LUND UNIVERSITY
School of Economics and Management

Investing to Curb Climate Change

The Performance and Risk of Green Mutual Funds

Mira Schwarz and

Sophie Glossmann

May 2016

Master's Program in Finance

Supervisor: Hossein Asgharian

Abstract

Environmental concerns have come to increased investors' attention and have raised the number of investment opportunities in green mutual funds. We advance an emerging debate on the link between financial and environmental performance by measuring the effects of green in a regional, sectoral and fossil fuel setting. We hypothesize that green funds are able to compete with conventional funds and that an increasingly favorable regulatory environment and a growing awareness in the society have led to performance improvements over time. Analyzing an equally weighted sample of 202 green and non-green funds for the period from 2002-2015, we find that in fact environmental funds do not perform significantly different from their conventional peers and that performance has improved over time. If we focus on more recent years (2013-2015) and the US market, green funds were even able to outperform conventional funds. While limited diversification possibilities borne by screening for environmental stocks let us to expect higher idiosyncratic risk of green funds, we do not find significant differences in risk exposure either. Indeed, we find a positive trend of green funds becoming significantly less volatile in later years (2013 and 2014), likely due to an increased investment horizon as more and more firms are 'going green'.

Keywords: Green mutual funds, Environmental mutual funds, Green investment, Financial performance, Idiosyncratic risk, Fossil-free investing

Table of Contents

List of Tables

List of Figures

Abbreviations and Symbols

CAPM	Capital Asset Pricing Model
ESG	Environmental, Social and Governance
HML	High Minus Low
IMF	International Monetary Fund
MOM	Momentum
RMRF	Return of Market Portfolio minus Risk Free Rate
SMB	Small Minus Big
SRI	Socially Responsible Investing

1. Introduction

"The life of money-making is one undertaken under compulsion, and wealth is evidently not the good we are seeking for; it is merely useful and for the sake of ***something else****."*
(Aristotle, written around 350 B.C.)

Nowadays, the emphasis for many investors has switched to altering the way money is used toward a more moral, transformative way encouraging a truly sustainable society (Keane, 2009). What the Greek philosopher Aristotle proclaimed around 350 B.C. has become an urgent task to tackle today's challenges of global warming causing the disruption of ecosystems, the endangerment of natural resources and immense droughts and flooding jeopardizing entire societies. Environmental concerns have encouraged individual movements and political action, but have also come to increased investors' attention. One way for investors to reach their twofold investment aim, financial and environmental, is to invest in environmental mutual funds, also known as green funds. Green funds can be classified as a subset of socially responsible investment (SRI) funds and defined as "*those that invest in companies producing a broader range of environmental goods and services […] and that seek out mainstream companies that have remodeled their business practices to mitigate climate change impacts*".[1] Morningstar describes green funds in broader terms as those that "*invest in companies which are deemed to be friendly to the environment*".[2] This paper takes a closer look at the performance and risk of green funds and compares them to those of conventional mutual funds.

Private and institutional investors are frequently declared as an alternative source of capital to traditional bank financing and government grants in order to fund an economy-wide green growth, and therefore have an important role to play in the transition to a low-carbon and climate-resilient economy (Inderst et al., 2012). While green funds have been around since 1980, a sharp growth of sustainability investing has taken off in the 2000s when concerns about climate change and natural resource depletion have come to increased research and media attention. In the United States alone, the assets managed by green focus funds have increased by over 750% from USD 211.5mn in 1995 to USD 1.8bn in 2012 (Muñoz et al., 2014).

A clear advantage of green investing springs from combining money management with environmental concerns. Investors can derive non-financial utility by contributing to combat

[1] Bloomberg New Energy Finance (BNEF, 2012)

[2] Morningstar (2016)

climate change. Apart from that, investing in environmentally friendly companies does not only provide benefits from a mere social viewpoint but also financially. Companies that apply environmentally sound practices have been found to show strong financial performance the like. Moreover, stock picking of green fund managers does not differ fundamentally from that of conventional fund managers. Whether or not environmental screens are applied, the final investment decision ought to be overall financially vital and not based on charitable criteria alone. On the other hand, green investment opponents might argue that screening for environmental criteria inevitably results in limitations in the investment horizon. This in turn leads to a decrease in financial performance combined with higher levels of risk for the investment. It can therefore be argued that investors would be better off investing in conventional funds and then directing any gains made on these investments to environmental causes. Stemming from these two strings of argumentation and in the light of the economy-wide and globally increasing importance of green investments, the question arises if green funds can cope with the performance and risk profile of traditional funds. Can investors let their environmental beliefs be reflected in their money management without being worse off than conventional investors?

Although addressing this question constitutes an essential centerpiece of information for investors, practitioners, policy makers as well as researchers, and while there exists a broad pool of SRI fund literature, only a good handful of studies have tackled the aspect of green. White (1995) is the first to focus on thematic environmental funds. He studies performance differences between green funds and their conventional peers in the German as well as the US market and finds positive results for German but negative results for US green funds. Climent and Soriano (2011) as well as Muñoz et al. (2014) apply a matched-pair approach to compare the performance between environmental funds and their conventional counterparts. The former paper distinguishes between different time periods within their analysis and finds evidence that green funds do not perform differently from conventional funds during more recent years. The latter paper allows for differences in European and US funds and their respective global or domestic investment styles, and also finds no significant performance differences for either sample compared to conventional funds. Chang et al. (2012) as well as Ibikunle and Steffen (2015) evaluate performance differences by comparing the average performance between samples. Both papers find evidence for an underperformance of green mutual funds. Ito et al. (2013) use a mean-variance approach for evaluating performance differences between green funds and conventional mutual funds. Their study provides inconclusive results with equivalent or slightly superior risk-adjusted returns of green funds. Adamo et al. (2014) provide a descriptive analysis for a sample of 257 green funds, with particular emphasis of performance and volatility differences in that sample, however not in comparison to non-green funds. Overall, literature on green mutual funds provides ambiguous results and does not go beyond performance measures since none of the papers above tackles the issue of green fund risk compared to conventional funds. Studied empirically for SRI funds, Geczy et al. (2005) find significant diversification costs of the SRI constraint confirming previous literature on SRI funds suffering from limited diversification possibilities (Clow, 1999; Le Maux & Le Saout, 2004; Girard et al., 2007). Due to their selective investment approach, SRI funds tend to focus on one or just a few sectors that in turn results in higher risk exposure and is in line with the study by Khorana and Nelling (1997) examining sectorally focused funds. Besides that most of the mentioned studies have omitted green fund risk, there exists no previous research on the impact of specific factors determining the performance or risk of green funds.

This paper conducts an analysis of an equally weighted sample of green and conventional mutual funds over a 14-year period spanning the years 2002-2015 in terms of performance and risk. The first part of our paper addresses the aspect of green fund performance. Abnormal performances are determined by the four-factor model as introduced by Carhart (1997), first for each fund over the whole time period and then for each year. Besides the evaluation of green fund performance compared to conventional funds, other variables of interest are tested cross-sectionally. After controlling for general factors such as fund size and fund age for instance, we empirically test if green funds invested in the worldwide most established financial market, the United States, as well as in other world regions such as Europe and Asia perform statistically different from non-green funds. With clean-technology on the rise, another variable of interest is the technology sector and differences in performance of green funds that are heavily invested in this sector. With the divestment movement away from carbon-intensive fossil fuel firms and clean technology becoming more affordable, we additionally test a subsample for the effect of fossil fuel holdings on performance. Fossil fuels (oil, gas and coal) are associated as one of the main contributors to global carbon emissions, thus crucially driving global warming. A fully sustainable economy would require excluding the extraction and utilization of fossil fuels. In order to raise the importance of this environmental variable also in financial literature, we factor in the exposure to fossil fuel holdings into our regression. Furthermore, performing a cross-sectional analysis for the yearly abnormal performance of our fund sample and our general control variables setting, we are able to examine how the performance of green funds has evolved over time.

As theoretically established and empirically observed, a fund's screening activity and specialized focus have shown to impact its diversifiable risk. In order to provide a comprehensive analysis of a fund's financial position that goes beyond return analysis, the second part of this paper addresses the idiosyncratic risk of our sample funds. As in the section regarding performance, control variables as well as additional variables of interest and their effect on idiosyncratic risk are tested in a cross-sectional analysis over the whole time period. Again, we test between differences in risk for various regional investment styles. We determine if being 'green' and mainly invested in the US, Europe or Asia translates into a different risk profile than being non-green mainly invested in those regions. With potential bias of clean-technology firms towards small and growth firms and given a fast moving regulatory environment, it is worth taking a look at the effect of green funds mainly invested in technology firms and how it alters their risk position. In order to mitigate climate change, stranded asset theory claims a large amount of burnable resources underground to become stranded in the future, threatening the existence of fossil fuel firms. Therefore, we evaluate the aspect of fossil fuel on idiosyncratic risk of our sample funds. Finally, a cross-sectional evaluation for yearly idiosyncratic risk allows us to determine changes in risk over time.

This paper is timely and contributes to existing literature by not only analyzing green funds with respect to performance but also in terms of risk. To the best of our knowledge, none of the previous studies addresses the aspect of idiosyncratic risk of green funds compared to conventional peers. Moreover, we aim at identifying factors influencing green fund performance and risk. We include additional variables into our empirical model that have not been observed in combination with the factor green in previous work, with an important extension of the emerging fossil free argument. We have only been able to identify one other paper by Ibikunle and Steffen (2015) to address the issue of fossils, however not in a statistical regression analysis but rather descriptive. Overall, our paper attempts a new approach in environmental fund analysis by applying a two-step regression model in the spirit of Fama and MacBeth determining green fund performance and risk in a time-series regression, followed by a cross-sectional analysis of certain variables of interest.

The remainder of this paper is structured as follows. We start by reviewing important literature related to the topic. This is followed by the derivation of our hypotheses in chapter 3. In chapter 4 and 5, the data and methodology are described. Chapter 6 covers an extensive analysis and discussion of our empirical results with Chapter 7 testing their robustness. Finally, we conclude this paper with a summary of the major findings and future outlook.

2. Literature Review

In this section, we present past findings on the financial performance and risk of mutual funds relevant for our hypotheses derivation and empirical analysis. We start by showing how fund performance has been affected based on overall social screening as the majority of academic literature as of today identifies environmental investment as a subset of socially responsible investing (SRI). This is followed by a review whether environmental performance of a firm translates into financial returns on corporate level, complemented by presenting literature on our major topic of interest, green fund performance. Approaching the second aspect of our paper, idiosyncratic fund risk, we will continue by introducing previous literature on diversifiable mutual fund risk given screening activity and investment focus.

2.1 The Performance of SRI Mutual Funds

A larger set of empirical research compares the performance of mutual funds that screen their holdings based on overall social criteria with those that do not. The US Social Investment Forum defines SRI as an investment that applies a set of screens to pick or expel assets based on environmental, social or governance (ESG) criteria, which often engages in shareholder activism and local communities to ensure the implementation of SRI policies in corporate strategies. While there are findings of abnormal SRI fund returns (Goldreyer, Ahmed, and Diltz, 1999; Blank and Daniel, 2002; Kempf, A. and P. Osthoff, 2007; Weber, Mansfeld, Schirmann, 2010; Derwall, Koedijk, Horst, 2011), other studies show that SRI funds perform worse than unscreened funds (Rudd, 1979, Teper, 1992, Geczy, Stambaugh, and Levin, 2003). Reflecting the ongoing debate on the link between social and financial performance, many studies give evidence for mixed or neutral results (Hamilton, Joe, Statman, 1993; Statman, 2000; Bauer, Koedijk, and Otten, 2002 and 2005; Renneboog, Ter Horst, Zhang, 2008b; Hoepner and McMillan, 2009, Chegut et al., 2011, Cortez et al., 2012). Comprehensive meta analyses show that SRI funds yield returns similar to those of conventional benchmarks, noting that only a minority of the studies extend beyond 2008 (DB Climate Change Advisors, 2012; Revelli and Viviani, 2015).

Based on portfolio theory, one may predict that if social screenings generate value-relevant information, conventional portfolio managers could easily replicate the screens such that abnormal returns diminish. This may explain why we do not see performance differences between screened and non-screened investments (Renneboog, Horst, Zhang, 2008). In addition, as those studies recognize SRI as a homogenous set of mutual funds, Muñoz et al. (2014) argue that they suffer from an important bias: SRI mutual funds can apply a variety of screening strategies that could be the reason for the different financial performance results at hand. Several studies have investigated the effect of screening intensity and types of screens that may alter fund performance (Renneboog et al., 2005; Barnett and Salomon, 2006; Statman and Glushkov, 2009; Lee et al., 2010; Humphrey and Lee, 2011; Revelli and Viviani, 2015). In sum, the more a fund screens out a large pool of firms or even entire industries, the more it will be characterized by less diversified portfolios and will potentially underperform. On the other hand, the broader the investment scope or the more a fund selects best ethical performers among their industry competitors, the more capital is attracted and the better are return results in the future.

2.2 The Link between Corporate Environmental and Financial Performance

Far more conclusive results have been found for firm level data. A growing body of literature has analyzed environmental, societal and corporate governance (ESG) criteria of individual corporations and in particular addressed the question whether strong environmental performance correlates with strong corporate financial performance. In summary, the environmental factor "E" has demonstrated a strong positive correlation with stock outperformance, i.e. 'it pays out to be green' (Diltz, 1995; Hamilton, 1995; Cormier and Magnan, 1997; Yamashita, Sen, and Roberts, 1999; Konar and Cohen, 2001; Al-Tuwaijri et al., 2003; Guestner, Derwall, Bauer, and Koedijk, 2006; Hassel and Semenova, 2008; Flammer, 2013). It can be argued that firms with harmful environmental practices carry implicit environmental liabilities (Cormier and Magnan, 1997). It puts firms at risk of protest by activist groups, aversion by consumers, negative media coverage, and general degradation of their reputation (Fombrun et al.,2000; King and Lenox, 2000). Firms with poor environmental performance may also risk serious industrial accidents that result in large regulatory fines, costly lawsuits, and even the shutdown of operations (Perrow, 1984; Rees and Wackernage, 1994). Therefore, 'greenness' is associated with lower insurance costs, as well as enhanced learning and innovation, improved operational efficiency and better relationships with stakeholders that can offset the costs of implementing environmental strategies (Porter and van der Linde, 1995; Hart and Ahuja, 1996; Klassen and McLaughlin, 1996; Russo and Fouts, 1997; Klassen and Whybark, 1999; Konar and Cohen, 2001; King and Lenox, 2002; Guenster, Derwall, and Koedijk, 2011).

Blank and Daniel (2002) extend the previous literature and compare a self-composed environmentally screened portfolio with a regular investment portfolio and find that the equally weighted eco-efficiency portfolio delivered a somewhat higher Sharpe ratio than the S&P 500 index during 1997 and 2001. An extension to this study by Derwall, Guenster, Bauer, and Koedijk (2005) finds that the most eco-efficient firms deliver significantly higher returns than less eco-efficient firms (6% p.a. during the period 1995-2003) concluding that using environmental information could help to improve portfolio performance. The concept of eco-efficiency used in their studies is a relative measure of environmental performance and can be defined as the economic value the company generates by producing products relative to the waste it produces in the process of generating this value. Their definition allows them to create a broad portfolio also consisting of environmentally sensitive industries, such as mining, chemical, and energy. Even firms that are often considered to be high polluters but do well relative to their competitors are included.

