regarding the selection of outperforming funds, Cavagnaro et al. (2019), Sensoy et al. (2014) and Lerner et al. (2007) note that investment skill, information, and access is unevenly distributed among LPs. We contribute by analyzing *risk*-related LP skills. Our findings indicate that some LPs persistently work with general partners (GPs) that manage well-diversified funds, and have a particularly high ability to select the most diversified funds of a certain GP. We do not find evidence that a higher number of simultaneous buyout fund investments negatively affects an LPs' performance in contrast to Cavagnaro & Wang (2019), who trace their findings back to limited due diligence capacities.

Third, we look at overlap-related concentrations within these diversified portfolios. We ask whether these overlaps are systematic or due to random chance and analyze how they affect portfolio performance. Our results indicate that certain LPs have more overlapping deals in their portfolio as luck would have it. Our simulation analysis in section 4.3 shows that deal overlaps generally increase idiosyncratic portfolio risk. Nevertheless, we reveal that overlaps occurring in real LPs' portfolios tend to generate returns above the median compared to other syndicates.

We create a unique dataset that contains data on real LPs, their funds, deals and cash flows by combining three data sources. We retrieve large LPs' portfolio compositions from Preqin as most comprehensive source of PE investor data. We obtain return histories on a selected deal sample and match this with our Preqin data. We round out our data with information on certain deal characteristics and PE index returns from Thomson Reuters Eikon.

Our portfolio risk analysis is based on a Monte Carlo simulation technique, testing a representative number of potential portfolio combinations. Transferring the mixed effects model developed by Korteweg & Sørensen (2017) to study GP skills in generating high returns allows us to assess LPs' diversification skills. Finally, we make use of a bootstrap procedure to assess whether we observe portfolio concentration on certain deals due to chance or purpose.

Our contribution is threefold. First, we contribute to the growing literature stream that assesses risk in the PE market (Ang et al., 2018, Korteweg & Nagel, 2016, Ewens et al., 2013, Franzoni et al., 2012, Driessen et al., 2012, Korteweg & Sørensen, 2010, Cochrane, 2005). Our approach most closely relates to Ewens et al. (2013), who investigate whether idiosyncratic risk is priced in PE funds. Unlike their paper, we assess how idiosyncratic risk of *LP* portfolios is affected by diversification.

Second, research analyzing LP portfolios is sparse. Previous contributions investigate LPs' skills regarding the selection of high-performing funds (Cavagnaro et al., 2019, Sensoy et al., 2014, Hochberg & Rauh, 2013). We look at LPs' skills concerning the selection of well-diversified funds. Additionally, we contribute to the literature regarding due diligence capacity and fund selection.

Finally, our results are relevant to practitioners as well. LPs are erroneously assumed to be well-diversified and therefore only simulate their exposure to systematic risk in practice. Nevertheless, we show for a sample of large LPs that idiosyncratic risk in fact *is* relevant and therefore scrutinize whether LPs should additionally report the idiosyncratic risk of their PE portfolio.

The remainder of this study is organized as follows. Section 4.2 presents our dataset. Section 4.3 describes the methodology and results of our risk simulation, taking a random diversification procedure as a basis. In section 4.4, we analyze large LPs' diversification skills. In section 4.5, we analyze whether there is more than random chance to the portfolio concentration on certain deals we observe in large LPs' portfolios. We discuss several explanations of our results. Our paper concludes with section 4.6.

4.2 Data

To study the relation of diversification and risk in PE, we combine three data sources such that we have data on real LPs, their funds, deals, and cash flows. First, we retrieve information on LPs' portfolio compositions from Preqin. Our second dataset is a private one that provides us with the deal returns we require to estimate portfolio risk. Third, we combine this data with information from Thomson Reuters Eikon on PE index returns and the number of involved deal partners to identify deals as syndicated deals. This gives us a unique dataset to address our questions.

We rely on Preqin as most comprehensive database of LP investments, providing information on more than 5,300 institutions actively investing in PE. Preqin reports fund investments, and venture and buyout deals for each LP. We restrict the obtained sample to those LPs that report more than 100 venture and buyout funds in their portfolio in order to ensure that we have a balanced sample of LP-fund-observations and that all LPs have access to similar investments.

For reasons of data coverage, we further require deals to be realized after 1995. This gives us 5,497 distinct LP-fund observations for 139 unique LPs.

As the information on PE deal returns is not publicly available, we receive performance data on a quarterly basis for a selected sample of deals from an institutional investor. We also obtain information on the deal and fund characteristics. On the portfolio company level, we have detailed information on the country of origin, the industry it operates in, and the volume a fund invested in the respective portfolio company. On the fund level, we have information on a fund's vintage year, fund size, the responsible GP, as well as the fund's geographic and strategic focus.

We retrieve information on the number of partners involved in a deal and PE index returns from Thomson Reuters Eikon.

We match all information which gives us a sample of 130,088 LP-syndicate combinations that we observe returns for.

4.3 How relevant is diversifiable risk management?

When modeling PE investors' portfolio risk, practitioners focus is on systematic risk. Their portfolios are assumed to be sufficiently diversified, such that idiosyncratic risk can be neglected. In this sense, Ewens et al. (2013) argue that, even though GPs have an incentive to invest in riskier companies, the increased risk level of individual deals is negligible for the well-diversified LPs. The validity of this assumption is questionable, however. Previous literature focusing on *qualitative* diversification across vintage years, regions, industries, and investment types finds that large investors' portfolios are considerably concentrated on their own home state, the industries, and regions they are familiar with (Hochberg & Rauh, 2013, Choi et al., 2017). This puts additional emphasize on the importance of diversification across the number of deals comprised in a portfolio. Little attention is paid to this *quantitative* diversification, however.

The relationship between the number of deals in an LP portfolio and the level of idiosyncratic risk is not necessarily linear. An additional deal does not automatically correspond to lower portfolio risk. As individual GPs' monitoring capacities are limited, we observe a tremendous proportion of collective deal investments in the market during the past years. It is therefore feasible that several deal partners have one and the same investor. In particular, large investors work with the prominent GPs and the latter tend to stay among their own kind in syndicated deals (Du, 2016, Officer et al., 2010, Lerner, 1994). The effect of syndicated deals on LP performance is therefore ambiguous, as they allow for diversification and risk sharing on the one hand but increase chances of deal doubling within an LP portfolio on the other hand. While investment overlaps do not affect an LP's exposure to market risk, they might significantly increase idiosyncratic risk, even for large investors' portfolios with a high number of deals.

Consequently, diversifiable risk may be underestimated. In this section, we disentangle the diverse effects of diversification on LPs' idiosyncratic portfolio risk. To address our question, we resemble the typical investment procedure of an LP here. We apply a batch of controls. First, we exclude the effects of any investment strategies or biases by simulating a representative number of random portfolio allocations using Monte Carlo technique. We refer to it as unskilled portfolio diversification procedure. Second, we control for diversification across the geographic regions and industries. Third, we account for differences between investment types, conducting separate analyses for buyout and venture portfolios.

4.3.1 Data

In this section, we refer to the private dataset we have received from an institutional investor and rounded out with data from Thomson Reuters Eikon. It provides us with cash flow data on a deal-level basis for the portfolio companies of a fund assortment. In line with Preqin, we calculate quarterly fund returns based on deal-level cash flows and net asset values (NAVs) as

$$return_{i,t} = (NAV_{i,t} + D_{i,t})/(NAV_{i,t-1} + C_{i,t}) - 1,$$

where $NAV_{i,t}$ is the net asset value of fund i in quarter t, $NAV_{i,t-1}$ refers to the net asset value lagged by one quarter, $D_{i,t}$ denotes the distributed capital, and $C_{i,t}$ refers to the called capital. We distinguish between deals signed by one fund alone and syndicated deals jointly signed by several deal partners. We identify deals as *syndicated deals* if the number of involved deal partners reported by Eikon is larger than one.

4.3.2 Methodology

LP portfolio simulation

To analyze possible portfolio combinations, we apply a Monte Carlo technique simulating 10,000 LP portfolios and analyze their portfolio risk and diversification. Based on the descriptive statistics of real LPs, we resemble a typical LP's investment procedure here. Each year, a simulated LP randomly signs five funds out of the selection of funds launched in the specified year. Under the assumption that a fund has an average lifetime of ten years, the portfolio will reach its full size of 50 funds on average after ten years. To check for robustness, we re-estimate our results for LPs signing four, three or two funds each year. Funds are assumed to remain in an LP's portfolio until they run out. We consider a fund to be liquidated the quarter after the final cash flow is observed. Likewise, deals remain in a fund's portfolio as long as cash flows and NAVs are reported.

This leaves us with a time series of portfolio compositions for each LP, allowing us to assess an investor's idiosyncratic portfolio risk and diversification on a quarterly basis. As venture and buyout funds differ in terms of their size, number of investments, and the frequency of syndicated deals and deal overlaps, we conduct separate simulation procedures and analyses for LP's buyout and venture fund portfolios in the following.