2.3 The Performance of Green Mutual Funds

As previous research has confirmed a clear positive link between corporate environmental and financial performance, one may suspect that superior returns will also be reflected on aggregated fund level. Whereas the firm level debate concerns the question if costs of implementing environmental strategies can be exceeded or at least be offset by financial returns, mutual funds strive to maximize performance across a portfolio of firms rather than within a single firm. Besides a large pool of SRI fund literature, we could identify seven studies examining solely thematic green funds. The first study considering the specific case of environmental funds was undertaken by White (1995). He studies green funds from the German and the US market and finds that German green funds do not show performance differences compared to the German stock market as a whole. By contrast, US green funds experience lower performance results relative to conventional US and other SRI indices. Climent and Soriano (2011) as well as Chang et al. (2012) find similar results for the underperformance by the US green fund universe. When narrowing the overall time frame of 1987–2009 and focusing on a more recent time period, 2001-2009, Climent and Soriano (2011), however, find evidence that also US green funds did not perform significantly different from the rest of SRI and conventional mutual funds. They point out that before 2001 their green portfolio consists of new funds only, whereas after 2001 over half of their green funds are well established and better diversified. This is consistent with the so called 'learning effect' noted by some authors (Bauer et al., 2006, Revelli and Viviani, 2015). They argue that performance deviations between screened and conventional investments may only be transitory as long as they go through a catching-up phase. With data of 18 US and 89 European environmental funds from 1994 to

2013, Muñoz et al. (2014) provide empirical support for a broader sample and a time period exceeding the global financial crisis. Their findings indicate that green US and European funds do not perform significantly different from other forms of SRI mutual funds considering both, normal and crisis periods. Even when applying a dynamic mean-variance model as a complement to traditional asset pricing models on a US, European, and Japanese portfolio of green, SRI and conventional funds between 2000 and 2009, Ito et al. (2013) find no performance differences or just slightly superior risk-adjusted returns of green funds compared to conventional funds. In addition to previous work, Ibikunle and Steffen (2015) compare not only green and conventional, but also 'black' i.e. fossil energy and natural resource funds in Europe. While European green funds do not show performance differences to 'black' funds, the study finds evidence for an underperformance of green mutual funds compared to their conventional counterparts. Disaggregating the green portfolio into different sectors, Adamo et al. (2014) provide some descriptive statistical analysis of performance and volatility measures of 257 global green funds. The authors compare green funds across different sectors as well as with their sector index. Apart from the natural resources sector, the results show that total returns are positive for all sectors and especially high in healthcare (17.76%). A positive Sharpe ratio was found for the healthcare sector (1.18) and for the ecology sector (0.16). Funds of these sectors could achieve, on average, a higher return than the risk free asset. On the contrary, the alternative energy sector (-0.36) and the natural resources sector (-0.08) experienced lower returns than the risk free asset. To conclude, the majority of empirical research on environmental fund performance demonstrates that green funds do not show significant return differences to non-green fund investments.

2.4 Mutual Fund Risk

The just mentioned paper by Adamo et al. (2014) does not only compare returns and Sharpe ratio within the green fund market but also touches upon the issue of green fund risk. The authors present the standard deviation of green fund returns and find that it does not largely deviate across the sectors analyzed. Apart from that and to the best of our knowledge, there exists no literature, which analyzes thematic green fund risk in comparison to conventional funds. Instead, we can make use of SRI studies, although rather limited, that address the issue of fund risk. Applying social screens will limit the investment set to an ethical investment universe. According to the *traditional asset-pricing theory* and *modern portfolio theory* (Markowitz, 1952) that rely on the efficient market hypothesis, one may predict that social investors suffer from limited diversification possibilities and constraints on the risk-return optimization. In other words, the mean-variance frontier shifts down towards less favorable risk-return tradeoffs resulting in diversification costs (Clow, 1999; Le Maux & Le Saout, 2004; Girard et al., 2007). Geczy et al. (2005) test diversification costs of an SRI portfolio and find that restricting the investment universe can create significant risk-return costs for a mean-variance optimizing investor: the financial cost of the SRI constraints, as measured by differences in Sharpe ratio, is found to be five basis points per month for an investment evaluated based on the Capital Asset Pricing Model (CAPM). In case an investor believes in the Fama French three-factor or Carhart four-factor asset pricing model instead of CAPM, the SRI constraint imposes even higher diversification costs.

Instead of an ethically screened fund portfolio, a fund can also invest in one particular industry or sector. In a similar manner, this will result in a narrow investment focus and studies on those funds may allow us to draw some additional conclusions for green funds. The basic reasoning is analogical to the one from before. Sector funds tend to be more volatile due to homogenous risk in their holdings and limited diversification possibilities (Kaushik et al., 2014). Indeed, the results by Khorana and Nelling (1997) suggest that sector funds exhibit higher levels of idiosyncratic risk, which in turn implies that they should not be the only asset in an investor's portfolio. Claiming that socially screened funds are biased to one or a smaller number of sectors due to their selective investment approach, Clow (1999) has shown that sectorally focused SRI funds face higher risk exposure than conventional funds. To sum up, previous research reveals that limiting the investment horizon should be reflected in increased idiosyncratic fund risk as a larger amount of firms or industries is excluded from the investment pool.

3 Derivation of Hypotheses

Based on past literature and current trends in green investing we derive two hypotheses dedicated to green fund performance and green fund risk. We begin with some theoretical argumentation as well as a fact-based motivation to underpin the performance of green funds (*hypotheses 1.1 and 1.2*). Following, we discuss the potential characteristics and development of green fund risk (*hypotheses 2.1 and 2.2*).

Funds combining both investment targets, financial and environmental, have seen neutral performance results in past empirical studies. Further, given a potential strength of thematically specialized fund managers in line with the *over-performance hypothesis* and a positive link between environmental and financial performance according to the *stakeholder theory*, we have reason to believe in an overall solid performance of green mutual funds compared to their conventional counterparts.

According to the *over-performance hypothesis*, skilled fund management specialized in a certain investment area such as environmental investing may be better equipped to form a portfolio able to compete with or even outperform the market portfolio (Admati et al., 1994; Diltz, 1995a, b). It is largely fund managers' stock-picking skills and diversification possibilities while minimizing active management costs that are key determinants of fund performance (Friedman, 1970; Luther et al., 1992; Hudson, 2006). The paper by Gil-Bazo et al. (2008) confirms the ability of a specialized fund management to outperform conventional funds. Looking at the specific skills of green fund managers, green funds may in general be managed by a more forward-looking investment approach, thus return promising in the long run. Green fund managers apply thematic screenings to capitalize future trends, i.e. identify future winners, which puts them in clear contrast to the more widely used approach of market-capitalization investing where more attention is given to past winners that are assumed to continue to win out (Inderst et al., 2012). Moreover, environmental fund managers may be more personally inclined towards green investing and to act in investors' interests resulting in strong performance results. The *stakeholder theory* (Freeman, 1984) additionally foresees positive returns when taking stakeholder expectations into account. Sound environmental performance signals good managerial quality that translates into favorable financial performance. For example, positive goodwill from superior environmental agendas will result in economic and financial success over longer horizons. Key assumption is that stock markets misprice information on environmental efficiency in the short run as it rather reflects how well a company performs in the long run.

On the other hand and in clear contrast to the over-performance argumentation, one may expect green investors to accept a lower rate of return from environmentally responsible investments as they derive non-financial utility. Investors care about non-financial attributes of their investments and are willing to accept suboptimal financial performance in order to satisfy their personal values related to environmental responsibility (Chami et al., 2002; Benson and Humphrey, 2008; Renneboog, Horst, Zhang, 2008). Recent studies show that money flows into and out of SRI are less sensitive to lagged negative returns attracting more stable investors than those of conventional funds (Bollen, 2007; Renneboog et al., 2005; Benson and Humphrey, 2008; Renneboog, Ter Horst, and Zhang, 2011). The US Social Investment Forum (2003) also states that investments by social investors are typically 'stickier'.

Combining previous literature and theoretical discourse regarding an environmentally concerned investment approach with the idea that green investors are more inclined to stay with the same fund, green funds are well prepared to compete with conventional funds in terms of performance. We thus hypothesize:

- *Hypothesis 1.1: The performance of green funds is not worse than that of conventional funds.*

A positive regulatory environment in favor of green investments may additionally contribute to a growing interest in green funds as an asset class, potentially fostering improved performance over the last years (Renneboog et al., 2008). Many governments in Western countries and mostly in Europe have implemented regulatory initiatives to stimulate environmental responsibility. To mention some examples, in Germany the Renewable Energy Act has given a tax advantage to closed-end funds to invest in wind energy. In the Netherlands, the Dutch Tax Office introduced a 'Green Savings and Investment Plan', which applies a tax reduction for green investments in wind and solar energy as well as organic farming (Eurosif, 2003).

In addition, a growing awareness in the population and political pressure have encouraged and will likely continue to encourage green investments, resulting in performance improvements over time. Especially the Kyoto Protocol (1997) and annual UN Climate Change Conferences have brought the issue of climate change and the reduction of greenhouse gas emissions into binding climate action to be undertaken by participating countries. The members of the most recent conference in Paris (2015) agreed on reducing their carbon emissions to keep global warming below 2 degrees Celsius while recognizing a 1.5 degree pledge as the desirable target. Climate concerns among the population have also been shown in an increased number of private actions. The organization 350.org for instance runs succeeding fossil-free campaigns aiming to bring public institutions such as municipalities, universities and churches to stop using and investing in fossil fuels.

Summarizing, an increasingly favorable regulatory environment of green funds combined with growing political pressure and awareness in the population has led to an increased interest for green funds over time. Thus, we hypothesize:

- *Hypothesis 1.2: The performance of green mutual funds has improved over time.*

Environmental screening does not only impact a fund's performance but also imposes constraints on the investment universe, thus affects a fund's risk profile. Limiting the investment set to a green universe, according to the *traditional asset-pricing theory* and *modern portfolio theory* (Markowitz, 1952) one may predict that green investors suffer from limited diversification possibilities and constraints on the risk-return optimization.

Moreover, many green funds manage a concentrated portfolio in a particular industry (e.g. Calvert Global Water Fund as a water-based mutual fund) or emphasize smaller companies particularly in green industries such as solar, wind, and biofuels that are often early-stage firms, thus carry the risks common to all small-cap growth stocks (e.g. EIC Renewable Energy Fund concentrated in alternative energy). Bloomberg New Energy Finance (BNEF, 2012, 2014, 2015) shows that the underperformance of green indices in 2011 is likely due to the overcapacity in the wind and solar manufacturing sector and that funds solely focusing on renewable energy performed worse than broader environment funds. Investigating 194 thematic environmental funds affirms that least diversified funds were hit the hardest during the recent financial crisis (Novethic SRI Research Center, 2012).

In addition to the basic diversification argument, environmental investments might be more vulnerable to policy changes. Sullivan (2011) explicitly discusses the main uncertainties perceived by investors of low-carbon climate resilient projects. A ranking of the most significant risks based on the results of an expert roundtable conducted by Standard & Poor's shows that policy risks are amongst the highest ranked risks. Longevity risk ranks on first place. Longevity risk is described as concerns about the relatively short time frame of climate change regulations or policies (e.g. financial incentives for photovoltaics), compared to the long-term commitment periods required for capital investments. This is followed by risks from policy changes, whether legitimate or illegitimate, and risks that rules are not fully binding or difficult to enforce (Kennedy, 2012).

As a result, as green funds are based on a limited investment horizon due to their screening activity and potential sector focus, likely more biased towards small-cap and growth stocks as well as significantly affected by policy changes, we hypothesize that those funds are more subject to outside shocks and therefore carry more idiosyncratic risk than their conventional peers. We derive our hypothesis as follows:

- *Hypothesis 2.1: Green funds are riskier than their conventional counterparts due to limitation of diversification.*

At the same time, we see an increased number of firms 'going green' and green firms to spread over a larger range of sectors and over different geographic locations. Green business as of today is not only concentrated in the energy and technology sector but has also experienced a strong growth in construction, industrials and consumer goods for instance. Growth rates for US green consumer goods and services have been rising faster than conventional products, outpacing the overall economy according to the green opportunity report by Green America (2013) surveying over 1.300 businesses. To mention one example, in 2005, green building represented 5% of the US construction market and since then has grown to 38% by the end of 2011. Moreover, green growth is not only a US and European phenomenon as the lead in clean technology has shifted to Asia in more recent years (IMF, 2011). As a result, we predict the investment horizon to broaden over time providing better diversification possibilities and lower risk of green funds. Hence, our last hypothesis is as follows:

- *Hypothesis 2.2: Over time, the risk of green funds has decreased.*

4. Data

We evaluate a sample comprising an equal amount of green as well as conventional mutual funds in terms of performance and risk. We perform our analysis on US basis from a local investor perspective: the green and conventional fund universe is denoted in US dollars evaluated against US benchmark factors while using a local 30-day US Treasury bill rate as the risk-free measure. We are able to retrieve the benchmark factors as well as the risk free rate on a daily basis from the Kenneth R. French Data Library.

Regarding our green fund sample, we follow the definition of Morningstar regarding green investments and thus include those funds selectively invested in environmentally friendly firms, regardless of industry or sector. Consulting different sources of service providers such as Morningstar, the Wall Street Journal, CNBC, ECOreporter as well as Bloomberg we are able to extract a list of funds that correspond to the definition of green. We then cross-check each of these green funds for data availability with respect to prices and other fund characteristics required for our analysis. Thereby, Morningstar and Thomson Reuters Datastream serve as our main source of information and we exclude all green funds from our sample with no data availability. Since we are performing an analysis over time with yearly performance and risk evaluation, we restrict our sample to include only those funds that are still active and at least 12 months of age. Moreover, our analysis focuses on actively managed funds only and thus we exclude index funds from our sample. We finally end up with a number of 101 green funds.

As Morningstar provides information on the investment style of mutual funds, we are able to classify investments according to market capitalization as well as growth and value factors of the underlying stocks. We use these criteria to randomly collect a sample of conventional funds that match the green fund sample. This method helps us to overcome the difficulty of selecting only a very small amount of conventional funds relative to the vast amount of conventional funds available by dividing the conventional fund universe according to the investment style first. This results in a final sample of 202 green and conventional funds, for which we retrieve handpicked information about size, age, management tenure, sectoral and regional holdings as well as other fund characteristics from the Morningstar database. Daily price information and the daily Total Expense Ratio (TER) as a measure for mutual fund fees are provided by Thomson Reuters Datastream. Our fund data spans a period of 14 years from January 2, 2002 to December 31, 2015.

For the analysis with regards to the impact of fossil fuel holdings on fund performance and risk we are only able to test a subsample of our funds. Due to the fact that the fossil fuel movement in the area of finance is a rather new topic, data availability on fossil fuel holdings on fund level is scarce. Nevertheless, with the help of the financial service provider Fossilfreefunds.org and by consulting the respective funds' websites we are able to retrieve a subsample of 101 funds for which we have information about their fossil fuel status.

In Table 1, we provide summary statistics on our overall fund sample as well as on the subsample for which information on the fossil fuel status of the funds are available. The table shows an overview for the green and conventional portfolios, respectively. The full sample comprises of two equally weighted portfolios, with 101 funds in the green as well as in the conventional portfolio. The subsample comprises of almost equally weighted portfolios. The green sub-portfolio consists of 49 funds where 18 funds have fossil fuel holdings. The conventional sub-portfolio is made of 52 funds of which 40 funds hold fossil fuel shares. As 77% of the conventional funds have fossil fuel holdings compared to only 37% in the green fund portfolio, green funds seem to be more concerned about investing in fossil fuels recognized as an important driver of climate change.