Determining idiosyncratic risk

We determine LPs' idiosyncratic portfolio risk relative to public and private equity market indices. In essence, we relate the determined idiosyncratic portfolio risk to several measures of portfolio diversification.

To determine an LP's idiosyncratic portfolio risk, we transfer the approach proposed by Ewens et al. (2013) to our diversification analysis. They are the first to examine idiosyncratic risk in private equity portfolios. Their contribution challenges the validity of traditional asset pricing theory for the PE market, as their findings suggest that diversifiable risk happens to be priced in venture and buyout deals in contrast to the public market. They determine a fund's idiosyncratic risk as root mean squared error (RMSE) of the part of a fund's return that is not explained by market factor returns. Sorting funds into four portfolios according to their idiosyncratic risk and re-estimating fund portfolio returns yields a positive abnormal return for the fund portfolio with the highest and a negative abnormal return for the portfolio with the lowest idiosyncratic risk. We extend the approach of Ewens et al. (2013) by a PE-specific market index.

Based on the approach proposed by Ewens et al. (2013), we calculate our simulated LPs' idiosyncratic portfolio risk from the obtained time series of portfolio returns. This requires several steps.

First, we calculate quarterly excess portfolio returns from March 1999 to December 2018, separately for each simulated LP. Since LPs usually invest approximately the same amount in each fund they sign, we determine equally weighted portfolio returns. To prevent outliers from driving our results, fund returns have been winsorized on the 1% and 5% level, respectively. Subtracting the risk-free interest rate gives us a time series of excess returns.

Assuming that all funds of a certain type (venture or buyout) are exposed to the same market factors, we estimate the beta coefficients and the abnormal return for the entire market in the second step. We therefore calculate the mean excess portfolio return across all LPs in a given quarter. We call on CAPM as market model but need to make some adjustments to be able to apply it to PE portfolios. PE funds will likely report their assets' values with a time lag in contrast to publicly traded assets (Dimson, 1979). In line with Ewens et al. (2013), we account for this illiquid asset particularity in our model by projecting excess returns on current and lagged market returns. We therefore use excess market returns of the current and past three

quarters.[4] We use the time series of quarterly mean LP excess returns to estimate the following market model equation

$$r_t^{rf} = \alpha + \sum_{k=0}^{3} \beta_k^{rmrf}\, r_{t-k}^{rmrf} + \epsilon_t. \tag{4.1}$$

where r_t^{rf} is the mean excess portfolio return in quarter t across all LPs, α_i is the abnormal return, r_{t-k}^{rmrf} is the quarterly excess return for the market index publicly available on the Kenneth French website lagged by k periods, β_k^{rmrf} is the corresponding beta coefficient estimate, and ϵ_t is the residual return.

In the next step, we calculate an LP-specific error term $\epsilon_{i,t}$ for each quarter, by rearranging equation 4.1 in the following way:

$$\epsilon_{i,t} = r_{i,t}^{rf} - \alpha - \sum_{k=0}^{3} \beta_k^{rmrf}\, r_{t-k}^{rmrf}. \tag{4.2}$$

$r_{i,t}^{rf}$ is the LP i's excess portfolio return in quarter t and $\epsilon_{i,t}$ is the term of interest.

In a final step, we use a rolling window technique to determine an individual LP's idiosyncratic portfolio risk, calculating the RMSE of the respective past four years' (16 quarters) residual obtained from equation 4.2. The computed time series allows us to study how idiosyncratic risk corresponds to changes in portfolio diversification calculated as average over the same period of time.

A batch of studies have shown that the Fama French three-factor model is as well suitable for explaining PE returns (see Ang et al. (2018), Ewens et al. (2013), Franzoni et al. (2012) among others). To test the robustness of our findings for an alternative market model specification, we re-estimate our results with the Fama French three-factor model, adding a small-minus-big (SMB) and high-minus-low factor (HML) to the equations 4.1 and 4.2. Now equation 4.2 becomes

$$\epsilon_{i,t} = r_{i,t}^{rf} - \alpha - \sum_{k=0}^{3} \beta_k^{rmrf}\, r_{t-k}^{rmrf} - \sum_{k=0}^{3} \beta_k^{smb}\, r_{t-k}^{smb} - \sum_{k=0}^{3} -\beta_k^{hml}\, r_{t-k}^{hml}. \tag{4.3}$$

The reference models like CAPM and Fama-French that are traditionally applied to public equity returns can only be applied to private equity returns under strongly simplifying assumptions (Korteweg & Nagel, 2016). To address this concern, we additionally construct a PE market index. As we aim to resemble the approach typically applied by institutional investors to calculate their exposure to market risk, we closely match the VaR approach. Each quarter, we determine

[4] We test significance and find significant covariances with market returns that are lagged by up to three quarters. Ewens et al. (2013) even find significant coefficients for returns lagged up to four quarters.

each LP's portfolio weights allocated to a certain asset class and region, and map the associated index returns retrieved from Thomson Reuters Eikon. We thereby calculate an LP-specific PE index. We obtain excess LP and market returns by subtracting the respective MSCI return from both. We calculate an LPs' idiosyncratic risk as square root of the difference between the observed 16-quarter variance of portfolio returns and the variance of the LP-specific market returns over the same period:

$$\epsilon_{i,t} = \sqrt{\sigma^2(r_{i,t}^{msci}) - \sigma^2(r_{i,t}^{rmmsci})}. \tag{4.4}$$

Measuring portfolio diversification

Our independent variables express a portfolio's degree of diversification relative to the diversified market portfolio in terms of the scope of deals, geographic regions, and industries respectively.

Measuring diversification is in fact not trivial. Though counting the number of deals, N, in a portfolio seems to be a straightforward measure, it can severely overestimate the diversification of the regarded portfolio. A portfolio comprising several large and small deals, for instance, would be assumed to have the same degree of diversification as a portfolio with approximately equally large deals according to this measure, even though the latter is obviously more diversified. We therefore take deal sizes into account.

To quantify diversification, we transform the Herfindahl Index as suggested by Goetzmann & Kumar (2008). The idea is to quantify by how much a certain portfolio deviates from the market portfolio. We rely on deal sizes instead of the number of deals in a portfolio. We calculate the portfolio weight w of a certain deal j in the portfolio of an LP i for each quarter t as deal value divided by the total portfolio value. We next take the sum of squared portfolio weights of all deals in a portfolio and obtain our diversification index. To ease interpretation, we subtract this diversification index from one as new reference value and use these estimates in our regressions such that a higher value of the index refers to a higher level of diversification. The transformed diversification index TDI can formally be described as

$$TDI_{i,t} = 1 - \sum_{j=1}^{N}(w_{i,j,t} - w_{m,t})^2 = \sum_{j=1}^{N}(w_{i,j,t} - \tfrac{1}{N_{m,t}})^2 \approx 1 - \sum_{j=1}^{N} w_{i,j,t}^2,$$

where $w_{m,t}$ denotes the weight of each portfolio company in the equally weighted PE market portfolio and $N_{m,t}$ describes the total number of deals in the PE market. As literature findings show that portfolio diversification across industries and geographic regions is relevant, we control for both with a separate diversification measure (Buchner, 2017, Humphery-Jenner, 2013, Gompers et al., 2009, Norton & Tenenbaum, 1993). We quantify the scope of regions an LP covers through the deals in his portfolio as

$TDI_{i,t}^{Region} \approx 1 - \sum_{r=1}^{R} w_{i,r,t}^2$,

where $w_{i,r,t}$ is the accumulated portfolio value of an LP i that is concentrated in a certain region r in quarter t relative to the total portfolio value at that time. We distinguish between the main geographic regions North America, Europe, Asia/Pacific and Rest of the World.

Likewise, we obtain deal distributions across industries as

$TDI_{i,t}^{Industry} \approx 1 - \sum_{p=1}^{P} w_{i,p,t}^2$,

where $w_{i,p,t}$ is the accumulated portfolio value of an LP i that is concentrated in a certain industry p in quarter t relative to the total portfolio value at that time. We differentiate between ten main industries comparable to the first digit SIC and GICS code.

Moreover, we analyze how deals whose risk is shared by several partners affect diversifiable portfolio risk. Syndicated deals allow the deal partners to circumvent capital and time constraints, complement skills, get a foot in the door, build up networks, and spread investment risk (Officer et al., 2010), thereby increasing the number of feasible portfolio investments. Syndicated deals might therefore have performance characteristics that differ from those of single deals and affect idiosyncratic portfolio risk in a different manner. We calculate the fraction $w_{i,t}^{Syndicates}$ of an LP's portfolio value that is comprised by syndicated deals in quarter t.