We can observe that all funds of our portfolios are either domiciled in the United States or in Europe and are mainly invested in equity (on average more than 90%). The conventional portfolios show higher mean excess returns compared to the green portfolios, indicating better performance, on average, of the former. Regarding the whole sample of funds, the conventional portfolio has average excess returns of 0.064% compared to an average of 0.016% in the green portfolio. This holds true for the subsample the like where the conventional portfolio shows on average 0.025% higher excess returns than the green portfolio. Furthermore, green funds, on average, charge higher fees than conventional funds, as indicated by a larger total expense ratio in both samples.

TABLE 1: Descriptive statistics for the green and conventional portfolio

		Full sample		Subsample	
		Green	*Conventional*	*Green*	*Conventional*
Number of funds		101	101	49	52
Number of fossil fuel holdings				18	40
Domicile	USA	23	41	23	22
	Europe	78	60	26	30
Average equity holdings		93	91	95	94
Mean excess return (%)		0,016	0,064	0,001	0,026
Mean total expense ratio (TER)		1,7	1,5	1,7	1,4
Size (USD million)	mean	308	499	236	715
	median	143	170	148	240
Age (years)	mean	11	14	13	16
	median	9	13	9	15
Management tenure (years)	mean	7	7	9	7
	median	6	6	8	6
# of funds with top holdings in the following sector	Technology	27	21	16	11
	Industrials	36	13	17	7
	Utilities	6	0	6	0
	Healthcare	10	8	0	6
	Financial Services	11	22	5	9
	Consumer Cyclical	3	20	2	8
	Consumer Defensive	5	6	2	2
	Basic Materials	3	3	1	3
	Retail	0	1	0	0
	Energy	0	5	0	4
	Real Estate	0	2	0	2
# of funds with top holdings in the following region	USA	59	56	33	28
	Europe	36	36	14	18
	Asia	6	3	2	1
	Others	0	6	0	5

This table reports the summary statistics for each portfolio (green and conventional) of our overall sample as well as our subsample for which data on fossil fuel holdings are available. The table shows the number of funds comprising each portfolio, the number of funds domiciled in the United States and Europe, mean daily excess returns in percent, mean daily total expense ratios (TER), the mean and median for size in million USD (measured as total assets under management), for age in years (since inception date) and for tenure of current management in years. Further, the table presents the number of funds with top holdings in different sectors and regions.

Moreover, in terms of size, conventional funds are, on average, larger with USD 499mn total assets under management compared to green funds with an average of only USD 308mn assets under management. This observation is even stronger in the subsample with conventional funds managing on average USD 715mn compared to USD 236mn under green management. However, the conventional portfolio seems to contain very large funds as indicated by a median of USD 240mn.

We can observe that, in general terms, green portfolios are younger than conventional portfolios. For example, the green portfolio contains funds that present a median age of about 9 years (9 years in the green sub-portfolio as well), whereas the conventional portfolio is older, with a median age of about 13 years (15 years in the conventional sub-portfolio). The case for management tenure measured in years, gives different insights. Apart from a small difference in means within the subsample, both green and conventional portfolios have a management tenure of about 7 years on average.

Regarding top holdings in a specific sector such as technology, industrials, utilities, healthcare, financial services, consumer cyclical, consumer defensive, basic materials, retail, energy and real estate, we find that the technology sector plays an important role both in the green and conventional portfolio. For the full sample, green fund investments are mainly concentrated in the following sectors: industrials (36% of the funds have their top holdings in this sector), technology (27%), and financial services (11%). At the same time, 22% of the conventional funds have their top holdings in financial services, 21% in technology and 20% in consumer cyclical. Even though the sectoral dispersion slightly differs in the subsample, the technology sector plays an equally important role for investment.

When looking at the regional dispersion of holdings, it becomes apparent that a majority of funds in all portfolios has major holdings in the United States, followed by major holdings in Europe. For example, in the full sample 58% of the green funds have top holdings in the US (55% in the conventional portfolio) and 36% of the green funds are mainly invested in Europe (36% of the conventional funds as well). Contrary, only a small amount of green and conventional funds have major holdings in Asia (6% and 3% respectively) or in other regions of the world such as Canada, Africa/Middle East, Australia and Latin America (none of the green funds and 6% of the conventional funds). This indicates that the United States are the most important market for investing, both for green as well as conventional funds, followed by the European market, while Asia and other markets only play a minor role in attracting investment.

To consider potential relationships among the variables in our empirical model, we present pairwise correlations between the general control variables and the variables of interest relevant for our analysis. Table A1 shows a correlation matrix for the full sample and Table A2 for the subsample, respectively. For both samples, the correlations are generally as to be expected. We find for example a positive relationship between fund size and age indicating that older funds tend to be bigger. The negative relationship between size and total expense ratio as well as between age and total expense ratio is also intuitive, such that older and larger funds can make use of experience and economies of scale to charge lower fees. The negative correlation coefficient for green and size and green and age shows that green funds tend to be younger and smaller. We furthermore find a positive relation between the factor green and TER as well as sectorally focused, so that green funds tend to charge more and are likely to focus on a certain sector. The relatively strong negative correlation between green and fossil confirms our assumption from before that green funds are concerned with fossil fuel aspects. Only one correlation coefficient namely between top holdings in Asia and top holdings in Asia as well as being green, shows a value slightly greater than 80%. This however can be attributed to the fact that only very few funds of our sample have major holdings in Asia and of those two thirds are actually green. Overall, however, despite a few high correlations between the regional dummies and their interaction terms, multicollinearity does not appear to be a serious concern as most correlation coefficients are low in both samples.

5. Methodology

In order to estimate differences in performance and idiosyncratic risk between green funds and their conventional peers, earlier studies compare either means of groups or use the so-called matched-pair analysis. Since we are not only interested in comparing the difference in performance and risk, but also in identifying determining factors, we will use a different approach. We apply dummy variables to filter out risk and performance differences within our sample. In our analysis, we follow a two-step procedure in the spirit of Fama and MacBeth (1973). In the first step, we make use of the four-factor performance model to measure abnormal performance and risk of each fund in a time-series estimation, both for the whole time period of 14 years as well as for each year separately. In a second step, we apply a cross sectional regression to test the effect of additional variables on the performance and risk measures obtained from the previous step.

5.1 Four-Factor Asset-Pricing Model

The academic literature has proposed different performance measures of risk-adjusted returns such as the Treynor measure (Treynor, 1965), the Sharpe ratio (Sharpe, 1966) and Jensen's alpha (Jensen, 1968). We will use the latter as our measure for abnormal fund performance. This performance measure can be estimated by either single-index or multi-factor models. However, due to repeated discussion about the inability of the single index model to sufficiently capture the cross-section of fund returns, we follow most recent empirical studies and estimate Jensen's alpha from the Carhart four-factor model (Carhart, 1997). Formally, we estimate the following regression model:

$$r_{i,t} = \alpha_i + \beta_{i,t} RMRF_t + \mu_{i,t} SMB_t + \delta_{i,t} HML_t + \rho_{i,t} MOM_t + \varepsilon_{i,t} \qquad (1)$$

As an extended version of the single-index CAPM model, the Carhart four-factor model does not only include the three factors proposed by Fama and French (1993), namely market (RMRF), size (SMB), and book-to-market (HML), but an additional momentum factor (MOM) that is able to capture the momentum strategy proposed by Jegadeesh and Titman (1993). In the above expression, $r_{i,t}$ stands for the return in excess over the risk free asset for fund *i* at time *t*, the coefficients $\beta_{i,t}$, $\mu_{i,t}$, $\delta_{i,t}$ and $\rho_{i,t}$ represent the factor loadings for fund *i* at time *t* and α_i represents Jensen's alpha. $RMRF_t$ is the return on excess of the market at time *t*. SMB_t represents the difference in return between a small-cap and a large-cap stock portfolio at time *t*, HML_t captures return differences between a value stock portfolio and a growth stock portfolio at time *t*, and MOM_t reflects the return difference between the previous year's winning stock portfolio and the losing stock portfolio at time *t*. The four-factor model is therefore able to take into account the investment style of a fund that is said to impact performance. Finally, $\varepsilon_{i,t}$ is the error term in the estimation.

We also investigate the risk of our fund sample and focus on idiosyncratic risk. We obtain the idiosyncratic risk as measured by the standard error from the above mentioned four-factor regression for each fund i. We estimate Jensen's alpha as well as the idiosyncratic risk both yearly and over the entire sample period with daily observations, respectively.

5.2 Cross-Sectional Models for Green Fund Performance

Previous research has demonstrated that a fund's performance is crucially impacted by its fund characteristics such as size, age, management tenure and expense ratio (Carhart, 1997, Chan et al., 2004, Kaushik, 2014). In our cross-sectional analysis, we have to account for such attributes as they knowingly vary across funds and play a significant role in explaining abnormal returns. Therefore, we apply the general cross-sectional model with five control variables:

$$\alpha_i = \gamma_{0,i} + \gamma_{1,i}Size_i + \gamma_{2,i}Age_i + \gamma_{3,i}Tenure_i + \gamma_{4,i}TER_i + \gamma_{5,i}GREEN_i + \varepsilon_i \qquad (2)$$

In the above model, α_i represents Jensen's alpha for fund *i* estimated over the whole time period of 14 years, $\gamma_{j,i}$ ($j \in 1, 2, \ldots, 5$) stand for the factor loadings of the control variables fund size ($Size_i$), fund age (Age_i), tenure of current management ($Tenure_i$), total expense ratio (TER_i) and the factor green ($GREEN_i$), which takes on 1 if fund *i* is green and 0 otherwise. Size, age and tenure show non-normal skewness and kurtosis and therefore their values are included after taking natural logarithms. ε_i, as in all the following models, represents the error term of the estimation.

With *age*, a fund accumulates experience and moves along the learning curve (Bauer et al., 2002; Barnett, 2006). We therefore expect a positive relationship between fund performance and age. Fund *size*, as proxied by net total assets, is likely to further positively impact fund performance. Due to economies of scale in fund management, such as dividing information collection costs as well as costs of investor acquisition and communication among a greater asset base, larger funds may show stronger performance results than smaller funds. With increasing trading volume and a better market position, larger funds might be able to negotiate more favorable brokerage commissions and spreads (Ferreira et al., 2007). Similar to a fund's age, the *duration of a fund manager's term* reflects experience in adding value for investors and to handle risks important in any mutual fund (Morningstar, 2007). We expect higher alphas with increasing management tenure. Additionally, higher *management fee*, measured by average total expense ratio (TER) might indicate more active fund management and higher skilled fund managers, thus better fund performance. On the other hand, high fees may also be an indicator of bad performance (Dahlquist et al., 2000; Kaushik et al., 2014; Carhart, 1997). The *green* dummy variable captures performance differences between green and conventional funds and is of major interest in our analysis.

Besides the above mentioned control variables in our general setting, we want to identify the effect of other factors on fund performance, thus we are extending the general setting by adding other variables of interest to capture regional, sectoral and fossil fuel effects in three additional estimations.

First, we want to filter out performance differences between green funds mainly invested in the US, Europe, Asia and the rest of the world compared to the reference group of conventional funds invested in those regions. Over half of global investment fund net assets are managed by mutual funds in the United States as reported by the Investment Company Institute (2015). We therefore expect a greater potential of assets available for green equity financing in the US than in other markets. Moreover, Europe has traditionally been a market that to a large extent supports the development of green technologies through governmental funding, while Asia has been on the rise to push green development in recent years. Accordingly, we estimate the following regression:

$$\begin{aligned} \alpha_i = \ & \gamma_{0,i} + \gamma_{1,i} Size_i + \gamma_{2,i} Age_i + \gamma_{3,i} Tenure_i + \gamma_{4,i} TER_i + \gamma_{5,i} GREEN_i \\ & + \gamma_{6,i} EUROPE_i + \gamma_{7,i} ASIA_i + \gamma_{8,i} OTHERS_i \\ & + \gamma_{9,i} EUROPE_{green,i} + \gamma_{10,i} ASIA_{green,i} + \varepsilon_i \end{aligned} \tag{3}$$

where $EUROPE_i, ASIA_i$ and $OTHERS_i$ take on the value 1 if fund *i* has major holdings in that region and 0 otherwise. $EUROPE_{green,i}$ and $ASIA_{green,i}$ are interaction terms springing from the multiplication of the green dummy variable and the respective regional dummy for fund i. There is no interaction term for green funds in other regions included in the model as there are only a few funds with major holdings in other world regions and those are all non-green. The information is therefore captured in the other variables of the model.

Furthermore, we have identified the technology sector as an important investment area for green funds. Besides increased policy support and favorable public awareness, the accumulation of green capital has been led by technological progress and economies of scale (IMF, 2011).

Coping with the challenges of global warming, creative technological solutions to problems such as water and energy scarcity, environmental cleanups and waste reduction, declining biodiversity as well as the need for power derived from renewable energy sources are required. This may have brought significant business and investment opportunities. We will include a dummy variable for top holdings in the technology sector ($TECH_i$), which takes on the value 1 for funds with top holdings in the technology sector and 0 otherwise. As green technology firms are on the rise and typically younger, smaller and with high growth potential we expect the financial performance of green funds allocating most of their assets to the technology sector to be positively associated and include the interaction term $TECH_{green,i}$ to test the following model:

$$\alpha_i = \gamma_{0,i} + \gamma_{1,i}Size_i + \gamma_{2,i}Age_i + \gamma_{3,i}Tenure_i + \gamma_{4,i}TER_i + \gamma_{5,i}GREEN_i + \gamma_{6,i}TECH_i + \gamma_{7,i}TECH_{green,i} + \varepsilon_i \quad (4)$$

Lastly, in light of the fossil fuel divestment movement in which institutions and individuals commit to divest assets involved in extracting fossil fuels (Arabella Advisors, 2015) we want to investigate if funds that have fossil fuel shares perform differently from their reference group. While prices of fossil fuels have been rising, the renewable energy sector has seen a decline in the cost of important technologies in recent years to the point at which they are starting to challenge fossil-fuel alternatives. We would therefore expect to see a better performance of funds that do not hold fossil fuel shares. We are interested in potential performance differences between funds with fossil fuel holdings compared to fossil fuel free funds and to see if green funds that include fossil fuel holdings perform worse than fossil free green funds. We test our subsample by adding a dummy for fossil fuel shares ($FOSSIL_i$) which takes on the value 1 if fund *i* has fossil fuel holdings (0 otherwise), as well as the interaction term $FOSSIL_{green,i}$, that takes on the value 1 if fund *i* is green and has fossil fuel holdings. We test the following model:

$$\alpha_i = \gamma_{0,i} + \gamma_{1,i}Size_i + \gamma_{2,i}Age_i + \gamma_{3,i}Tenure_i + \gamma_{4,i}TER_i + \gamma_{5,i}GREEN_i + \gamma_{6,i}FOSSIL_i + \gamma_{7,i}FOSSIL_{green,i} + \varepsilon_i \quad (5)$$

In addition to our cross-sectional analysis of different factors affecting performance, we conduct an analysis of fund performance over time. Therefore, we estimate the cross-section of performance and standard control variables as in the above setting (2), but for each of the 14 years separately. This allows us to identify possible changes in coefficients over time, with our focus of interest lying on the green aspect.