Finally, we are interested in the impact of concentration due to randomly overlapping deals within a portfolio. A deal is defined as an *overlap* if two or more funds participating in the same deal appear in an LP's portfolio together. We therefore calculate the value proportion of overlaps, $w_{i,t}^{Overlaps}$, in an LP's portfolio.

4.3.3 Regression model

Our final model relates an LP's idiosyncratic portfolio risk during a 16-quarter-period τ to the degree of diversification as average over the same time period. The formal notation can be gathered from equation 4.5:

$$rmse(\epsilon_{i,\tau}) = c + w_{i,\tau}^{Overlaps} + w_{i,\tau}^{Syndicates} + TDI_{i,\tau} + TDI_{i,\tau}^{Region} + TDI_{i,\tau}^{Industry} + \phi_{i,\tau} \qquad (4.5)$$

Note that we rely on the time period between December 2011 and December 2018 for our regressions. As PE funds have an average lifetime of 10 years and we start drawing funds in January 1999, LP portfolios reach their full size in January 2008. We then need four years of observations to reasonably calculate portfolio risk (December 2011). We control for LP fixed effects and use robust standard errors to adjust for heteroskedasticity.

4.3.4 Descriptives

Our regression sample consists of 290,000 simulated LP-quarter portfolio observations for 10,000 hypothetical LPs during the period December 2011 and December 2018. Table 4.7 in the Appendix presents the descriptive statistics. Panel A shows the values for buyout portfolios, Panel B presents the statistics for venture portfolios. On average, a buyout portfolio comprises approximately 58 funds simultaneously, while venture portfolios have a slightly higher number of 69 funds, indicating a slightly longer lifetime of the latter. Venture capital funds tend to have more but comparably smaller deals than buyout funds. We therefore observe twice the number of venture capital deals in a simulated portfolio over the entire sample period as compared to buyout deals (1,310 versus 652). Venture portfolios have a slightly higher proportion of syndicated deals and overlaps in their portfolio (62% versus 57% and 14% versus 11%). The average diversification across deals and industries is comparable among the two investment classes, whereas diversification across regions is higher in buyout portfolios.

4.3.5 Results

Table 4.1 and 4.2 present the results of our ordinary least squares (OLS) regressions of simulated LPs' idiosyncratic portfolio risk on diversification. Table 4.1 contains the results for buyout fund portfolios, Table 4.2 refers to the sample of venture fund portfolios. Column numbers (1) to (3) refer to different specifications of the dependent variable. Specification (1) exhibits our estimates when idiosyncratic risk is determined relative to the CAPM as reference model, specification (2) shows the estimates for the Fama-French three factor model as underlying reference model. Equation (3) shows our estimates when an LP-specific PE index is applied.

In line with traditional capital asset pricing theory, we find that buyout portfolios with higher level of diversification show lower idiosyncratic risk. Coefficients are positive and statistically significant regarding all specified dimensions of diversification, i.e. across deals, industries, and geographic regions. These findings are robust to all reference model specifications.

Our findings show that syndicated buyout deals mitigate idiosyncratic portfolio risk. This is in line with Marquez & Singh (2013) and Officer et al. (2010) who find that syndicated buyout deals tend to outperform single deals and generate high premiums for their investors thanks to deal partners' increased negotiation power.

In line with our hypothesis, unintentional portfolio concentration due to deal overlaps have a strongly adverse effect on diversifiable portfolio risk. Together with the previous finding that syndicated buyout deals generally tend to decrease portfolio risk, this finding prefigures that deal partners manage to effectively share the risk of syndicated buyout deals.

Table 4.1: Idiosyncratic risk modeling for buyout portfolios

This table presents the coefficients of three OLS regressions, as described in section 4.3, based on the sample of buyout portfolios. We apply different specifications of idiosyncratic portfolio risk $rmse(\epsilon)$ as dependent variable. In regression (1), we determine idiosyncratic risk relative to CAPM as reference model. In regression (2), we compute idiosyncratic risk with Fama-French as reference model. In regression (3), we calculate idiosyncratic risk relative to an LP-specific PE index. For definitions of the remaining variables, see the description in Table 4.7 in the Appendix. Our sample comprises the period between Dec 2011 and Dec 2018. Robust standard errors are reported in parentheses. *, ** and *** relate to the 5%, 1% and 0.1% confidence level, respectively.

	(1)	(2)	(3)
$rmse(\epsilon)$	CAPM	Fama-French	PE Index
$w^{Overlaps}$	0.0171***	0.0163***	0.202***
	(0.000945)	(0.000845)	(0.00374)
$w^{Syndicates}$	-0.0626***	-0.0523***	-0.0976***
	(0.00137)	(0.00119)	(0.00515)
TDI	-0.816***	-0.461***	-4.108***
	(0.0568)	(0.0498)	(0.216)
TDI^{Region}	-0.0376***	-0.0354***	-0.282***
	(0.00113)	(0.000993)	(0.00446)
$TDI^{Industry}$	-0.0534***	-0.0822***	-0.452***
	(0.00401)	(0.00361)	(0.0162)
Constant	0.927***	0.590***	4.677***
	(0.0559)	(0.0490)	(0.213)
Observations	290,000	290,000	257,949
Adjusted R^2	0.104	0.182	0.508

Our results are economically significant. A one standard deviation increase in quantitative diversification (TDI) reduces idiosyncratic portfolio risk by 4.24 (3.65) percentage points. A one standard deviation increase in the overlap proportion raises the risk by 6.66 (9.68) percentage points. Syndicated deals lower the risk by 14.77 (18.79) percentage points. The reported values refer to risk measured relative to CAPM as reference model. The values reported in parentheses refer to risk measured relative to the Fama-French reference model. Our aforementioned results are robust to alternating portfolio sizes. Table 4.8 in the Appendix contains the results for LPs signing two to four funds per year.

In contrast, we find ambiguous results for venture capital. Our results are neither robust to alternative market model specifications nor to alternating portfolio sizes (see Table 4.2 and Table 4.9 in the Appendix). This can, at least partially, be explained by the strongly deviating motives that urge GPs to induce syndicated buyout versus syndicated venture deals. Venture capital deals naturally have higher risk and more skewed returns, which the deal partners might favor to spread. Moreover, as early-stage investments those deals might require a broad set of skills which can be jointly covered by deal partners with complementary experience. In line with this argumentation, we note that the vast majority of venture capital deals are realized as

syndicated deals, while this is less frequently the case for buyout deals (90.80% compared to 43.40% among buyout deals in our Preqin sample). We will look at this issue in further detail in section 4.5.

Table 4.2: Idiosyncratic risk modeling for venture capital portfolios

This table presents the coefficients of three OLS regressions, as described in section 4.3, based on the sample of venture capital portfolios. We apply different specifications of idiosyncratic portfolio risk $rmse(\epsilon)$ as dependent variable. In regression (1), we determine idiosyncratic risk relative to CAPM as reference model. In regression (2), we compute idiosyncratic risk with Fama-French as reference model. In regression (3), we calculate idiosyncratic risk relative to an LP-specific PE index. For definitions of the remaining variables, see the description in Table 4.7 in the Appendix. Our sample comprises the period between Dec 2011 and Dec 2018. Robust standard errors are reported in parentheses. *, ** and *** relate to the 5%, 1% and 0.1% confidence level, respectively.

	(1)	(2)	(3)
$rmse(\epsilon)$	CAPM	Fama-French	PE Index
$w^{Overlaps}$	0.0155***	0.00942***	0.00895***
	(0.000857)	(0.000561)	(0.00213)
$w^{Syndicates}$	-0.00538*	0.0109***	0.0974***
	(0.00239)	(0.00153)	(0.00569)
TDI	-1.061***	-0.590***	-0.310***
	(0.0177)	(0.0113)	(0.0406)
TDI^{Region}	-0.00767***	-0.0104***	-0.142***
	(0.000425)	(0.000273)	(0.000970)
$TDI^{Industry}$	-0.439***	-0.238***	0.566***
	(0.00509)	(0.00320)	(0.0114)
Constant	1.438***	0.794***	-0.102*
	(0.0190)	(0.0120)	(0.0429)
Observations	290,000	290,000	169,866
Adjusted R^2	0.269	0.198	0.686

4.4 Do LPs actively manage portfolio diversification?

In the previous section, we have analyzed diversification effects for random portfolio allocations. In this section, we examine how real LPs manage diversification. Our portfolio simulation has shown that diversification *per se* favorably impinges on the idiosyncratic risk of PE portfolios, and diversification across the number of deals exerts a strong and economically significant influence. Selecting well-diversified funds (in terms of deal numbers) can therefore be seen as a particular investment skill.

Regarding the selection of funds with high returns, skill seems to be asymmetrically distributed among institutional investors, allowing some LPs to shine thanks to continuously promising

fund investments (Cavagnaro et al., 2019). Certain LP types, namely endowments and pension funds, have emerged as especially successful investors (Lerner et al., 2007), even though it is controversial whether these fortunate fund choices are by virtue of sophistication or better access due to linkage with the prominent GPs (Sensoy et al., 2014).