5.3 Cross-Sectional Models for Idiosyncratic Green Fund Risk

Similarly to the case of performance, a fund's idiosyncratic risk can be impacted by various fund characteristics. Therefore, we control for fund size, age, management tenure, total expense ratio as well as the characteristic of being green. Additionally, we control for a sector as well as regional focus, which both limit diversification possibilities and therefore should have a direct effect on fund risk. Global economic cycles may impact funds differently that solely focus on one market compared to funds with international holdings that can diversify their investments globally (Barnett, 2006). We control for funds that are regionally focused versus globally allocated by adding the dummy $Focus_{Region,i}$ to our model, which takes on the value 1 if fund *i* has more than 75% of investments in one region and 0 otherwise.[3] Additionally, we add the dummy variable $Focus_{Sector,i}$ which takes on the value 1 if fund *i* has more than 50% of its holdings allocated to one sector, 0 otherwise.[4] Similar to the argumentation for regionally focused, funds that are mainly invested in one sector might not be able to diversify away sector specific risk and are therefore more exposed to industry-related shocks, which translates into higher levels of idiosyncratic risk. We estimate the following general model:

$$SE_i = \gamma_{0,i} + \gamma_{1,i}Size_i + \gamma_{2,i}Age_i + \gamma_{3,i}Tenure_i + \gamma_{4,i}TER_i + \gamma_{5,i}Focus_{Region,i} + \gamma_{6,i}Focus_{Sector,i} + \gamma_{7,i}GREEN_i + \varepsilon_i \quad (6)$$

where SE_i corresponds to the idiosyncratic risk of fund *i* and the other control variables capture fund size ($Size_i$), fund age (Age_i), management tenure ($Tenure_i$), management fees measured by the total expense ratio (TER_i) and the green dummy ($GREEN_i$). The coefficients $\gamma_{j,i}$ ($j \in 1, 2, \ldots, 7$) stand for the factor loadings on the latter. Finally, ε_i as in all the following models corresponds to the error term of each estimation, respectively.

As it was the case with performance, we want to identify the effect of other factors on fund risk as well, and therefore we extend the general setting by adding other variables of interest to capture regional, sectoral and fossil fuel effects. We start by examining potential regional effects on idiosyncratic fund risk. We are interested in seeking out potential differences in risk between green funds that are mainly invested in the US, Europe, Asia or the rest of the world compared to conventional funds with major holdings in those regions. The United States have been taking the position at the center of the global financial system and are characterized by a

[3] According to the Morningstar definition, funds with more than 75% invested in one region are considered regionally focused

[4] According to the Morningstar definition, funds with more than 50% invested in one sector are considered sectorally focused

sophisticated and sizably liquid financial market. Thus, funds predominantly invested in the US appear to be better able to identify a sufficient number of green stocks to form a well-diversified portfolio. Besides the United States, we have identified Europe and Asia as the most important markets for green investments. As those markets differ from each other in terms of various characteristics, they obviously offer different investment environments for green funds. Thus, we are interested if differences in world markets transfer into different risk profiles of green funds. To test the matter further, we estimate the following model:

$$\begin{aligned} SE_i = \gamma_{0,i} + \gamma_{1,i}Size_i + \gamma_{2,i}Age_i + \gamma_{3,i}Tenure_i + \gamma_{4,i}TER_i \\ + \gamma_{5,i}Focus_{Region,i} + \gamma_{6,i}Focus_{Sector,i} + \gamma_{7,i}GREEN_i \\ + \gamma_{8,i}EUROPE_i + \gamma_{9,i}ASIA_i + \gamma_{10,i}OTHERS_i \\ + \gamma_{11,i}EUROPE_{green,i} + \gamma_{12,i}ASIA_{green,i} + \varepsilon_i \end{aligned} \tag{7}$$

where $EUROPE_i, ASIA_i$ and $OTHERS_i$ take on the value 1 if fund *i* has major holdings in that region and 0 otherwise. $EUROPE_{green,i}$ and $ASIA_{green,i}$ are interaction terms springing from the multiplication of the green dummy variable and the respective regional dummy for fund i. No interaction term for green funds invested in other world regions is included in the model. The reason for this is that our sample only comprises a few funds with major holdings in regions other than Europe, Asia or the US, and those are all non-green. The information will therefore be captured in the other variables of the model.

Moreover, as a large part of the green funds in our sample have top holdings in the technology sector, we want to examine differences in idiosyncratic risk of green funds mainly invested in this sector compared to their reference group. The technology sector by nature carries high business risk as highly innovative firms are usually characterized as capital-intensive while carrying larger shares of intellectual property particularly in early stages of development. Beyond the riskiness of the technology sector by itself, green technology firms may be more vulnerable to changes in policy regulation (e.g. decisions on the amount of subsidies), compared to their reference group. The following model will be tested:

$$\begin{aligned} SE_i = \gamma_{0,i} + \gamma_{1,i}Size_i + \gamma_{2,i}Age_i + \gamma_{3,i}Tenure_i + \gamma_{4,i}TER_i \\ + \gamma_{5,i}Focus_{Region,i} + \gamma_{6,i}Focus_{Sector,i} + \gamma_{7,i}GREEN_i \\ + \gamma_{8,i}TECH_i + \gamma_{9,i}TECH_{green,i} + \varepsilon_i \end{aligned} \tag{8}$$

where $TECH_i$ takes on the value 1 for funds with major holdings in the technology sector (0 otherwise) and the interaction term $TECH_{green,i}$ as a product of the green characteristic and main holdings in the technology sector, taking on the value 1 if fund *i* is green and focused on the technology sector (0 otherwise).

Finally, we want to test potential effects of the fossil fuel status of funds on idiosyncratic risk. National and international climate regulations, the demand and competition from alternative energy sources as well as private climate campaigns may have put current fossil fuel production at risk. If most global fossil fuel reserves become unburnable or stranded, fossil fuel companies might face significant write-offs in their balance sheets and losses in their stock market valuation. Similar to before, we test if the factor fossil translates into the riskiness of funds and further if green funds that have fossil holdings are riskier than green funds that are fossil free. Therefore we include the dummy $FOSSIL_i$ which takes on the value 1 for fossil fuel holdings (0 otherwise) as well as the interaction term $FOSSIL_{green,i}$ that takes on value 1 for green funds with fossil shares (0 otherwise). We estimate the following model based on our subsample:

$$\begin{aligned} SE_i = \gamma_{0,i} + \gamma_{1,i}Size_i + \gamma_{2,i}Age_i + \gamma_{3,i}Tenure_i + \gamma_{4,i}TER_i \\ + \gamma_{5,i}Focus_{Region,i} + \gamma_{6,i}Focus_{Sector,i} + \gamma_{7,i}GREEN_i \\ + \gamma_{8,i}FOSSIL_i + \gamma_{9,i}FOSSIL_{green,i} + \varepsilon_i \end{aligned} \quad (9)$$

6. Empirical Results and Discussion

The following chapters cover an analysis of mutual fund performance and risk for our sample funds between 2002 and 2015. First, we present the time-series regression results from the Carhart (1997) four-factor model determining the abnormal performance (α) and idiosyncratic risk measure (standard error). In a second step, we analyze the cross-sectional results first over the whole time period and second for each year. We, thereby, evaluate how general fund attributes and other variables of interest affect fund performance and risk in order to filter out the effect of green and the differences among the green and the conventional universe.

6.1 Four-Factor Regression Results

Results for the four-factor model are presented in Table 2. The average of statistically significant α's (5%-significance level) for the green portfolio is -0.0244 while the average of the conventional portfolio is slightly less negative with -0.0184, indicating a better performance of the conventional portfolio. The number of statistically significant α's at a 5%-significance level in the green portfolio amounts to a total of 14 funds, similarly to the number of non-green funds with 19 α's that are significantly different from zero. Of those significant alphas, the majority has a negative sign for both the green as well as the conventional portfolio, which is an indicator for negative abnormal performance in our sample regardless of the portfolio. Overall, however, the majority of α's in the sample is not significant, showing that, on a risk-adjusted basis, there is neither a financial cost nor benefit when investing in green funds over conventional funds. This is in line with previous literature on green fund performance (e.g. White, 1995; Climent and Soriano, 2011; Muñoz et al., 2014). On the other hand, if we acknowledge that green investors gain both financial and non-financial utility from their investment, these results imply that green investor utility may be maximized as they earn competitive returns while maximizing their environmental objective function. The average of statistically significant β coefficients on the market risk premium are positive across all green and conventional funds, and range similarly around a mean market beta of 0.58 for green and 0.63 for non-green. The large majority of statistically significant β coefficients is positive in sign for both portfolios. A significant positive market beta implies an exposure to systematic risk, which is, however, to be expected as our sample predominantly consists of equity funds. Turning to the other coefficients of the four-factor model, we can unveil interesting differences in investment styles (factor loadings) between the green and conventional sample funds. The mean of statistically significant SMB factors sees positive loadings for the green as well as the conventional funds, however different in size (0.08 and 0.04 respectively). In the green portfolio, the majority of statistically significant SMB coefficients has a positive sign, while for the conventional portfolio the number of significant coefficients with positive and negative sign are balanced. This is in line with Ibikunle and Steffen (2015) where the risk exposure of the green funds to the size factor is higher than that of the non-green portfolio. Also, Geczy et al. (2005), Gregory and Whittaker (2007), and Renneboog et al. (2008b) display a significant exposure to the SMB factor by the SRI portfolio relative to the non-SRI portfolio. This suggests that green funds tend to invest more in the smallest listed firms than their conventional reference group. While the statistically significant exposure to the value-style (HML factor) is on average negative for green funds, which would indicate a tendency towards growth stocks, and positive for conventional funds, indicating value stock investments, we find that the number of statistically significant loadings on the book-to-market factor with positive and negative sign more or less hold the balance in the green portfolio, while the majority of coefficient values is positive in sign for the conventional portfolio. Given our sampling method, by construction, the sample of matched conventional funds should have investment style characteristics that are similar to the green funds, but we note that there might be differences between market portfolios and the Morningstar investment categories. Regarding the momentum factor (MOM) we can observe a lower exposure of green funds to a momentum strategy with an average of statistically significant coefficients of -0.07, whereas conventional funds are seen on average to load significantly more on the mimicking momentum factor (-0.02). For both portfolios, the majority of statistically significant coefficients is negative in sign. As a result, green funds are more reluctant to follow recent stock market trends and to chase past winner stocks. This is in line with Inderst et al. (2012) who claim that green fund managers apply a forward-looking investment approach to identify future winners instead of giving enhanced attention to past winners. Our risk measure for idiosyncratic risk, the standard error from the four-factor regression model, appears to be slightly lower, on average, for the green funds (0.90) than for the conventional reference funds (0.93). The minimum and maximum values for each portfolio also show rather similar results, with slightly higher values in the conventional portfolio, as already indicated by the means. As a result, green funds, on average, seem to carry lower diversifiable risk than non-screened conventional funds, suggesting a different outcome than proposed under *hypothesis 2.1*. Green funds were expected to carry higher idiosyncratic risk due to environmental screening activity limiting their investment horizon.

TABLE 2: Results from the four-factor asset-pricing model

	Green			*Conventional*		
	mean	*# positive statistically significant at 5% level*	*# negative statistically significant at 5% level*	*mean*	*# positive statistically significant at 5% level*	*# negative statistically significant at 5% level*
Alpha	-0,0244	2	12	-0,0184	3	16
RMRF	0,5849	95	2	0,6283	94	1
SMB	0,0812	36	17	0,0435	30	31
HML	0,0000	27	22	0,0737	34	13
MOM	-0,0709	16	36	-0,0189	24	33
	mean	*max*	*min*	*mean*	*max*	*min*
Standard error	0,9005	1,9991	0,1170	0,9263	2,2234	0,2191

This table reports the average of statistically significant alphas at the 5% level, as well as the number of statistically significant positive and negative alphas (5% level) for the green and the conventional portfolio, respectively. The same is reported for each of the factors in the model (RMRF, SMB, HML and MOM). The table further shows the average standard error as well as the minimum and maximum for each portfolio.

6.2 Green Fund Performance

Following, we examine specific fund attributes that are expected to alter fund performance. We present the cross-sectional results for the effect of general control variables and specific variables of interest on fund performance, first over the whole time period and second for each year.

6.2.1 Factors Determining Green Fund Performance

Table 3 shows the cross-sectional regression results from our general control variable setting (2). It becomes evident that size, age and management fees all have a significant positive impact on fund performance, even though on different significance levels. This is in line with previous literature and confirms our expectation that larger and older funds can translate experience and advantages arising from economies of scale into better fund performance. In this case, if size increases by 1%, fund performance will increase by 0.000028, while a 1% increase in fund age would result in a fund performance increase of 0.000113. For every one-unit increase in management fees, the fund performance will experience an increase by 0.0037 units. This finding confirms that higher fees indicate more active and better skilled fund management and contradicts with findings by Carhart (1997), Dahlquist et al. (2000) and Kaushik et al. (2014) who report that funds charging higher fees perform poorly compared to funds charging lower fees. Tenure of current management shows a negative but insignificant regression coefficient. The same holds true for the green dummy variable whose coefficient is -0.0005 indicating no significant performance differences between green and conventional funds. This is in line with our very first hypothesis that green funds do not perform worse than conventional funds and we are able to confirm some of the findings by White (1995), Climent and Soriano (2011), Ito et al. (2013) as well as Ibikunle and Steffen (2015), however for a more recent time period.

TABLE 3: Regression results for the general cross-sectional model on fund performance

	Constant	Size (log)	Age (log)	Tenure (log)	TER	Green
Jensen's alpha	-0,0498***	0,0028**	0,0112***	-0,0007	0,0037*	-0,0005
t-statistic	-4,9745	2,5338	4,3907	-0,6028	1,6555	-0,1669
p-value	0,0000	0,0121	0,0000	0,5473	0,0994	0,8676
R-squared	0,1286					

This table presents the results from testing the effect of fund size, age, tenure of current management, total expense ratio (TER) and being green on fund performance as specified in equation (2). Size is the natural logarithm of total assets under management of fund i at the end of 2015; Age is the natural logarithm of a fund's age at the end of 2015 since inception date in years; Tenure is the natural logarithm of current management tenure in years; TER is the total expense ratio at the end of 2015; dummy Green is 1 if fund i is a green fund and 0 otherwise. T-statistics, p-values and R-squared of the regression are presented as well. The sample period is January 2, 2002-December 31, 2015. *, **, *** denote significance at 10, 5 and 1%, respectively.

Table 4 shows regression results for the extended model specification of equation (3) which allows for comparison of performance results in different world markets, namely Europe, Asia, the United States and the rest of the world. As has been previously the case, we find a significant positive impact of fund size and age on performance. Total expense ratio also shows a significant positive relation with performance, albeit only on a 10%-significance level. Interestingly, in this model specification the green dummy variable coefficient shows a positive and significant coefficient at the 10%-significance level, indicating the ability of green funds to slightly outperform their conventional counterparts when they are all mainly invested in the United States. Since a great majority of fund assets worldwide are managed in the US, the US market clearly offers great potential for investments in general, but green equity financing in particular. Also, in the wake of the global financial crisis and due to less aggressive policy support, green investments experienced a severe decline in the United States in 2009 but quickly picked up in the following years (Eyraud et al., 2011) which should result in strong performance of green funds over the whole sample period.

The regression coefficients for Europe and Europe & Green are highly significant and take on values of 0.027 and -0.0179, respectively, while Asia, Others, and Asia & Green show no significant results. Overall, we note that the performance gap between green and conventional funds varies in size and sign between the different world markets. Whereas green funds with major holdings in the US significantly outperform their conventional US peers, the performance difference between green and conventional funds in Asia takes on a negative, but non-significant value. Performance differences between green funds mainly invested in Europe compared to conventional funds mainly invested in Europe are even more pronounced with a statistically significant underperformance of -0.0113 by green funds. Historically, Europe has been the market leader in clean technology and green infrastructure investments with a global market share of 45% in 2010. Once world leading, however, investments plunged by more than half to 18% of the global total in 2015. Even though government interventions, in particular through feed-in-tariffs, remained strong in the years following the global financial crisis, European investment continued to decline in 2010 in the wake of the sovereign debt crisis (BNEF, 2015). On the other hand and even though the US and Europe have been the strongest markets to invest in renewable energy since 2004 as recorded by Bloomberg New Energy Finance (2012), green investing can nowadays be considered as a global phenomenon. The share of Asia and Oceania in green investments increased from 28 percent in 2004 to 42 percent in 2010. In 2009, China outpaced the United States in renewable energy investments. Encouraged by governmental financial support and regulation, in the following year, in 2010, China invested more in green projects than whole Europe alone, making it the world leader in the production of photovoltaic modules and wind power equipment. China has also significantly expanded its research and development initiatives and has gained the lead in clean technology patents and Initial Public Offerings in the renewable sector (Eyraud et al., 2011). These developments might help, at least to a certain extent, to explain the differences of green fund performance in these world markets. Our findings on performance differences between green and conventional funds with major holdings in different world markets explicitly extends the research by Muñoz et al. (2014) who examine performance differences between green and SRI funds with major holdings in the US and Europe.

TABLE 4: Regression results for the regional cross-sectional model on fund performance

	Constant	Size (log)	Age (log)	Tenure (log)	TER	Green	Europe	Asia	Others	Europe & Green	Asia & Green
Jensen's alpha	-0,0588***	0,0036***	0,0094***	-0,0011	0,0037*	0,0066*	0,0269***	0,0154	-0,0033	-0,0178***	-0,0215
t-statistic	-6,3595	3,5640	4,0033	-1,0169	1,7773	1,8019	6,3925	1,3319	-0,3656	-3,0444	-1,4963
p-value	0,0000	0,0005	0,0001	0,3105	0,0771	0,0731	0,0000	0,1845	0,7151	0,0027	0,1362
R-squared	0,3083										

This table presents the results from testing the effect of fund size, age, tenure of current management, total expense ratio (TER), being green, being majorly invested in Europe, Asia or other world regions (besides Europe, Asia and the US) as well as being green and majorly invested in Europe or Asia on fund performance as specified in equation (3). Size is the natural logarithm of total assets under management of fund i at the end of 2015; Age is the natural logarithm of a fund's age at the end of 2015 since inception date in years; Tenure is the natural logarithm of current management tenure in years; TER is the total expense ratio at the end of 2015; dummy Green is 1 if fund i is a green fund and 0 otherwise; Europe is 1 for funds with major holdings in Europe and 0 otherwise; Asia is 1 for funds with major holdings in Asia and 0 otherwise; Others is 1 or funds with major holdings in other world regions, 0 otherwise; Europe & Green is 1 for funds with major holdings in Europe and being green at the same time, 0 otherwise; Asia & Green is 1 for funds with major holdings in Asia and being green at the same time, 0 otherwise. T-statistics, p-values and R-squared of the regression are presented as well. The sample period is January 2, 2002-December 31, 2015. *, **, *** denote significance at 10, 5 and 1%, respectively.

Table 5 shows the results of estimating model (4). As before, we find a positive and highly significant relationship between both, fund size and performance and fund age and performance, while the coefficients of management tenure and total expense ratio are not significantly different from zero. Funds invested in the technology sector seem to underperform funds of other sectors, as indicated by a coefficient of -0.0098 (significant at the 10% level). The performance gap between green and conventional funds with major holdings in the technology sector would result in an over-performance of green funds by 0.0046, but both the green dummy variable coefficient and the coefficient for the interaction term are not statistically significant. Therefore, we conclude that green and conventional funds with major holdings in the technology sector do not perform differently from each other. Even though green technology firms are typically younger, smaller and with high growth potential, and despite favorable governmental policies and the increasing need for environmentally-friendly technologies, these advantages have not yet translated into distinct performance results. On the other hand, even though environmentally friendly technology is on the rise and becomes a larger share of the technology sector, there is still a vast amount of technology firms not specialized on green technology. Examining green funds mainly invested in the technology sector does not necessarily mean that those funds are invested in young and innovative green-tech growth firms, but also in traditional technology firms that conduct business in an environmentally friendly manner. This could explain why we are not able to confirm our assumptions by our empirical outcomes. We are, however, the first to pick up the idea of Adamo et al. (2014) to examine sectoral differences with regard to green investments.

TABLE 5: Regression results for the sectoral cross-sectional model on fund performance

	Constant	Size (log)	Age (log)	Tenure (log)	TER	Green	Technology	Technology & Green
Jensen's alpha	-0,0468***	0,0030***	0,0103***	-0,0006	0,0036	-0,0017	-0,0097*	0,0063
t-statistic	-4,6379	2,7560	3,9835	-0,5097	1,5870	-0,4735	-1,8081	0,8620
p-value	0,0000	0,0064	0,0001	0,6109	0,1141	0,6364	0,0721	0,3898
R-squared	0,1455							

This table presents the results from testing the effect of fund size, age, tenure of current management, total expense ratio (TER), being green, being majorly invested in the technology sector as well as being green and majorly invested in the technology sector on fund performance as specified in equation (4). Size is the natural logarithm of total assets under management of fund i at the end of 2015; Age is the natural logarithm of a fund's age at the end of 2015 since inception date in years; Tenure is the natural logarithm of current management tenure in years; TER is the total expense ratio at the end of 2015; dummy Green is 1 if fund i is a green fund and 0 otherwise; Technology is 1 for funds with major holdings in the technology sector and 0 otherwise; Technology & Green is 1 for funds with major holdings in the technology sector and being green at the same time, 0 otherwise. T-statistics, p-values and R-squared of the regression are presented as well. The sample period is January 2, 2002-December 31, 2015. *, **, *** denote significance at 10, 5 and 1%, respectively.

Table 6 depicts regression results of model specification (5) for our analysis of the factor 'fossil fuel' on fund performance. In this estimation, we are only able to find a positive significant relationship between fund age and performance. All other regression coefficients remain insignificant. We had reason to believe that we could find empirical evidence on an emerging debate, the fossil-free argument, considered as a powerful tool to mitigate carbon emissions. By September 2014, 181 institutions and 656 individuals had committed to divest over USD 50bn from assets involved in extracting fossil fuels (Arabella Advisors, 2015). As reported by The Guardian (2015), fossil fuel divestment has been the fastest growing divestment movement in history. Proponing beliefs argue that fossil-free investing by a critical mass of institutions and individual investors could create public pressure on policymakers and on companies that are currently involved in fossil fuel extraction to rather invest in renewable energy (Cambridge Associates, 2014). Current price developments show that excluding fossil fuels might actually be financially rewarding. The MSCI ex Fossil Fuels Index outperformed the conventional MSCI world index over the past 5 years according to MSCI research (2016). While prices of fossil fuels have been rising, the renewable energy sector has seen a decline in the cost of important technologies in recent years to the point at which they are starting to challenge fossil-fuel alternatives, even without climate, health and other benefits factored in (BNEF, 2014). In addition, government restrictions on extracting fossil fuels (e.g. closing down of coal plants) as well as carbon regulation to reduce carbon emission in the economy (e.g. carbon tax) might foster investor interest away from fossil fuels towards fossil free investments. All these arguments led us to expect that fossil fuel holdings would translate negatively into fund performance. Additionally, on green fund level we would have expected to find that funds with fossil holdings would show worse performance than fossil free funds. We do not find empirical evidence for either. However, the fossil fuel movement is a rather new concern. Dedicated fossil free funds might currently be in a catching-up phase slowly gaining investors' attention. The issue has only been investigated in empirical research by one other paper (Ibikunle and Steffen, 2015) who find no significant risk-adjusted performance differences between green and so-called black, i.e. fossil fuel funds.

TABLE 6: Regression results for the fossil fuel cross-sectional model on fund performance

	Constant	Size (log)	Age (log)	Tenure (log)	TER	Green	Fossil	Fossil & Green
Jensen's alpha	-0,0489***	0,0017	0,0134***	0,0000	0,0007	-0,0066	0,0042	0,0070
t-statistic	-3,0003	1,0508	3,4364	0,0089	0,0861	-1,2505	0,7956	0,6634
p-value	0,0035	0,2961	0,0009	0,9929	0,9316	0,2142	0,4283	0,5087
R-squared	0,1880							

This table presents the results from testing the effect of fund size, age, tenure of current management, total expense ratio (TER), being green and holding fossil fuel shares on fund performance as specified in equation (5). Size is the natural logarithm of total assets under management of fund i at the end of 2015; Age is the natural logarithm of a fund's age at the end of 2015 since inception date in years; Tenure is the natural logarithm of current management tenure in years; TER is the total expense ratio at the end of 2015; dummy Green is 1 if fund i is a green fund and 0 otherwise; Fossil is 1 if fund i has fossil fuel holdings and 0 otherwise; Fossil & Green is 1 for funds with fossil fuel holdings and being green at the same time, 0 otherwise. T-statistics, p-values and R-squared of the regression are presented as well. The sample period is January 2, 2002-December 31, 2015. *, **, *** denote significance at 10, 5 and 1%, respectively.

6.2.2 The Development of Green Fund Performance over Time

Figure 1 plots the average performance results over all funds for each year. The plot over time fluctuates roughly between +0.05% and -0.05%, with one major spike in 2008 lying far outside of this range. The performance seems to follow a negative downward trend, as performance was positive in the years 2003-2007 but since then has frequently shown stronger negative values. Therefore, the downward trend seems to begin with the global financial crisis in 2007/2008 with a short recovery in fund performance in the year 2009 when average abnormal fund performance recovered from a one-time low of almost -0.15% in 2008 to a positive value of almost 0.05% in 2009. After that, we see negative performance for the years between 2009 and 2012, yet not as severe as in 2008. These years of negative fund performance are most likely the result of the sovereign debt crisis taking place in Europe and covering the same time period. After 2012, fund performance seems to slowly recover as performance fluctuates only slightly around zero.

FIGURE 1: Development of the average Jensen's alpha from 2002-2015

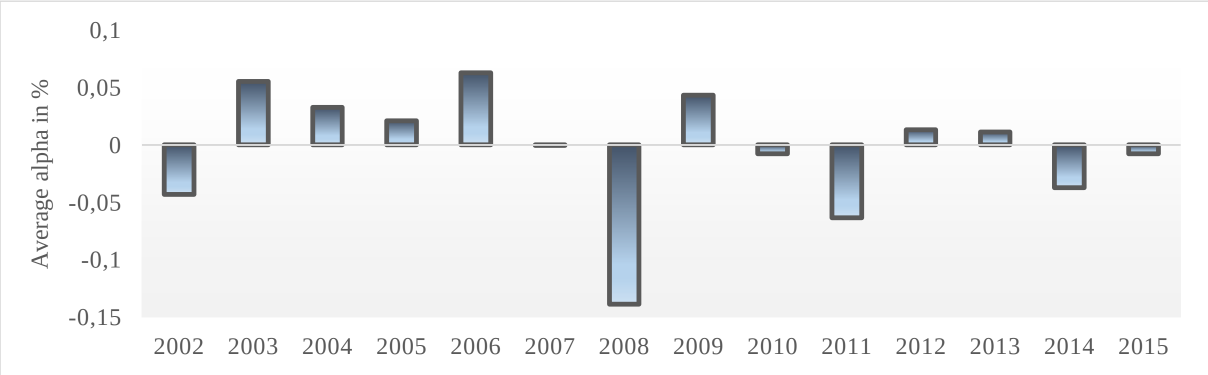


Figure 2 shows the development of the regression coefficient for being green over the same time period. Here however, we note an overall positive trend. The coefficient values roughly lie between -0.015 and +0.015, with two extreme outliers in the year 2007 (0.035) and 2010 (-0.04). Interestingly, green funds seem to have performed better than conventional funds during the global financial crisis in 2007 and 2008. During the European sovereign debt crisis, however, green funds seem to underperform their conventional peers (negative coefficient values for 2009-2012). After 2012, the coefficient takes on positive values and seems to continue with a positive upward trend.

FIGURE 2: Development of the green variable coefficient from 2002-2015

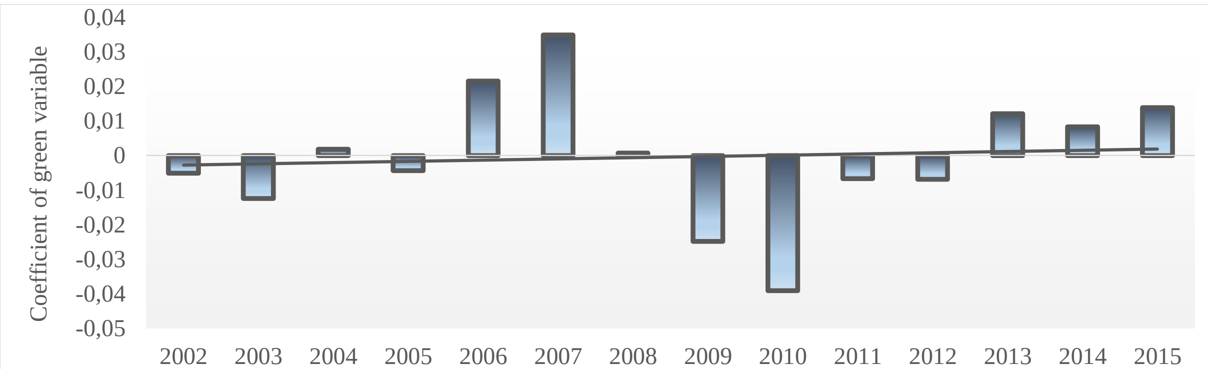


Table 7 shows the yearly regression results for estimating model (2) for each year separately. In fact, the coefficient values for the years 2013-2015 are statistically significant, confirming the positive upward trend that became apparent by looking at the plotted coefficient values. This confirms the prediction of *hypothesis 1.2* that green fund performance is improving over time and even suggests an outperformance of green funds in recent years. We therefore confirm the findings by Ibikunle and Steffen (2015) that also note a discernible improvement of

European green fund returns over time compared to their conventional peers. Moreover, not only do the coefficient values for the last three years show statistically significant results, also the years 2007, 2009 and 2010 are statistically significant. This leads us to confirm what we have already noticed from the plot: green funds were able to outperform conventional funds during the financial crisis in 2007, but performed poorly compared to their non-green peers during the sovereign debt crisis.