We apply a mixed effects model to analyze whether investors differ regarding their level of *diversification* skill in this section. The model enables us to disentangle an LP's persistent ability to choose the most diversified funds from GP-specific diversification skills.

4.4.1 Data

Our analysis rests upon LPs' investments reported by Preqin. Table 4.10 in the Appendix describes LP-related descriptive statistics of our dataset. In total, we analyze diversification skills of 139 LPs. The largest group in our sample are public pension funds, with 54 investors. They have the second largest PE investment volume (8,436 million USD) after fund managers. Buyout funds represent the majority of our LP investments with 77% on average. Pension funds and endowments have a relatively high proportion of venture capital investments, ranging between 28% and 31%. We analyze 50 funds on average to assess an LP's diversification skill. We are interested in the number of deals a fund adds to an LP portfolio. We therefore count the number of deals each fund in an LP's portfolio has signed during its lifetime.

4.4.2 Methodology

We need a random effects model to parametrically estimate potential differences in diversification skill *between* LPs. In a multi-step regression approach proposed by Cavagnaro et al. (2019), we transfer the return model of Korteweg & Sørensen (2017) to our measurement of diversification skill and remove all non-LP-related diversification effects.

Korteweg & Sørensen (2017) develop a model that assesses GP-specific fund management skills. To determine how much of the cross-sectional variation in funds' total performance can be attributed to skill differences between GPs, they decompose the fund return variance into three components: the component of interest corresponding to a GP-specific random effect γ_i showing persistent differences in GP skill; a component referring to a GP-fund year-specific random effect $\eta_{i,t}$ that applies to each year that the fund exists and accounts for multiple funds being simultaneously managed by the same GP; and a fund-specific component $\epsilon_{i,u}$.

In the first regression step, we transfer the return model of Korteweg & Sørensen (2017) to our measurement of diversification skill. We refer to the mixed effects model version in which they control for vintage year fixed effects, as it adjusts for any set of observed or unobserved risk factors that are common to funds established in the same year. The dependent variable in our model is the level of diversification a fund u realizes throughout its lifetime. We rely on

the transformed Herfindahl Index here and compute the index based on deal numbers.[5] For simplicity, we suppose that each fund has a 10-year lifetime. This allows us to formally describe a fund u's diversification as transformed Herfindahl Index

$$THI_{iu} = X_{iu}\beta + 10\gamma_i + \sum_{\tau=t_{iu}}^{t_{iu}+9} \eta_{it} + \epsilon_{iu}, \tag{4.6}$$

where i indicates the managing GP, t_{iu} is the fund's vintage year, and X_{iu} refers to a vector of vintage year fixed effects. γ_i describes a GP-specific random effect expressing the skill persistence of a particular GP i. η_{it} represents a GP-fund year-specific random effect, shared by all funds that are simultaneously managed by the same GP in a certain year. The latter two, random effects are accumulated over the 10-year lifetime of the respective fund and assumed to be i.i.d. following a normal distribution with zero mean and variance equal to σ_γ^2 respectively σ_η^2. We jointly estimate the described fixed and random effects along with these variances. Rearranging equation 4.6 after the error term ϵ_{iu} gives us the fund-specific effect. It is supposed to be i.i.d. across funds, GPs, and over time.

We remove all non-LP-related diversification effects from the observed fund diversification level stepwise as suggested by Cavagnaro et al. (2019). We start by removing vintage year fixed effects and GP-fund year-specific effects, which gives us the part of fund diversification that can be attributed to GP skill:

$$THI_{iu}^{GP-fund\,selection} = THI_{iu} - X_{iu}\beta - \sum_{\tau=t_{iu}}^{t_{iu}+9} \eta_{it}. \tag{4.7}$$

Subtracting the GP-fund year random effects $\sum_{\tau=t_{iu}}^{t_{iu}+9} \eta_{it}$ controls for the fact that some LPs invest in subsequent funds of a certain GP while still holding the previous fund. When we observe that some LPs persistently invest in well-diversified funds, the observed diversification ability can be traced back to two different skill types: first, an LP's skill to select particularly diversified GPs as investment partners; second, the skill to choose the most diversified funds managed by those GPs. The latter skill implies that an LP bypasses less diversified fund generations of a given GP and will be estimated based on equation 4.7. When we additionally remove the fund-specific effect ϵ_{iu}, we obtain the basis to calculate an LP's dexterity to network with the most diversified GPs:

$$THI_{iu}^{GPselection} = THI_{iu} - X_{iu}\beta - \sum_{\tau=t_{iu}}^{t_{iu}+9} \eta_{it} - \epsilon_{iu}. \tag{4.8}$$

[5]See Goetzmann & Kumar (2008) for the application of the Herfindahl Index in portfolio diversification measurement.

To prepare the final step of our regression, we match the above information with our LP-fund-combinations. We estimate our variable of interest, an LP's diversification skill, as parameter in another mixed effects model. Rearranging

$$THI_{iuj}^{GP-fund\,selection} = X_{LP_j}\beta_{LP} + 10\lambda_j + \pi_{iuj} \tag{4.9}$$

provides the skill λ_j of an LP j to pick particularly *diversified funds of a given GP*. Reordering

$$THI_{iuj}^{GPselection} = X_{LP_j}\beta_{LP} + 10\kappa_j + \psi_{iuj} \tag{4.10}$$

allows us to calculate an LP's skill κ_j to work with more *diversified GPs*. Comparing 4.9 and 4.10 infers how much of the skill variation among LPs can be traced back to the capacity to select well-diversified funds.

We estimate two specifications of the fixed effects in equations 4.9 and 4.10. Once, X_{LP_j} is a single intercept for all LPs and β_{LP} can be understood as the skill differential between the LPs in our analyzed sample and the remaining LPs in the Preqin universe that we do not cover in our dataset. Another time, X_{LP_j} is a set of LP-type fixed effects and β_{LP} indicates by how much certain LP types, i.e. endowments, public pensions funds, etc., outperform others.

If several LPs in our sample invest in the same fund, information on the latter will appear multiple times in our regression. The dependent variables will then be the same for all LPs investing in that fund, i.e. $THI_{iuj}^{GP-fund\,selection} = \bar{THI}_{iu}^{GP-fund\,selection}$ and $THI_{iuj}^{GPselection} = \bar{THI}_{iu}^{GPselection}$. Therefore, the error terms π_{iuj} and ψ_{iuj} in equations 4.9 and 4.10 align for the fact that a high-skilled and a low-skilled LP will sometimes invest in the same fund, even though this choice does not imply that the two are equally skilled.

As the sample size is small and the error terms follow a non-normal distribution, we use Bayesian Markov Chain Monte Carlo (MCMC) technique when estimating our model.[6] The obtained Bayesian estimates are more robust to outliers than the corresponding maximum likelihood estimates.

4.4.3 Results

Table 4.3 presents our results of the mixed effects model regressions. We report our results for the full fund sample in specification (1) and (2) as well as separately for buyout ((3) and (4)) and venture funds ((5) and (6)). Odd numbers correspond to the estimates of fund selection skills among LPs according to equation 4.9, even numbers refer to the estimates of GP selection skills among LPs according to equation 4.10.

[6] See also Cavagnaro et al. (2019), Korteweg & Sørensen (2017), Driessen et al. (2012) and Cochrane (2005).

We decompose the (sample) variance of fund diversification, $\sigma^2_{\hat{y}}$, into an LP-specific diversification skill differential, σ^2_λ (σ^2_κ), and a fund-specific noise, σ^2_π (σ^2_ψ). The larger the part of variation that is explained by skill heterogeneity, the more relevant LP skills are in explaining diversification differences across the funds they select. Reordering

$$\sigma^2_{\hat{y}} = 10^2\sigma^2_\lambda + \sigma^2_\pi \tag{4.11}$$

gives us the signal-to-noise ratio

$$signal - to - noise_\lambda = \frac{100\sigma^2_\lambda}{\sigma^2_{\hat{y}}}. \tag{4.12}$$

We do the same decomposition for σ^2_κ and σ^2_ψ. Comparing the realized values of the signal-to-noise ratio gives us an idea where LP skill is most important. Panel A reports the results for the regression specification with no LP-type-specific intercepts. For the full sample specification, we find that an LPs' skill differential in selecting diversified GPs explains 12.2% of the variance in fund diversification, while the ability to select well-diversified funds from a specified GP makes up 10.3% of the variation, indicating that the former is slightly more informative.