TABLE 7: Changes in factors determining performance over time

	Constant	Size (log)	Age (log)	Tenure (log)	TER	Green
2002	0,0186	0,7723***	-0,0040	-0,0014	-0,0066	-0,0052
2003	0,0657*	0,1500	0,0001	-0,0056	0,0054	-0,0124
2004	0,0451*	0,161***	-0,0050	0,0041	0,0044	0,0018
2005	0,0240	0,085*	-0,0024	0,0001	0,0077	-0,0044
2006	0,0513	0,1410	-0,0027	-0,0065	0,0205	0,0215
2007	0,0138	0,1299**	-0,0042	-0,0069	0,0046	0,0349***
2008	-0,1448***	-0,0885	0,0119**	0,0015	-0,0381**	0,0007
2009	0,0358	0,1624**	0,0000	-0,0004	0,0152**	-0,0248***
2010	-0,0297	0,0719*	0,0063***	-0,0001	0,0072	-0,0391***
2011	-0,0945***	0,0004	0,0106***	0,0009	-0,012**	-0,0067
2012	-0,0099	0,0011	0,0029	0,0001	0,0073	-0,0069
2013	-0,0068	-0,0011	-0,0033	0,0009	0,0172***	0,0121*
2014	-0,076***	-0,0005	0,0056***	-0,0004	0,0052	0,0083*
2015	-0,0306**	-0,0008	0,0022	0,0003	0,0032	0,0139***

This table presents the estimated coefficients for size, age, current management tenure, total expense ratio (TER) and the green dummy variable for the cross-sectional regression of the general control variable setting on performance every year (equation 2). The dependent performance measures are the yearly estimated Jensen's alphas. Size is the natural logarithm of total assets under management of fund i; Age is the natural logarithm of a fund's age at the end of year t since inception date measured in years; Tenure is the natural logarithm of current management tenure for each year t in years; TER is the average total expense ratio of year t; dummy Green is 1 if fund i is a green fund and 0 otherwise. The sample period spans yearly from 2002 to 2015. *, **, *** denote significance at 10, 5 and 1%, respectively.

6.3 Green Fund Risk

Now, we turn to examine specific fund attributes that are expected to alter idiosyncratic fund risk. We present the cross-sectional results for the effect of general control variables and specific variables of interest on idiosyncratic fund risk, first over the whole time period and then for each year.

6.3.1 Factors Determining Green Fund Risk

Table 8 presents the results of the multivariate fund risk regression (6) for our general control variables. Mutual fund size has a significant and negative effect on diversifiable risk of our sample funds. As funds become larger by 1%, diversifiable risk is reduced by 0.0006. This is intuitive as larger funds are assumed to be well established and to be able to obtain favorable investment positions not available to smaller funds (Ciccotello and Grant, 1996), thus carry lower diversifiable risk. Mutual fund age is significantly and positively related to idiosyncratic risk. A 1% increase in fund age translates into a 0.0016 increase in fund risk. Even though the performance of younger funds may suffer from a lack of experience during the initial learning period, younger funds may be more attentive and alert to investment opportunities resulting into more carefully chosen and diversified portfolios. The tenure of current management appears to not significantly affect diversifiable risk. We do, however, find a positive and significant relationship between idiosyncratic risk and total expense ratio (TER). Diversifiable risk increases by 0.12 if TER increases by one unit. This might be counterintuitive as higher management fees signal more active fund management that seeks better diversification opportunities than a passive management team. On the other hand, an actively trading fund manager might take on more risk to achieve superior returns in order to justify higher charges. Funds that are regionally focused do not show significant results of affecting diversifiable risk compared to international funds. This is likely due to the fact that most of our sample funds are invested in the US or in Europe. Those regions provide sophisticated financial markets, both in size and market importance, thus a larger pool of stocks to choose from, offering sufficient diversification opportunities. We further find that sectorally focused funds have a significant and positive sign (0.22). This finding is expected as funds heavily invested in one particular sector significantly limit the investment opportunity set and therefore the ability to fully diversify. Comparing the effect of being green on idiosyncratic risk, we do not find a significant relationship. Green funds are not more volatile due to a lack of diversification compared to non-green funds and thus the evidence contradicts *hypothesis 2.1,* which states that green funds carry higher idiosyncratic risk. This is in line with Bello (2005) and Lee et al. (2010) who find no relationship between a fund's diversifiable risk and SRI screening activity. An even highly screened portfolio is able to obtain sufficient levels of diversification. As we can observe from our sample, this is likely due to the fact that the green funds select stocks from a broad investment set. The green sample predominantly consists of funds screening for efforts to operate in an environmentally friendly manner no matter in which industry or region.

TABLE 8: Regression results for the general cross-sectional model on fund risk

	Constant	Size (log)	Age (log)	Tenure (log)	TER	Focus region	Focus sector	Green
Standard deviation	0,6521***	-0,0613***	0,1581***	0,0057	0,1198***	-0,0002	0,2213***	-0,0701
t-statistic	3,6150	-3,0979	3,4742	0,2774	2,9583	-0,0029	2,7980	-1,2535
p-value	0,0004	0,0022	0,0006	0,7818	0,0035	0,9977	0,0057	0,2115
R-squared	0,1914							

This table presents the results from testing the effect of fund size, age, tenure of current management, total expense ratio (TER), being regionally focused, being sectorally focused and being green on idiosyncratic fund risk as specified by equation (6). Size is the natural logarithm of total assets under management of fund i at the end of 2015; Age is the natural logarithm of a fund's age at the end of 2015 since inception date in years; Tenure is the natural logarithm of current management tenure in years; TER is the total expense ratio at the end of 2015; dummy Focus region is 1 if fund i holds more than 75% in one region and 0 otherwise; dummy Focus sector is 1 if fund i holds more than 50% in one sector and 0 otherwise; dummy Green is 1 if fund i is a green fund and 0 otherwise. T-statistics, p-values and R-squared of the regression are presented as well. The sample period is January 2, 2002-December 31, 2015. *, **, *** denote significance at 10, 5 and 1%, respectively.

Turning to Table 9, we examine the effect of investments in certain world regions as tested under model specification (7). Of main interest in this regression is the comparison between green and non-green funds with major holdings in the US as well as how green and non-green funds majorly invested in Europe and Asia, respectively, differ from each other. The general coefficients on fund size, age, TER, and being sectorally focused remain significant and with their respective positive or negative sign. We can further show that idiosyncratic risk in comparison to US investments is slightly positively and significantly related with being majorly invested in Europe (0.44 at a 1%-significance level) as well as strongly positively and significantly related with top holdings in other regions of the world (excluding Europe, Asia and the US, 1.08 at a 1%-significance level). This may be caused by relatively underdeveloped financial markets in other parts of the world consisting of regions such as Latin America and the Middle East as well as in Europe compared to the strength of the US stock market and vast hedging opportunities offered there. Looking at being green and majorly invested in the US, as captured in the dummy green, there exists no significant relationship between diversifiable risk and being a green fund holding top shares in the US. US funds screening for environmental issues are not any riskier than US funds investing in conventional stocks. These findings can be explained by the important role the United States play as a world financial market. Over half of global investment fund net assets are managed by mutual funds in the United States as reported by the Investment Company Institute (2015). Therefore, we can confirm that US focused funds are able to choose from a sufficiently large investment universe, and that being green does not significantly alter diversification possibilities. The same holds true for green European and green Asian funds compared to non-green European and non-green Asian investment vehicles, as captured in the dummy green plus the interaction terms Europe & Green and Asia & Green, respectively. We do not find significant differences in their risk exposure. Overall, we find a risk gap between green and conventional funds with major holdings in the US (0.0217), between green and conventional funds majorly invested in Europe (-0.0728) as well as a risk gap between green and conventional funds in Asia (0.1755), however neither of these gaps turn out to be statistically significant, concluding that there are no differences between green and conventional funds throughout the world regions.

Specification (8) tests the impact of funds mainly invested in the technology sector with specific focus on the effect of being green (see Table 10). Sign and significance of all general control variables do not alter compared to our previous results. Green funds that allocate their highest share to technology appear to not differ significantly from non-green technology funds. This implies that green technology does not, as first expected, carry higher risk than their conventional peers. As we can argue from our sample, green funds that mainly invest in the technology sector do not predominantly hold young and innovative growth firms, but rather invest in large and mid-cap, thus established technology firms as well as in a well-balanced mix of growth, blend, and value firms that conduct business in an environmentally-friendly manner. This could explain why we are not able to empirically confirm our assumptions.

Lastly, we turn to the fossil fuel model specification (9) where we are interested in whether holding fossil fuel shares can significantly impact a fund's exposure to diversifiable risk (see Table 11). The coefficient outputs of all general control variables do not change compared to the full sample, with two exceptions. For the first time we can observe significant results for the variable Focus region, however only at a 10%-significance level, and the Green variable (1%-level). This is interesting since now screening for green appears to reduce idiosyncratic risk of mutual funds by 0.54. Considering the fossil fuel variable in isolation, a negative and significant sign at the 10%-significance level indicates that having fossil fuel shares in the investment portfolio is actually able to reduce diversifiable risk. The results imply that funds may still need fossil fuel companies in order to build a well-diversified portfolio regardless of the increasing pressure on fossil fuel extraction and rising competition from renewable energy sources. We note that the divestment movement is a rather recent phenomenon that has likely not been reflected in financial stock returns yet. The same holds true when specifying the universe to green funds. Fossil fuel holdings of green funds can slightly decrease the exposure to idiosyncratic risk with a risk gap between green and conventional funds holding fossil fuel shares of -0.0441 (statistically significant at the 1%-level).

TABLE 9: Regression results for the regional cross-sectional model on fund risk

	Constant	Size (log)	Age (log)	Tenure (log)	TER	Focus region	Focus sector	Green	Europe	Asia	Others	Europe & Green	Asia & Green
Standard deviation	0,4267***	-0,0313*	0,1155***	0,0106	0,1011***	-0,0419	0,1598**	0,0217	0,4431***	0,0689	1,0782***	-0,0945	0,1538
t-statistic	2,8753	-1,9245	3,1095	0,6369	3,0047	-0,8795	2,3309	0,3680	6,6280	0,3754	7,0918	-1,0058	0,6770
p-value	0,0045	0,0558	0,0022	0,5250	0,0030	0,3802	0,0208	0,7133	0,0000	0,7078	0,0000	0,3158	0,4993
R-squared	0,4877												

This table presents the results from testing the effect of fund size, age, tenure of current management, total expense ratio (TER), being regionally focused, being sectorally focused, being green, being majorly invested in Europe, Asia or other world regions (besides Europe, Asia and the US) as well as being green and majorly invested in Europe or Asia on idiosyncratic fund risk as specified by equation (7). Size is the natural logarithm of total assets under management of fund i at the end of 2015; Age is the natural logarithm of a fund's age at the end of 2015 since inception date in years; Tenure is the natural logarithm of current management tenure in years; TER is the total expense ratio at the end of 2015; dummy Focus region is 1 if fund i holds more than 75% in one region and 0 otherwise; dummy Focus sector is 1 if fund i holds more than 50% in one sector and 0 otherwise; dummy Green is 1 if fund i is a green fund and 0 otherwise; Europe is 1 for funds with major holdings in Europe and 0 otherwise; Asia is 1 for funds with major holdings in Asia and 0 otherwise; Others is 1 for funds with major holdings in other world regions and 0 otherwise; Europe & Green is 1 for funds with major holdings in Europe and being green at the same time, 0 otherwise; Asia & Green is 1 for funds with major holdings in Asia and being green at the same time, 0 otherwise. T-statistics, p-values and R-squared of the regression are presented as well. The sample period is January 2, 2002-December 31, 2015. *, **, *** denote significance at 10, 5 and 1%, respectively.

TABLE 10: Regression results for the sectoral cross-sectional model on fund risk

	Constant	Size (log)	Age (log)	Tenure (log)	TER	Focus region	Focus sector	Green	Technology	Technology & Green
Standard deviation	0,7269***	-0,0547***	0,1354***	0,0084	0,1147***	0,0123	0,1953**	-0,0964	-0,2432**	0,1554
t-statistic	4,0382	-2,7720	2,9661	0,4166	2,8647	0,2151	2,4835	-1,5419	-2,5399	1,2172
p-value	0,0001	0,0061	0,0034	0,6775	0,0046	0,8299	0,0139	0,1247	0,0119	0,2250
R-squared	0,2219									

This table presents the results from testing the effect of fund size, age, tenure of current management, total expense ratio (TER), being regionally focused, being sectorally focused, being green, being majorly invested in the technology sector as well as being green and majorly invested in the technology sector on idiosyncratic fund risk as specified in equation (8). Size is the natural logarithm of total assets under management of fund i at the end of 2015; Age is the natural logarithm of a fund's age at the end of 2015 since inception date in years; Tenure is the natural logarithm of current management tenure in years; TER is the total expense ratio at the end of 2015; dummy Focus region is 1 if fund i holds more than 75% in one region and 0 otherwise; dummy Focus sector is 1 if fund i holds more than 50% in one sector and 0 otherwise; dummy Green is 1 if fund i is a green fund and 0 otherwise; Technology is 1 for funds with major holdings in the technology sector and 0 otherwise; Technology & Green is 1 for funds with major holdings in the technology sector and being green at the same time, 0 otherwise. T-statistics, p-values and R-squared of the regression are presented as well. The sample period is January 2, 2002-December 31, 2015.
*, **, *** denote significance at 10, 5 and 1%, respectively.

TABLE 11: Regression results for the fossil fuel cross-sectional model on fund risk

	Constant	Size (log)	Age (log)	Tenure (log)	TER	Focus region	Focus sector	Green	Fossil	Fossil & Green
Standard deviation	1,0680***	-0,0795***	0,1268*	0,0109	0,1549**	-0,1397*	0,3559***	-0,5417***	-0,235*	0,4976***
t-statistic	3,7864	-2,8234	1,9117	0,4545	2,4432	-1,7461	3,3670	-4,0643	-1,7493	2,8330
p-value	0,0003	0,0058	0,0591	0,6505	0,0165	0,0842	0,0011	0,0001	0,0836	0,0057
R-squared	0,3703									

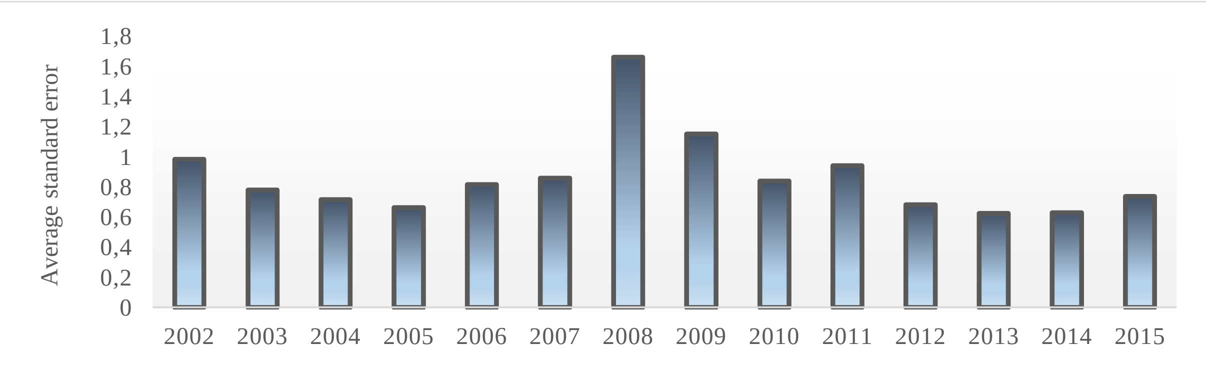
This table presents the results from testing the effect of fund size, age, tenure of current management, total expense ratio (TER), being regionally focused, being sectorally focused, being green and holding fossil fuel shares on idiosyncratic fund risk as specified in equation (9). Size is the natural logarithm of total assets under management of fund i at the end of 2015; Age is the natural logarithm of a fund's age at the end of 2015 since inception date in years; Tenure is the natural logarithm of current management tenure in years; TER is the total expense ratio at the end of 2015; dummy Focus region is 1 if fund i holds more than 75% in one region and 0 otherwise; dummy Focus sector is 1 if fund i holds more than 50% in one sector and 0 otherwise; dummy Green is 1 if fund i is a green fund and 0 otherwise; Fossil is 1 if fund i has fossil fuel holdings and 0 otherwise; Fossil & Green is 1 for funds with fossil fuel holdings and being green at the same time, 0 otherwise. T-statistics, p-values and R-squared of the regression are presented as well. The sample period is January 2, 2002-December 31, 2015. *, **, *** denote significance at 10, 5 and 1%, respectively.

6.3.2 The Development of Green Fund Risk over Time

In this subsection, we draw our attention to the evolution of idiosyncratic risk over time. Overall, we can observe a decreasing trend in volatility of our main group of interest, environmentally screened funds.

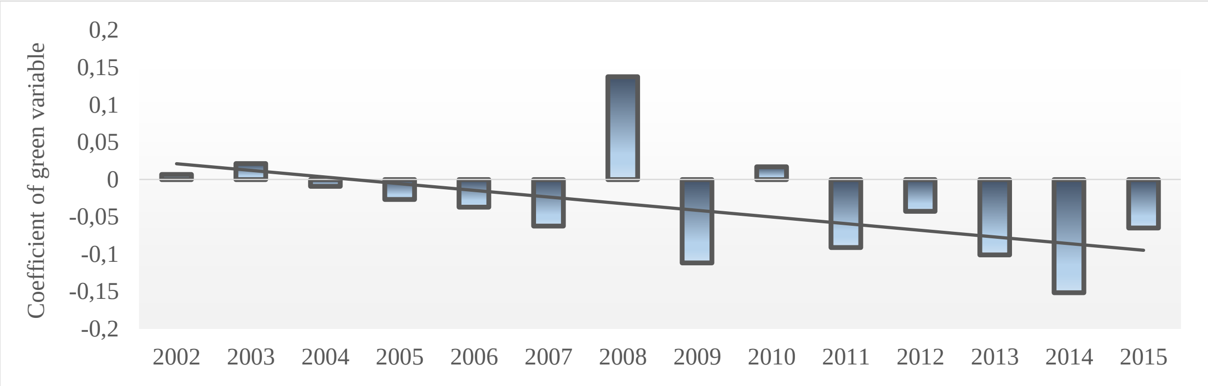
Plotting the standard error retrieved from the four-factor regression model for each year separately, Figure 3 illustrates that, on average, idiosyncratic risk of our sample has not deviated largely from 0.6-0.8, but has remained rather stable throughout time. On the other hand, one can clearly observe a divergence during the global financial crisis starting in 2007 and transitioning into the European sovereign crisis until 2011. All developed markets were affected by a broad and active reversal of capital that caused the overall uncertainty and volatility in major financial markets to increase.

FIGURE 3: Development of the average standard error from 2002-2015



Turning to the green fund universe, Figure 4 shows how the effect of being green compared to not being green on idiosyncratic fund risk has moved over the last 14 years. Regardless of the significance of the coefficient results, the overall trend is decreasing and turning negative in the years 2004-2007, in 2009 and after 2010. Green funds seem to be able to more sufficiently diversify their portfolios than conventional funds, particularly in the years following the global and European recession.

FIGURE 4: Development of the green variable coefficient from 2002-2015



However, nearly all coefficients are not statistically different from zero, as can be seen in Table 12. This corresponds to our results from the overall regression analysis above where green funds are seen to not suffer from a lack of diversification in comparison to their conventional counterparts.

In the later years, 2013 and 2014, the negative sign, however, becomes significant. Screening for green results in a reduction of idiosyncratic risk by 0.1 and 0.15, respectively. The results suggest a positive development of risk over time as it was proposed under *hypothesis 2.2*. Remarkably, the green funds' idiosyncratic risk profile progressively improves over time until green funds are even outperforming their conventional peers in recent years. One may be inclined to justify this development by the investment style characteristics of the funds in the sample. It could be argued that by random sampling of the conventional funds, not only the most diversified ones have been included but also ones that carry higher risk due to their focus on riskier asset classes, such as growth or value stocks for instance. However, since we matched the investment style of the conventional portfolio to that of the green portfolio in our sampling procedure, we control for such a bias and therefore we may acknowledge that green funds in fact have been able to carry lower idiosyncratic risk compared to their conventional peers in recent years. This is in line with the general risk idea proposed by the *stakeholder theory*. Firms focusing on stakeholder interests are willing to not only reduce the risk exposure of their shareholders but to ensure they are able to fulfill claims of all relevant internal and external stakeholders. As firm managers will take proactive steps to reduce the overall risk profile of their company, funds applying environmental screens will automatically invest in lower risk firms, which in turn will offset negative effects imposed by limited diversification abilities (Freeman, 1984; Cornell and Shapiro, 1987; Speckbacher and Wentges, 2009). Additionally, green business as of today is not only concentrated in the energy and technology sector but has also experienced a strong growth in construction, industrials and consumer goods for instance. Growth rates for US green consumer goods and services have been rising faster than conventional products, outpacing the overall economy according to the green opportunity report by Green America (2013). Moreover, green growth is not only a US and European phenomenon as the lead in clean technology has shifted to Asia in more recent years (IMF, 2011), therefore creating vast diversification opportunities for green funds over time.

TABLE 12: Changes in factors determining risk over time

	Constant	Size (log)	Age (log)	Tenure (log)	TER	Focus region	Focus sector	Green
2002	1,2036***	-2,3666**	-0,0357	-0,1138	0,0146	0,1204	0,1338**	0,0068
2003	1,1779***	-0,6132	-0,0556*	-0,0804	0,0206	-0,0675*	0,0024	0,0213
2004	1,2749***	1,1516***	-0,0803***	-0,0384	-0,0175	-0,1229***	0,0765***	-0,0091
2005	0,9403***	1,1509***	-0,05***	0,0138	-0,0093	-0,0774	0,1152	-0,0269
2006	1,2456***	1,4934***	-0,0786***	0,0047	0,0102	-0,1739**	0,2724**	-0,037
2007	1,2211***	1,1696**	-0,0547**	-0,0436	0,019	-0,1413*	0,3168***	-0,0622
2008	1,8613***	1,069	-0,1151**	-0,01	0,2514*	-0,2238	0,3544	0,1375
2009	1,2553***	0,9548*	-0,0709**	0,0045	0,1777**	-0,0085	0,2128	-0,1119
2010	1,0105***	0,6112*	-0,0767***	0,0011	0,122**	-0,0018	0,0677	0,0171
2011	0,9318***	0,0067	-0,0525**	0,0041	0,1601***	0,0671	0,1407	-0,0909
2012	0,8943***	0,0017	-0,0588***	-0,0006	0,0484	-0,0038	0,1383**	-0,0427
2013	0,6468***	0,0072	-0,0336***	0,0022	0,0899***	0,0395	0,2237***	-0,1011***
2014	0,9128***	0,0066	-0,0502***	0,0071	-0,004	0,0109	0,1836***	-0,1515***
2015	0,8226***	0,009	-0,0441**	0,0075	0,0735**	0,0344	0,1779**	-0,0651

This table presents the estimated coefficients for size, age, tenure of current management, total expense ratio (TER), the dummy variable for regionally focused, the dummy variable for sectorally focused and the green dummy variable for the cross-sectional regression of the general control variable setting on idiosyncratic risk per year (equation 6). The dependent risk measures are the yearly estimated standard errors. Size is the natural logarithm of total assets under management of fund i at the end of 2015; Age is the natural logarithm of a fund's age at the end of year t since inception date in years; Tenure is the natural logarithm of current management tenure at the end of year t measured in years; TER is the average total expense ratio at the end of year t; Dummy Focus region is 1 if fund i holds more than 75% in one region and 0 otherwise; Dummy Focus sector is 1 if fund i holds more than 50% in one sector and 0 otherwise; Dummy Green is 1 if fund i is a green fund and 0 otherwise. T-statistics, p-values and R-squared of the regression are presented as well. The sample period is 2002-2015. *, **, *** denote significance at 10, 5 and 1%, respectively.

7. Robustness Checks

We tested our general model setting on different measures of performance and risk in order to see how sensitive our estimations are with regards to the data applied and thus how robust our findings are with respect to our main hypotheses. Besides the four-factor Carhart model, which we have used to estimate abnormal performance and idiosyncratic risk, a number of other models are available as well. In financial literature, however, there exists some discussion about which of the asset-pricing model is best in predicting returns. Therefore, we used raw average excess returns and the standard deviation of excess returns as dependent variables for our robustness tests. We calculated these alternative measures of performance and risk both over the whole sample period as well as yearly, and estimated the general model for performance and risk with those measures, respectively. Overall, we are able to confirm our findings from before. We find no significant over- or underperformance of green funds compared to their conventional counterparts when using average excess returns instead of abnormal performance in the form of Jensen's alpha (Table A3). Moreover, based on the alternative data we are able to confirm a positive trend of performance improvement over time, similar in statistical significance, however slightly weaker in magnitude (Table A4). With regards to idiosyncratic risk, we actually find a green dummy coefficient negative in sign and statistically significant at the 10% level for the estimation over the whole sample period (Table A5). This is contradicting our hypothesis, that green funds carry higher idiosyncratic risk than their traditional peers but supporting our empirical findings of decreasing risk over time. When looking at the development of green funds in terms of risk over time, again we are able to confirm a negative trend of the green coefficient, however much stronger in magnitude than shown under the idiosyncratic risk measure obtained from the four-factor Carhart model. Moreover, this analysis over time identifies more years with a statistically significant green dummy coefficient (Table A6). We note that our results are somewhat sensitive to the measure used for performance and risk, which is however to be expected since our original analysis is based on an additional estimation step compared to the robustness check setting. Overall, within the sensitivity analysis we are able to confirm to a relatively large extent the major traits of our findings, concluding that we have come to valid results from our original data setting.

8. Conclusion

This research provides insights into the performance and risk of environmental mutual funds for the time period between 2002 and 2015. We have addressed the question whether mutual funds mandated to an environmental investment strategy are able to compete with the performance and risk profile of traditional funds. We provide an in-depth analysis of performance and idiosyncratic risk differences between green and conventional funds by examining specific factors determining fund performance and risk, and by conducting an analysis of the factor green throughout time. Thereby and to the best of our knowledge, we are the first to examine the risk exposure of green funds relative to non-green funds as a question of interest in general and more specifically to study the effect of fossil fuel shares as well as certain regional and sectoral variables in a regression analysis.

As suggested by classical financial models, green investors may be considered as irrational investors since their utility function is not only based on maximizing end-of-period wealth but also on environmental concerns. Our results, however, suggest that the financial logic of *modern portfolio theory* and the arguments proposed by *stakeholder theory* as well as *over-performance hypothesis* can coexist and are not at odds. In line with previous literature on green fund performance (White, 1995; Climent and Soriano, 2011; Ito et al., 2013; Ibikunle and Steffen, 2015) there is neither a financial cost nor benefit from investing in green funds compared to conventional funds. Rather, green investors may have been able to maximize their utility as they earn competitive returns while maximizing their environmental objectives. Over time and especially in recent years, we even see a positive trend in green fund performance. Green funds seem to have evolved to more established financial assets with the potential to outperform their conventional peers as evidentiary in recent years (2013-2015) and during the global financial crisis. The underlying investment strategy seems to pay off: environmentally-friendly positioning is characterized by a long-term focus and future value creation that allow fund managers to capture strong stock performance results of environmentally conscious firms and to incorporate them on fund level. As economic and regulatory conditions are distinct from conventional markets, we expected that changes in national and multilateral regulatory frameworks as well as increased political and sociopolitical pressure have favorably supported the development of the green mutual fund landscape and have increased investors' interest for such assets. Our results identify the US as the strongest market. Green funds could significantly outperform conventional funds supporting the findings by Eyraud et al. (2011). The US has been considered as one of the world's leading markets in fostering green growth where investments have quickly recovered in the years following the financial recession of 2007-2009. While green funds mainly invested in Europe have weakened and show significant underperformance, especially in the wake of the sovereign debt crisis, Asian green funds seem to catch up and to perform as well as their Asian conventional peers. Asia is on the rise to outpace Europe and the US and to become the new world leader in terms of green research initiatives and investments. In contrast to theoretical reasoning and recent trends, we could not identify any positive effect of being focused in the technology sector nor being a fossil-free fund to improve fund performance.

Besides competitive performance results of green mutual funds over the entire time period and an upward trend over time, we also find evidence that idiosyncratic risk is not significantly different for green and non-green funds. Remarkably, green funds appear to become less volatile over time, especially to show significantly lower risk profiles than their conventional peers in recent years. This is likely due to the fact that the number of firms 'going green' and with that the investment horizon to have broadened over time. Even though policy uncertainties represent an important risk factor for environmental businesses, green funds might be well equipped to offer well-diversified portfolios. This holds also true when focusing on specific world regions. Green funds predominantly invested in the US, Europe, and Asia are not any riskier than their conventional counterparts. All of those markets seem to provide a sufficiently large investment universe where being green does not significantly alter diversification possibilities. Moreover, being a green technology fund does not translate into higher idiosyncratic risk exposure either. As opposed to being predominantly invested in young and innovative green-tech growth firms, our sample shows that green technology funds also invest in traditional and well-established technology firms that conduct business in an environmentally-friendly way. Turning to the fossil-free argument, we do find evidence that having fossil fuel shares in the investment portfolio can actually reduce diversifiable risk. Funds may still need fossil fuel companies in order to build a well-diversified portfolio regardless of the increasing pressure on fossil fuel extraction and rising competition from renewable energy sources.

Conducting robustness checks for our general model setting by applying alternative measures for performance and risk as our dependent variables, we find our statistical results to be robust with respect to our main hypotheses and empirical findings from before. All in all, we are able to confirm our hypotheses on green fund performance (*hypothesis 1.1 and 1.2*) stating that screening for environmental concerns does not result in performance differences compared to conventional portfolios, and that abnormal performance of green funds has improved over time. Whereas diversifiable green fund risk is not any different than that of traditional funds, in contrast to what was expected under *hypothesis 2.1*, evidence allows us to confirm that green funds have become less risky throughout time and thus confirming *hypothesis 2.2*.

Even though our research has extended previous work by certain new insights, we have to acknowledge some limitations that shall be enhanced by future research. Due to limited scope of this thesis and data access, we have not distinguished between different screening techniques and screening intensities applied by fund managers that have seen to alter fund performance and risk. Barnett and Salomon (2006) and Hemphrey and Lee (2011) for instance show that negative screening, as opposed to positive screening, results in a more negative effect on diversification. Whereas positive screens actively select firms based on a set of non-financial criteria, negative screens exclude non-conform assets (Lee et al., 2010). Therefore, negative or exclusionary screening may screen out a large pool of stocks and sometimes entire industries and may consequently significantly reduce the investment universe and therefore the ability to fully diversify. Our analysis did not allow to examine the effects of positive and negative screens, thus remains open for later studies. Future research shall further address the emerging debate on fossil-free investing that is considered a powerful tool to mitigate carbon emissions, and examine the risk exposure of stranded assets in more depth. Due to data constraint at the present time, our research spans a rather small sample with respect to the fossil fuel argument. We expect that investing in firms engaging in the transition from carbon dependence to more sustainable alternatives will continue to rise and will mark an important research field not only in natural sciences but also in financial literature. The topic is, therefore, worth investigating within a broader scope of data.

References

Adamo, R., D. Federico, and A. Notte (2014). Performance and risk of green funds. Investment Management and Financial Innovation, 11(1), 134-145.