Especially when we control for LP types in Panel B, our estimated effects are economically significant. Given a specific GP, we estimate that an LP with one standard deviation higher skill than average will select funds that are 3.23 percentage points more diversified (σ_λ). Likewise, the estimated standard deviation within the model that explains GP selection skills among LPs is 3.24 percentage points (σ_κ) of a fund's diversification *THI*. Our results indicate differences in diversification skills across LP types. A particularly high beta coefficient $\beta_{endowments}$ indicates that endowments seem to pay more attention to working with diversified GPs, and selecting the most-diversified funds when choosing their buyout investments. This can be traced back to their lower investment volume. Public pension funds seem to compensate the higher risk of venture capital through higher levels of diversification ($\beta_{publicpension}$). They are particularly skilled at choosing both diversified GPs as well as diversified funds of this asset class.

Table 4.3: LP diversification skill

This table presents the results of a mixed effects model using Bayesian MCMC technique, described in section 4.4. Panel A reports the results for a regression with a common constant term for all LPs. Panel B reports the results for a regression where we control for LP-type specific effects. Columns with odd numbers refer to a particular LP's skill to select the most diversified funds of a certain GP, as determined in equation 4.9. Columns with even numbers refer to a particular LP's skill to select diversified GPs, as determined in equation 4.10. σ_λ and σ_κ refer to the respective variation in fund diversification that is related to individual LP-specific effects. σ_π and σ_ψ refer to the respective variation due to noise. The signal-to-noise ratio indicates the proportion of fund diversification variance that is explained by LP skill. Standard errors obtained from Monte Carlo simulations (msce) are reported in parentheses.

	All		Buyout		Venture	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: No LP-type-specific intercept						
σ_λ	0.0017		0.0017		0.0025	
mcse	(0.000)		(0.000)		(0.000)	
σ_π	0.049		0.047		0.069	
mcse	(0.000)		(0.000)		(0.000)	
σ_κ		0.0016		0.0017		0.0024
mcse		(0.000)		(0.000)		(0.000)
σ_ψ		0.044		0.042		0.066
mcse		(0.000)		(0.000)		(0.000)
β_{allLPs}	0.893	0.890	0.897	0.896	0.900	0.884
mcse	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)
signal-to-noise	0.103	0.122	0.120	0.134	0.113	0.118
Panel B: LP-type-specific fixed effects						
σ_λ	0.0323		0.0325		0.0312	
mcse	(0.000)		(0.000)		(0.000)	
σ_π	0.050		0.047		0.069	
mcse	(0.000)		(0.000)		(0.000)	
σ_κ		0.0324		0.0326		0.0301
mcse		(0.013)		(0.000)		(0.000)
σ_ψ		0.044		0.042		0.067
mcse		(0.000)		(0.000)		(0.000)
$\beta_{endowments}$	0.892	0.903	0.914	0.929	0.881	0.860
mcse	(0.001)	(0.009)	(0.010)	(0.066)	(0.012)	(0.015)
$\beta_{fundmanagers}$	0.913	0.939	0.900	0.918	0.895	0.857

Continued

Table 4.3: *Continued*

	All		Buyout		Venture	
	(1)	(2)	(3)	(4)	(5)	(6)
mcse	(0.001)	(0.007)	(0.009)	(0.031)	(0.012)	(0.010)
$\beta_{privatepensions}$	0.890	0.874	0.885	0.883	0.897	0.849
mcse	(0.001)	(0.009)	(0.008)	(0.042)	(0.010)	(0.011)
$\beta_{publicpensions}$	0.917	0.922	0.877	0.865	0.913	0.885
mcse	(0.001)	(0.004)	(0.004)	(0.032)	(0.008)	(0.005)
signal-to-noise	0.977	0.982	0.980	0.984	0.953	0.953
Observations	5,497	5,497	3,800	3,800	1,978	1,978
Number of LPs	139	139	139	139	139	139

Our approach has practical applications. It allows to determine and compare the diversification skills of individual LPs. In this way, we notice the highest diversification skills[7] for the insurance companies Liberty Mutual Insurance and AXA US as well as for the investment company Brederode. An excerpt of our analysis is presented in Table 4.11 in the Appendix.

Cavagnaro & Wang (2019) raise concerns that the number of fund investments an LP is able to manage simultaneously might be limited. They find that a higher number of simultaneous buyout *fund* investments negatively affects LPs' performance, which they trace back to limited due diligence capacities. This would imply that the benefits of diversification on the fund level are limited. We pursue this issue by running an OLS regression that relates a fund's IRR to the number of its investors' simultaneous fund investments within a ten-year time window. We restrict our sample to all funds established between 2000 and 2010. We control for performance effects related to LPs' investment experience at the investment date. Additionally, we control for a series of LP- and fund-specific fixed effects. The results of this regression can be inferred from Table 4.4. In contrast to Cavagnaro & Wang (2019), our results do not point at an adverse relation between LPs' diversification across the number of funds and the performance of the individual funds. Instead, our control for LPs' investment experience, measured in terms of the cumulative number of fund investments, positively relates to fund performance.

[7] regarding the selection of diversified funds, given a certain GP.

Table 4.4: Relation between fund performance and LP diversification

This table presents the coefficients of OLS regressions based on the sample of fund investments undertaken by the LPs in our sample. The continuous dependent variable is the *Fund IRR*. The number of simultaneous fund investments (funds established between 2000 and 2010) is our main variable of interest. As a proxy of investment experience at the time the investment is undertaken, we subtract the number of fund investments undertaken since 2000 from the total number of reported fund investments. Robust standard errors are reported in parentheses. *, ** and *** relate to the 10%, 5% and 1% confidence level, respectively.

	(1)	(2)	(3)
	Fund IRR	Fund IRR	Fund IRR
Investment experience	0.0127*	0.0127**	
	(0.00667)	(0.00621)	
Number of simultaneous investments	0.0000103		0.0218
	(0.0821)		(0.0782)
LP-country FE	yes	yes	yes
LP-type FE	yes	yes	yes
Asset class control	yes	yes	yes
Vintage year FE	yes	yes	yes
Constant	14.01**	14.01**	14.13**
	(6.031)	(6.008)	(5.975)
Observations	310	310	310
Adjusted R^2	0.227	0.229	0.214

4.5 Does portfolio concentration result from bias or rational portfolio structuring?

So far, we have shown that diversification across the number of deals in a portfolio mitigates idiosyncratic risk. However, there is a substantial chance that deals incidentally overlap within large LPs' portfolios due to the following circumstances. First, large investors' effective fund assortment per vintage year is considerably limited. Institutional investors repeatedly make a series of investments, and funds need to exceed a certain size in the first place to be interesting for such investors. Second, if any, these large funds will share syndicated venture and buyout deals among each other, as GPs tend to search for deal partners of similar prominence (Du, 2016, Officer et al., 2010, Lerner, 1994). Third, LPs' preference for funds located in their own home state (Hochberg & Rauh, 2013) or with a focus on familiar regions and industries (Choi et al., 2017) additionally tightens the investment scope. Consequently, the number and characteristics of the funds in a portfolio gives each LP a unique statistical probability of finding himself with a series of incidental deal doubling. We wonder whether the overlap ratio that we observe in the market equals its calculative probability. Potentially, deal overlaps occur more frequently in the market than luck would have it. In this case, several effects could be at play. On the one

hand, Hochberg et al. (2007) find evidence for a network effect among GPs who invite others to participate in their promising deals, hoping to have access to the deal flows and network of the latter in the future. LPs investing in such networks would therefore benefit from those syndicates.

Under the assumption that large LPs can foster the realization of certain deals by their fund investments, for instance as members in the funds' advisory boards, the information advantage could also be on the LP side on the other hand. A comparable collaboration between LPs and GPs occurs when they co-invest in certain deals (Braun et al., 2020, Fang et al., 2015). Choi et al. (2017), for example, find evidence that LPs have an information advantage on certain markets and industries, which they capitalize by concentrating their portfolios in accordance.

In this section, we ask whether the deal overlaps we observe in the market occur – at least partly – systematically or by mere random chance. To address our question, we match the Preqin dataset described in section 4.4.1 with deal returns obtained from the institutional investor. We first bootstrap our LP portfolios to assess whether the observed overlap proportion equals random chance or is in fact higher. We then examine how these deals affect LPs' performance. We aim to shed further light on the portfolio concentration puzzle with our analysis.

4.5.1 Are overlaps random?

Data

We base the analysis on our sample of large LPs retrieved from Preqin. For descriptive statistics on that sample, we refer the reader to Table 4.10 in the Appendix again. Additionally, Table 4.5 shows the number of funds we use for the analysis and their year of establishment. Our sample comprises all funds that Preqin reports and that have been established since 2000. We spot deal overlaps within an LP portfolio as those deals where the particular LP is simultaneously invested in more than one participating deal partner.

Table 4.5: Descriptives on the fund universe

This table allocates the fund sample we draw from for our bootstrap analysis in section 4.5.1 to the respective vintage year.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	All
Buyout	190	129	139	128	176	292	363	411	326	198	289	364	3005
Venture	376	261	185	143	200	251	312	338	318	232	298	398	3312
All	566	390	324	271	376	543	675	749	644	430	587	762	6317

Methodology

In essence, we analyze whether the overlap proportions we observe for our LPs follow a distribution of randomly simulated overlaps. As the true distribution of the overlap probability is unknown, we fall back to a bootstrap technique as non-parametric approach to address our question.

The bootstrap technique has already been applied in private equity research by Weidig & Mathonet (2004), Driessen et al. (2012) and Cavagnaro et al. (2019), among others. The idea of this approach is that – given deal overlaps do not occur systematically – the frequency of overlaps observed for a certain LP should not be statistically different from that of another random fund portfolio where funds have been selected in a manner that they closely match the characteristics of the original portfolio. That means, for each fund in an LP's portfolio we randomly draw one fund from the subsample of similar funds in the investment universe to construct a hypothetical portfolio for each LP. In this manner, we can estimate how many overlaps would have occurred randomly in a certain LP's portfolio by accounting for the investment goals and restrictions of the particular LP. When creating the described fund subsamples, we include the entire Preqin fund universe into our analysis – not only the funds that LPs actually have invested in – in order to closely replicate LPs' investment problem. This enhances the power of our test. Subsamples are constructed comprising all funds pertaining to the same asset class (i.e. buyout or venture), established in the same vintage year, focusing on the same geographic region (United States, Europe, Asia/Pacific and Rest of the World), and that resemble in terms of the deal number and fund size. Regarding the latter characteristics, we distinguish between more active funds with at least 50 deals and less active funds as well as larger funds with at least 1.25 billion USD investment volume and smaller funds.

The sampling procedure is repeated 1,000 times. We perform analyses for all funds as well as for buyout and venture funds separately, as we have noted that the syndication motives might differ across fund types.

To compute our variable of interest, we adapt the approach proposed by Cavagnaro et al. (2019) to our setting. We compute the following measures for the original sample and each of the 1,000 iteration samples, respectively. The median overlap ratio M_t over all LPs in our original sample, respectively in an iteration sample, in a certain year t gives us our respective baseline overlap ratio. Then we determine by how much an LP's overlap ratio deviates from the respective year's baseline on average. In what follows, we refer to this measure as overlap deviation, δ_j. Formally, we obtain the overlap deviation of a certain LP j as

$$\delta_j = \frac{\sum_t (overlap\,ratio_{j,t} - M_t)}{Y_j}, \tag{4.13}$$

where Y_j denotes the total number of years that we have observations for LP j.

In contrast to Cavagnaro et al. (2019), we calculate the differences to the baseline overlap ratio as average over the observed investment years instead of counting the number of times an LP's overlap ratio exceeds the market baseline. This allows us to account for the extent of overlap persistence. We expect the positive and negative deviations to cancel out across the market and over time such that we will see an average overlap deviation measure close to zero if overlaps occur randomly within LP portfolios.

The observed overlap deviation of a certain LP can be understood as a statistical estimate of the true probability of deviating from the baseline overlap ratio. To account for the fact that longer investment histories will give us more accurate estimates of an LP's overlap deviation, we normalize δ_j. We do so by calculating the z-score of δ_j relative to the assumed baseline overlap deviation of 0,

$$\Phi_j = \frac{\delta_j}{\sqrt{\frac{1}{Y_j}}}, \tag{4.14}$$

where Y_j savors larger numbers of reported investment years. In contrast, Cavagnaro et al. (2019) account for the number of fund investments.

What we are actually interested in is the cross-sectional standard deviation of the distribution of z-scores. Under the assumption that overlaps randomly arise in LPs' portfolios, LPs' z-scores follow a standard normal distribution with a standard deviation

$$\omega_\Phi = \sqrt{\frac{\sum_j (\Phi_j - \bar{\Phi})^2}{n-1}} \tag{4.15}$$

equal to 1, as it is the case for our replicated LP portfolios. $\bar{\Phi}$ refers to the average sample z-score and n indicates the number of LPs in the sample. To statistically assess whether there is more variation in the original sample than would appear by random chance, we check whether the sample z-scores deviate by more than 1.

We conduct our analysis for the full sample as well as separately for venture and buyout portfolios. Moreover, we re-estimate our results separately for each LP type to assess type-specific differences.

Results

Our bootstrap results indicate that deal overlaps occur, at least in parts, systematically. Less than 1% of the sampling iterations have a standard deviation ω_Φ greater than what we observe for our original LP sample. This is equivalent to rejecting the null hypothesis of random overlap persistence at a 1% significance level.

When we compare the mean overlap ratio of the original sample with the one of the simulated samples, we find an upward bias that is statistically significant at a 0.01% level. A Kolmogorov-

Smirnov test of equal distributions confirms that the overlap ratios in the original sample follow a different distribution than those obtained in our simulations.

Several explanations for our results are conceivable. First, it is possible that our results are driven by a home state bias (Hochberg & Rauh, 2013). Even though we assure that the drawn funds match the original funds' geographic region (US, Europe, etc.) when resembling LPs' portfolios, we cannot control for the state a fund is head-quartered in, as the subsamples of similar funds would become too small.

Second, our observations could be explained by network effects. Assuming that GPs respectively their fund managers know each other, it is likely that they jointly invest in potentially promising deals. Hochberg et al. (2007) elaborates on networks among VC firms. An LP that invests in several funds of a certain network will therefore be more exposed to deal overlaps.

Another potential driver of our results could be that deal overlaps are induced in consultation with the concerned LP. The findings of Choi et al. (2017) indicate that LPs have superior information on the geographic regions and industries their portfolios are concentrated on. Such an information advantage might also arise on the deal level. Similar to co-investments, LPs can increase their own stake in a company by urging their funds to jointly realize a promising deal. In support of this argument, Sensoy et al. (2014) find that close linkage with the prominent GPs fuels certain LP (type)s' investment success. In order to be able to exert influence on their fund investments at all, e.g. as member in the fund's advisory board, LPs need to be sufficiently large. Dyck & Pomorski (2016) pronounce that LPs with larger PE portfolios might better overcome information asymmetries, indicating that a certain size is necessary in the PE market to have access to superior information.

A favorable performance of the observed overlapping investments would especially prefigure the latter two explanations. We look at this issue in the next section.

4.5.2 On the performance of deal overlaps

Data

Following the approach by Braun et al. (2020), we compare in how far overlapping deals differ from the remaining deals in the *same* LP portfolio to rule out to the greatest possible extent that unobserved effects drive potential performance differences. We calculate IRRs for the subsample of deals that we have return information for. We first restrict our sample to only those LPs that have both, syndicated deals *and* overlaps, in their portfolio. In a second step, we drop all non-syndicated deals. This allows us to directly compare the characteristics of overlaps with those of regular syndicated deals, controlling for any unobserved traits that underlie the specific LP and deal.

On average, a buyout deal remains in a fund portfolio for four years (Franzoni et al., 2012). Venture deals have a slightly shorter investment period of three years. We therefore restrict our sample period to deals realized after January 2005 to be consistent with our analysis in section 4.3.[8]

Methodology

Our main variable of interest in this analysis is deal performance. If we are right and part of the deal overlaps occur due to network effects between fund managers within an LP's portfolio, or LPs themselves have an information advantage and encourage their funds to jointly invest in particularly promising deals, we expect to observe overlaps on deals that simultaneously promise high returns and low risk when compared to other investment opportunities in the respective investment year. We call these deals "cash cows". Their returns should be located above the respective year's median return but below that of risky assets. Extremely high returns are favorable, on the one hand, but indicate a high level of risk at the same time (Ewens et al., 2013). We therefore sort deals of the same investment year and type (buyout and venture) into quartiles according to their realized IRR.

We control for effects that are specific to certain LP types in our regression, arising from deviating investment goals, skills or information access. Furthermore, we control for deal-region and deal-year fixed effects as well as LP-country fixed effects.

Results

Table 4.6 shows the results of three probit regressions in which the dependent variable is equal to one if a deal overlaps in an LP portfolio, and zero otherwise. Column (1) reports the results for a full sample regression. Column (2) and (3) refer to the subsamples of buyout and venture deals respectively.

In line with our hypothesis, the full sample regression shows a significantly positive coefficient for the third return quartile. LPs are significantly more likely to have overlaps on syndicated deals that have favorable return expectations along with manageable risk.

Looking at the return quartiles two to four separately for buyout and venture deals shows that our results are driven by the former. Buyout deals whose performance is difficult to predict ex ante are less likely to occur more than once in an LP portfolio even if they turn out as promising investments afterwards (quartile 4). While syndicated buyout deals are more selective (43.40% in our sample), the vast majority of venture deals (90.80%) are syndicated, which enormously increases the probability of overlaps among venture deals. Due to the nature of venture capital as early-stage investments, we will observe a higher failure rate among venture deals that gather

[8]Four years prior to December 2008.

in the lowest return quartile compared to buyout investments. Therefore, chances are naturally higher that overlaps occur on venture deals outside of the lowest return quartile.

We observe considerable differences across LP types. Remarkably, private and public pensions show opposite results. While public pension funds have a higher likelihood to find themselves with deal overlaps for both asset classes, and sovereign wealth funds tend to have a high likelihood for overlaps in buyout deals, private sector pension funds in contrast are particularly likely to have venture deal overlaps in their portfolio. PE fund managers consistently show a high overlap probability across all asset classes. Buyout overlaps frequently occur in banks' portfolios, whereas government agencies and endowments show significantly negative coefficients.

In summary, the results lend support to our hypotheses of network effects and information advantages as drivers of deal overlaps in LP portfolios.

Table 4.6: Drivers of deal overlaps

This table presents the effects of three probit regressions described in section 4.5. Our sample comprises the syndicated deals of the largest LPs that have deal overlaps in their portfolio. Regression (1) refers to the complete sample. Regression (2) calls on the subsample of buyout deals. Regression (3) refers to the sample of venture deals. The dependent variable *Deal overlap* takes the value of one if a syndicated deal is shared by at least two deal partners with the same investor, and zero otherwise. *Return quartile 2-4* indicate how the likelihood for a deal overlap depends on deal performance. *Return quartile 1* is the omitted reference group. We control for several deal- and LP-specific effects: LP type, the LP's country, the portfolio company's region and the deal year. Robust standard errors are reported in parentheses. *, ** and *** relate to the 5%, 1% and 0.1% confidence level, respectively.

	(1)	(2)	(3)
Deal overlap	All	Buyout	Venture
Return quartile 2	-0.0314*	-0.103***	0.184***
	(0.0153)	(0.0179)	(0.0305)
Return quartile 3	0.0809***	0.0509**	0.195***
	(0.0137)	(0.0158)	(0.0273)
Return quartile 4	-0.129***	-0.335***	0.207***
	(0.0154)	(0.0194)	(0.0280)
Asset Manager	0	0	0
	(.)	(.)	(.)
Bank	0.253***	0.373***	0.0126
	(0.0767)	(0.0829)	(0.401)
Corporate Investor	0.337*	0.370*	0.752*
	(0.134)	(0.148)	(0.319)
Endowment Plan	-0.0852	-0.145**	0.179

Continued

Table 4.6: *Continued*

Deal overlap	(1) All	(2) Buyout	(3) Venture
	(0.0461)	(0.0547)	(0.0947)
Family Office - Multi	0	0	0
	(.)	(.)	(.)
Family Office - Single	-0.576***	-0.341	0
	(0.175)	(0.186)	(.)
Foundation	0.0141	-0.0415	0.243**
	(0.0426)	(0.0507)	(0.0890)
Fund Manager	0.215***	0.151**	0.460***
	(0.0423)	(0.0493)	(0.0904)
Government Agency	-0.0911	-0.235*	0.757**
	(0.0974)	(0.109)	(0.238)
Insurance Company	0.0531	0.0409	0.223*
	(0.0429)	(0.0493)	(0.0947)
Investment Bank	0.339	0	0.797
	(0.387)	(.)	(0.551)
Investment Company	0.0853	0.519***	0.159
	(0.0995)	(0.122)	(0.264)
Listed Fund of Funds Manager	0.0713	0.144	0
	(0.103)	(0.107)	(.)
Private Equity Firm (Investor)	-0.323*	-0.581**	0.226
	(0.129)	(0.184)	(0.224)
Private Equity Fund of Funds Manager	0.323***	0.0908	0.695***
	(0.0414)	(0.0491)	(0.0881)
Private Sector Pension Fund	0.0684	-0.00850	0.375***
	(0.0406)	(0.0475)	(0.0871)
Public Pension Fund	0.214***	0.205***	0.429***
	(0.0396)	(0.0458)	(0.0866)
Secondary Fund of Funds Manager	0.0494	0.0764	0.127
	(0.0625)	(0.0723)	(0.130)
Sovereign Wealth Fund	0.217***	0.252***	0.252

Continued

Table 4.6: *Continued*

Deal overlap	(1) All	(2) Buyout	(3) Venture
	(0.0642)	(0.0724)	(0.148)
Superannuation Scheme	0.00467	0.190	0
	(0.175)	(0.204)	(.)
Wealth Manager	0.0212	-0.136	0.410*
	(0.133)	(0.171)	(0.207)
Deal region FE	yes	yes	yes
Deal year FE	yes	yes	yes
LP country FE	yes	yes	yes
Constant	-1.044***	-0.840***	-2.237***
	(0.136)	(0.169)	(0.153)
Observations	130,088	96,087	33,645
Pseudo R^2	0.033	0.047	0.029

4.6 Conclusion

Risk models commonly used in practice disregard the diversifiable risk of LPs' PE portfolios. We analyze whether the relevance of idiosyncratic risk is underrated in PE. We address three questions in our paper: first, we assess the effect of diversification on idiosyncratic risk; second, we analyze potential diversification skill differentials among LPs; third, we ask whether deal overlaps observed within LP portfolios occur systematically and how they affect portfolio performance.

We create a unique dataset comprising data on real LPs, their funds, deals and cash flows, by combining private and public data sources.

Our risk simulation shows that diversification mitigates idiosyncratic portfolio risk in an economically significant manner – even in large LP portfolios. Especially for buyout portfolios, the proportion of syndicated deals in a portfolio positively affects risk, while random deal doubling significantly increase idiosyncratic risk. Looking at a sample of real LPs, our findings indicate that some investors have particularly high skills in identifying the most diversified GPs and selecting the most diversified funds. Additionally, we find that certain LPs have more overlapping deals in their portfolio than luck would have it, and that those deals tend to generate returns above the median when compared to other syndicated deals.

To summarize, our findings show that the relevance of idiosyncratic risk is underrated in the PE industry. We encourage to report this risk along with the systematic risk of a portfolio.

It would be interesting to analyze the relevance of idiosyncratic risk of PE allocations for the total LP portfolio allocated across different asset classes.

Analyzing how deal overlaps affect liquidity risk due to concentrated capital calls and distributions is beyond the scope of our research. Syndicated deals accelerate the investment period, and LPs that have doubling deals in their portfolio are affected multiply, which leads to faster capital calls and higher risk of capital distributions. It would therefore be interesting to assess whether these portfolio concentrations should be accounted for in the cash flow modeling.

4.7 Appendix

Table 4.7: Descriptives of our simulated LP portfolios

This table presents the descriptive statistics regarding our simulated LP portfolios in section 4.3, for the period Dec 2011 to Dec 2018. Panel A refers to buyout portfolios, panel B describes venture portfolios. Information is provided on the average number of funds that are simultaneously comprised in a simulated portfolio at a specific date, the total number of deals that those funds that are simultaneously comprised in a simulated portfolio at a specific date realize throughout their lifetime on average, as well as the total number of syndicates, and the total number of overlapping deals, the mean 16-quarter moving average of the transformed diversification measure TDI, respectively the diversification across regions TDI^{Region} and industries $TDI^{Industry}$, the mean 16-quarter moving average of the overlap proportion $w^{Overlaps}$, and of the syndicate proportion $w^{Syndicates}$.

	mean	p25	p50	p75	p90	p95	sd
				Panel A: Buyout portfolios			
No. of funds	57.661	55.000	58.000	61.000	63.000	65.000	5.121
No. of deals	651.740	598.000	657.000	717.000	770.000	802.000	100.137
No. of syndicated deals	268.520	228.000	269.000	309.000	354.000	383.000	66.523
No. of overlaps	45.194	18.000	32.000	56.000	108.000	147.000	42.208
TDI	0.995	0.994	0.995	0.995	0.995	0.996	0.001
TDI^{Region}	0.568	0.539	0.561	0.594	0.627	0.640	0.039
$TDI^{Industry}$	0.827	0.819	0.828	0.836	0.843	0.846	0.012
$w^{Overlaps}$	0.105	0.064	0.100	0.142	0.178	0.199	0.053
$w^{Syndicates}$	0.573	0.543	0.575	0.605	0.629	0.642	0.045
				Panel B: Venture portfolios			
No. of funds	69.221	67.000	69.000	72.000	74.000	74.000	3.444
No. of deals	1309.553	1249.000	1310.000	1371.000	1423.000	1453.000	87.936
No. of syndicated deals	687.751	629.000	689.000	746.000	793.000	819.000	80.518
No. of overlaps	118.317	70.000	98.000	168.000	208.000	223.000	58.466
TDI	0.996	0.995	0.997	0.997	0.998	0.998	0.002
TDI^{Region}	0.467	0.418	0.469	0.522	0.556	0.568	0.068
$TDI^{Industry}$	0.815	0.809	0.816	0.822	0.827	0.829	0.009
$w^{Overlaps}$	0.135	0.062	0.116	0.192	0.265	0.293	0.083
$w^{Syndicates}$	0.617	0.586	0.617	0.649	0.676	0.690	0.044
Observations	290,000						

Table 4.8: Robustness tests for idiosyncratic risk analysis of buyout portfolios

This table contains the results of our robustness checks for section 4.3. It presents the coefficients of six OLS regressions based on the sample of buyout portfolios, where portfolio sizes alternate across regressions, i.e. LPs sign two to four funds per year. Idiosyncratic portfolio risk $rmse(\epsilon)$ is determined relative to the CAPM and the Fama-French three factor model, respectively. For definitions of the remaining variables, see the description in Table 4.7 in the Appendix. Our sample comprises the period between Dec 2011 and Dec 2018. We control for LP fixed effects. Robust standard errors are reported in parentheses. *, ** and *** relate to the 5%, 1% and 0.1% confidence level, respectively.

	2 funds		3 funds		4 funds	
$rmse(\epsilon)$	CAPM	Fama-French	CAPM	Fama-French	CAPM	Fama-French
$w^{Overlaps}$	0.0146***	0.0111***	0.0191***	0.0157***	0.0193***	0.0174***
	(0.00151)	(0.00135)	(0.00126)	(0.00109)	(0.00114)	(0.000983)
$w^{Syndicates}$	-0.0279***	-0.0204***	-0.0316***	-0.0233***	-0.0311***	-0.0254***
	(0.00138)	(0.00127)	(0.00115)	(0.00101)	(0.00102)	(0.000885)
TDI	-0.397***	-0.229***	-0.403***	-0.199***	-0.274***	-0.129***
	(0.0334)	(0.0306)	(0.0272)	(0.0242)	(0.0240)	(0.0212)
TDI^{Region}	-0.0221***	-0.0161***	-0.0273***	-0.0220***	-0.0291***	-0.0251***
	(0.00126)	(0.00115)	(0.00105)	(0.000932)	(0.000941)	(0.000823)
$TDI^{Industry}$	-0.00944*	-0.0253***	-0.0147***	-0.0361***	-0.0264***	-0.0395***
	(0.00424)	(0.00394)	(0.00349)	(0.00316)	(0.00307)	(0.00273)
Constant	0.453***	0.292***	0.465***	0.272***	0.346***	0.206***
	(0.0326)	(0.0298)	(0.0266)	(0.0236)	(0.0235)	(0.0207)
Observations	290,000	290,000	290,000	290,000	290,000	290,000
Adjusted R^2	0.029	0.027	0.047	0.059	0.056	0.084

Table 4.9: Robustness tests for idiosyncratic risk analysis of venture capital portfolios

This table contains the results of our robustness checks for section 4.3. It presents the coefficients of six OLS regressions based on the sample of venture portfolios, where portfolio sizes alternate across regressions, i.e. LPs sign two to four funds per year. Idiosyncratic portfolio risk $rmse(\epsilon)$ is determined relative to the CAPM and the Fama-French three factor model, respectively. For definitions of the remaining variables, see the description in Table 4.7 in the Appendix. Our sample comprises the period between Dec 2011 and Dec 2018. Robust standard errors are reported in parentheses. *, ** and *** relate to the 5%, 1% and 0.1% confidence level, respectively.

	2 funds		3 funds		4 funds	
$rmse(\epsilon)$	CAPM	Fama-French	CAPM	Fama-French	CAPM	Fama-French
$w^{Overlaps}$	0.00363***	0.00212*	0.00458***	0.00293***	0.00792***	0.00458***
	(0.000970)	(0.000831)	(0.000778)	(0.000611)	(0.000728)	(0.000532)
$w^{Syndicates}$	-0.0106***	-0.00165	-0.0162***	-0.00355***	-0.0131***	-0.00118
	(0.00108)	(0.000905)	(0.00127)	(0.000993)	(0.00156)	(0.00109)
TDI	-0.0893***	-0.0402***	-0.257***	-0.144***	-0.493***	-0.273***
	(0.00679)	(0.00579)	(0.00892)	(0.00699)	(0.0120)	(0.00836)
TDI^{Region}	0.00687***	-0.00228***	0.00688***	-0.00355***	0.00366***	-0.00434***
	(0.000375)	(0.000318)	(0.000340)	(0.000270)	(0.000341)	(0.000242)
$TDI^{Industry}$	-0.128***	-0.0670***	-0.227***	-0.117***	-0.350***	-0.179***
	(0.00338)	(0.00271)	(0.00401)	(0.00295)	(0.00493)	(0.00317)
Constant	0.217***	0.116***	0.465***	0.259***	0.799***	0.435***
	(0.00797)	(0.00668)	(0.0105)	(0.00807)	(0.0139)	(0.00946)
Observations	290,000	290,000	290,000	290,000	290,000	290,000
Adjusted R^2	0.095	0.033	0.153	0.074	0.207	0.126

Table 4.10: Descriptives on the LP sample

This table presents the descriptive statistics for the sample of 139 investors we analyze in sections 4.4 and 4.5. It summarizes the overall investment characteristics by LP type and overall, as reported by Preqin in January 2020. *N* indicates the number of LPs in the respective group. *Average number of fund investments per LP* refers to the average number of funds we use in our regressions for an LP in the respective group.

	N	Total AUM (million USD)	Year of first PE investment	Total PE investments (million USD)	Buyout ratio	VC ratio	Average number of fund investments per LP
Fund manager	27	44,943	1997	20,215	0.900	0.100	70.5
Private pension funds	24	62,454	1998	1,728	0.700	0.300	43.4
Endowments	16	10,374	1996	2,392	0.690	0.310	40.3
Public pension funds	54	78,172	1997	8,436	0.721	0.279	56.2
Banks, insurance and investment companies	18	256,667	1998	4,366	0.839	0.161	40.9
Overall	139	90,522	1997	7,427	0.770	0.230	50.3

Table 4.11: LP-specific diversification skill

This table exemplary presents the regression effects of the individual LPs in our sample, obtained from our analysis in section 4.4.

Random Effect	Standard Deviation	Firm type	Firm name
0.908	0.007	Insurance Company	Liberty Mutual Insurance
0.907	0.010	Insurance Company	AXA US
0.900	0.008	Investment Company	Brederode
0.898	0.007	Insurance Company	Prudential Financial
0.895	0.016	Insurance Company	Hartford Financial Services Group
0.894	0.011	Insurance Company	Nassau Reinsurance Group
0.889	0.013	Insurance Company	Jackson National Life Insurance Company
0.889	0.006	Insurance Company	MetLife Insurance Company
0.888	0.009	Insurance Company	Ilmarinen Mutual Pension Insurance Company
0.887	0.007	Insurance Company	Chartis
0.887	0.007	Insurance Company	Travelers Companies
0.886	0.013	Insurance Company	Minnesota Life Insurance Company
0.884	0.008	Insurance Company	Northwestern Mutual Life Insurance Company
0.877	0.009	Insurance Company	American General Life Insurance Company
0.871	0.013	Insurance Company	Massachusetts Mutual Life Insurance Company
0.870	0.034	Insurance Company	Manulife Financial Corporation
0.869	0.010	Insurance Company	New York Life Insurance Company
0.812	0.035	Bank	European Bank for Reconstruction and Development
0.019	0.052	Foundation	Sherman Fairchild Foundation
0.018	0.047	Private Pension Fund	AT&T Pension Fund
0.018	0.053	Foundation	Richard King Mellon Foundation
0.016	0.052	Endowment Plan	University of Texas Investment Management Company
0.016	0.048	Private Pension Fund	Lockheed Martin Pension Plan
0.016	0.052	Foundation	John S. & James L. Knight Foundation
0.015	0.047	Private Pension Fund	Boeing Company Pension Fund

Continued

Table 4.11: *Continued*

Random Effect	Standard Deviation	Firm type	Firm name
0.015	0.048	Private Pension Fund	E.I.Du Pont De Nemours and Company Pension Plan
0.013	0.047	Private Pension Fund	Alcatel-Lucent Pension Fund
0.013	0.048	Private Pension Fund	BP America Retirement Trust
0.013	0.048	Private Pension Fund	Industry Pension Insurance
0.011	0.047	Private Pension Fund	HP Inc. Pension Fund
0.011	0.048	Private Pension Fund	Liberty Mutual Retirement Benefit Plan
0.008	0.052	Foundation	Rockefeller Foundation
0.008	0.053	Endowment Plan	Michigan State University Endowment
0.007	0.052	Endowment Plan	University of Washington Endowment
0.006	0.047	Private Pension Fund	Verizon Pension/Benefits
0.005	0.052	Endowment Plan	University of Michigan Endowment
0.004	0.052	Foundation	Andrew W. Mellon Foundation
0.003	0.048	Private Pension Fund	Mayo Pension Plan
0.003	0.047	Private Pension Fund	TIAA
0.001	0.052	Foundation	Wellcome Trust

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