Al-Tuwaijri, S., T.E. Christensen, and K.E. Hughes II (2004). The relations among environmental disclosure, environmental performance, and economic performance: A simultaneous equations approach. Accounting, Organizations, and Society, 29(5-6), 447-471.

Amenc, N. and V. Le Sourd (2010). Performance of socially responsible investment and sustainable development in France: An update after the financial crisis. Position paper EDHEC-Risk Institute, September 2010. URL: http://edhec.edu/servlet/com.univ.collaboratif.utils.LectureFichiergw?ID_FICHIER=1328885973639, accessed on 2016-03-15.

Arabella Advisors (2015). Measuring the global fossil fuel divestment movement. URL: http://www.arabellaadvisors.com/wp-content/uploads/2014/09/Measuring-the-Global-Divestment-Movement.pdf accessed on 2016-02-23.

Barnett, M. and M. Salomon (2006). The curvilinear relationship between social responsibility and financial performance. Strategic Management Journal 27(11), 1101–1122.

Bauer, R., J. Derwall, and R. Otten (2007). The ethical mutual fund performance debate: New evidence from Canada. Journal of Business Ethics, 70(2), 111-124.

Bauer, R., K. Koedijk, and R. Otten (2002). International evidence on ethical mutual fund performance and investment style. LIFE Working paper 02.59.

Bauer, R., K. Koedijk, and R. Otten (2005). International evidence on ethical mutual fund performance and investment style. Journal of Banking and Finance, 29, 1751–1767.

Bello, Z. (2005). Socially responsible investing and portfolio diversification. Journal of Financial Research, 28, 41–57.

Benson, K. L. and J. E. Humphrey (2008). Socially responsible investment funds: Investor reaction to current and past returns. Journal of Banking and Finance, 32(9), 1850–1859.

Biehl, C. F., M. Dumke, A.G.F. Hoepner, and J.O.S. Wilson (2011). SRI Funds: Does more social mean less financial performance. oikos PRI Young Scholars Academy 2011. URL: http://ssrn.com/abstract=1726146, accessed on 2016-01-22.

Black, F., M. Jensen, and M. Scholes (1972). The capital asset pricing model: Some empirical tests. In: Studies in the Theory of Capital Markets, Jensen, M., Greenwood Press and Praeger Publishers, 1st edition, 1972, New York City, New York, USA, 79–121.

Blank, H. D. and W. E. Daniel (2002). The Eco-Efficiency Anomaly. Innovest Strategic Value Advisors. URL: http://www.kellogg.northwestern.edu/faculty/mazzeo/htm/sp_files/021209/(4)%20innovest/studies%20using%20innovest%20data/Eco_Anomaly_7_02.pdf, accessed on 2016-01-22.

Bloomberg (2012, 2014, 2015). New energy finance global trends report. URL: http://about.bnef.com/, accessed on 2016-01-22.

Bollen, N. (2007). Mutual fund attributes and investor behavior. Journal of Financial and Quantitative Analysis 42, 683–708.

Branch, B., A. Ma, H. Shafa, and R. Shaw (2014). Socially responsible mutual funds in the era of financial turmoil. International Journal of Business, Accounting, and Finance, 8(1), 24-33.

Cambridge Associates (2014). The fossil fuel divestment discussion. URL: http://www.fossilfuelsreview.ed.ac.uk/resources/Evidence%20-%20Investment,%20Financial,%20Behavioural/Cambridge%20Associates%20-%20FF%20Divestment.pdf, accessed on 2016-02-15.

Campbell J, M. Lettau, B. Malkiel, and Y. Xu (2001). Have individual stocks become more volatile? An empirical exploration of idiosyncratic risk. Journal of Finance, 56(1), 1-43.

Capelle-Blancard, G. and S. Monjon (2014). The performance of socially responsible funds: does the screening process matter? European Financial Management, 20(3), 494-520.

Carhart, M. M. (1997): On persistence in mutual fund performance. Journal of Finance, 52(1), 57-82.

Chami, R., T. F. Cosimano and C. Fullenkamp (2002). Managing ethical risk: How investing in ethics adds value. Journal of Banking and Finance, 26(9), 1697-1718.

Chang, C., W. Nelson, and H. Witte (2012). Do green mutual funds perform well? Management Research Review, 35(8), 693-708.

Chegut, A., H. Schenk, and B. Scholtens (2011). Assessing SRI fund performance research: best practices in empirical analysis. Sustainable Development, 19, 77-94.

Chen J., H. Hong, M. Huang, and J. D. Kubik (2004). Does fund size erode mutual fund performance? The role of liquidity and organization. The American Economic Review, 94(5), 1276-1302.

Ciccotello, C. and T. Grant (1996). Equity fund size and growth: Implications for performance and selection. Financial Services Review, 5, 1-12.

Climent, F. and P. Soriano (2011). Green and Good? The investment performance of US environmental mutual funds. Journal of Business Ethics, 103, 275-287.

Clow, R. (1999). Money that grows on trees. Institutional Investor, 33(10), 212-215.

Cohen, M. A., S. A. Fenn, and S. Konar (1997). Environmental and Financial Performance: Are They Related? Working paper, Vanderbilt University.

Cormier, D. and M. Magnan (1997). Investors' Assessment of Implicit Environmental Liabilities: An Empirical Investigation. Journal of Accounting and Public Policy, 16, 215-241.

Cornell, B. and A. C. Shapiro (1987). Corporate stakeholders and corporate finance. Financial Management, 16, 5–14.

Cortez, M. C., F. Silva, and N. Areal (2012). Socially responsible investing in the global market: The performance of US and European funds. International Journal of Financial Economics, 17, 254-271.

Cremers, K. J. M. and V. B. Nair (2005). Governance Mechanisms and Equity Prices. Journal of Finance, 60(6), 2859-2894.

Cremers, K. J. M., and A. Ferrell (2013). Thirty Years of Corporate Governance: Firm Valuation and Stock Returns. Journal of Finance, forthcoming.

Dahlquist, M., S. Engström, and P. Söderlind (2000). Performance and characteristics of Swedish mutual funds. Journal of Financial and Quantitative Analysis, 35, 409-423.

Derwall, J., N. Guenster, R. Bauer, and K. Koedijk (2005). The Eco-Efficiency Premium Puzzle. Financial Analysts Journal, 61(2), 51-63.

Derwall, J., N., K. Koedijk, and J. T. Horst (2011). A tale of values-driven and profit-seeking social investors. Journal of Banking and Finance, 35(8), 2137-2147.

Deutsche Bank Climate Change Advisors (2012). Sustainable Investing: Establishing Long-term value and performance. Working paper, June 2012. URL: http://ssrn.com/abstract=2222740, accessed on 2016-02-14.

DiBartolomeo, D. and L. Kurtz (1999). Managing Risk Exposures of Socially Screened Portfolios. Working paper, Northfield Information Services. URL: http://www.northinfo.com/documents/63.pdf, accessed on 2016-03-15.

Diltz, D. J, (1995). Does Social Screening Affect Portfolio Performance? Journal of Investing, 4(1), 64-69.

Eccles, R. and G. Serafeim (2013). The performance frontier: Innovating for a sustainable strategy. Harvard Business Review, May 2013, 50-60.

Eccles, R. G., I. Ioannou, and G. Serafeim (2013). The Impact of Corporate Sustainability on Organizational Processes and Performance. Harvard Business School Working Paper Series. Harvard Business School.

European Sustainable and Responsible Investment Forum (Eurosif) (2003). Socially Responsible Investment among European Institutional Investors. URL: http://www.eurosif.org/publication/view/european-sri-study-2003/, accessed on 2016-02-20.

Eyraud L., A. Wane, C. Zhang, and B. Clements (2011). Who's going green and why? Trends and determinants of green investment. IMF working paper, 11(296). URL: https://www.imf.org/external/pubs/ft/wp/2011/wp11296.pdf, accessed on 2016-03-24.

Fama, E. F. and J. D. MacBeth (1973). Risk, return, and equilibrium: Empirical tests. The Journal of Political Economy, 81(3), 607-636.

Fernando, C.S., M.P. Scharfman, and V.B. Uysal (2010). Does greenness matter? The effect of corporate environmental performance on ownership structure, analyst coverage and firm value. Working Paper, University of Oklahoma. URL: https://www.researchgate.net/publication/242581747_Does_Greenness_Matter_The_Effect_of_Corporate_Environmental_Performance_on_Ownership_Structure_Analyst_Coverage_and_Firm_Value, accessed on 2016-03-12.

Ferreira, M. A., A. F. Miguel, and S. B. Ramos (2007). The determinants of mutual fund performance: A cross-country study. Swiss Finance Institute Research Paper, 31.

Flammer, C. (2013). Corporate social responsibility and shareholder reaction: The environmental awareness of investors. Academy of Management Journal, 56(3), 758-781.

Flammer, C. (2014). Does Corporate Social Responsibility Lead to Superior Financial Performance? A Regression Discontinuity Approach. Management Science, 61 (11), 2549-2568.

Fombrun, C. J., N. A. Gardberg, and J. M. Sever (2000). The Reputation Quotient: A multi-stakeholder measure of corporate reputation. The Journal of Brand Management, 7(4), 241-255.

Freeman, R. E. (1984). Strategic Management: A Stakeholder Approach. Pitman Series in Business and Public Policy, Financial Times Prentice Hall, Upper Saddle River, New Jersey, USA.

Galema, R., A. Plantinga, and B. Scholtens (2008). The Stocks at Stake: Return and Risk in Socially Responsible Investment. Journal of Banking and Finance, 32, 2646-2654.

Geczy, C., R. Stambaugh, and D. Levin (2005). Investing in socially responsible mutual funds. Working Paper, Wharton School, University of Pennsylvania USA. URL: http://ssrn.com/abstract=416380, accessed on 2016-03-28.

Gil-Bazo, J., P. Ruiz-Verdú, and A.A.P. Santos (2008). Performance of socially responsible mutual funds: Role of fees and management companies. Working Paper Department of Business Administration, Universidad Carlos III de Madrid, Spain. URL: http://ssrn.com/abstract=1307043, accessed on 2016-03-12.

Girard, E., H. Rahman, and B. Stone (2007). Socially responsible investment: Goody-two-shoes or bad to the bone. Journal of Investing, 16(1), 96-110.

Global Subsidies Initiative (2010). Relative subsidies to energy sources: GSI estimates. URL: https://www.iisd.org/gsi/sites/default/files/relative_energy_subsidies.pdf, accessed on 2016-03-28.

Goldreyer, E., P. Ahmed, and J. Diltz (1999). The performance of socially responsible mutual funds: Incorporating sociopolitical information. Managerial Finance, 25(1), 23-36.

Green America, Association for enterprise opportunity (2013). The big green opportunity for small business in the U.S. Small business sustainability report. URL: http://biggreenopportunity.org/wp-content/uploads/2013/05/Big-Green-Opportunity-Report-FINAL-WEB.pdf, accessed on 2016-04-10.

Gregory, A. and J. Whittaker (2007). Performance and performance persistence of 'ethical' unit trusts in the UK. Journal of Business Finance & Accounting, 34(7 and 8), 1327–1344.

Grossman, B. R. and W. F. Sharpe (1986). Financial Implications of South African Divestment. Financial Analyst Journal, July-August, 15-29.

Guenster, N., J. Derwall, R. Bauer, and K. Koedijk (2011). The economic value of corporate eco-efficiency. European Financial Management, 17(4), 679-704.

Hamilton, S., H. Joe, M. Statman (1993). Doing well while doing good? The investment performance of socially responsible mutual funds. Financial Analysts Journal, 49(6), 62–66.

Hart, S. L. and G. Ahuja (1996). Does it pay to be green? An empirical examination of the relationship between emission reduction and firm performance. Business Strategy and the Environment, 5(1), 30-37.

Hassel, L.G. and N. Semenova (2008). Financial outcomes and environmental risk and opportunity for US companies. Sustainable Development, 16(3), 195-212.

Heinkel, R., A. Kraus, and J. Zechner (2001). The Effect of Green Investment on Corporate Behavior. Journal of Financial and Quantitative Analysis, 36(4), 431-449.

Hoepner, A. and D. G. McMillan (2009). Research on responsible investment: an influential literature analysis comprising a rating, characterization, categorization and investigation. Working paper, University of St Andrews, UK. URL: http://ssrn.com/abstract=1454793, accessed on 2016-04-10.

Hudson, J. (2006). The Social Responsibility of the Investment Profession. London: Research Foundation of CFA Institute, 3. URL: https://www.cfainstitute.org/learning/products/publications/rf/Pages/rf.v2006.n3.4251.aspx, accessed on 2016-02-10.

Humphrey, J. E. and D. D. Lee (2011). Australian socially responsible funds: performance, risk and screening intensity. Journal of Business Ethics, 102, 519-535.

Ibikunle, G. and T. Steffen (2015). European green mutual fund performance: A comparative analysis with their conventional and black peers. Journal of Business Ethics, 2015, 1-19.

Iglesias, E. M. (2015). Value at Risk of the main stock market indexes in the European Union (2000-2012). Journal of Policy Modeling, 37, 1-13.

Inderst, G., C. Kaminker, and F. Stewart (2012), “Defining and Measuring Green Investments: Implications for Institutional Investors‟ Asset Allocations”, OECD Working Papers on Finance, Insurance and Private Pensions, No.24, OECD Publishing. URL: http://www.oecd.org/pensions/WP_24_Defining_and_Measuring_Green_Investments.pdf, accessed on 2016-01-22.

International Energy Agency (IEA) (2011), World Energy Outlook. International Energy Agency. URL: http://www.worldenergyoutlook.org/, accessed on 2016-01-18.

Investment Company Institute (2015). 2015 Investment Company facto book: A review of trends and activities in the US investment company industry. URL: https://www.ici.org/pdf/2015_factbook.pdf, accessed on 2016-03-24.

Ito, Y., S. Managi, and A. Matsuda (2013). Performances of socially responsible investment and environmentally friendly funds. Journal of the Operational Research Society, 64(11), 1583-1594.

Jensen, M. C. (1967). The performance of mutual funds in the period 1945-1964, Journal of Finance, 23(2), 389-416.

Johnson, D. and K. Lybecker (2009). Challenges to Technology Transfer: A Literature Review of the Constraints on Environmental Technology Dissemination. Working Paper, Colorado College, Colorado Springs, USA. URL: http://ssrn.com/abstract=1456222, accessed on 2016-03-24.

Kaminker, C., O. Kawanishi, F. Stewart, B. Caldecott, and N. Howarth (2013), “Institutional Investors and Green Infrastructure Investments: Selected Case Studies”, OECD Working Papers on Finance, Insurance and Private Pensions, No. 35, OECD Publishing. URL: http://dx.doi.org/10.1787/5k3xr8k6jb0n-en accessed on 2016-03-22.

Kang, N., P. Kondor, and R. Sadka (2014). Do hedge funds reduce idiosyncratic risk? Journal of Financial and Quantitative Analysis, 49(4), 843-877.

Kaushik, A., L. K. Saubert, and R. W. Suabert (2014). Performance and persistence of performance of healthcare mutual funds. Financial Services Review, 23, 77-91.

Keane, R. F. (2009). The Green Advisor: SRI & green investing grow up. URL: http://www.thinkadvisor.com/2009/11/01/the-green-advisor-sri-green-investing-grow-up, accessed on 2016-02-20.

Kempf, A. and P. Osthoff (2007). The effect of socially responsible investing on portfolio performance. European Financial Management, 13(5), 908-922.

Kempf, A. and P. Osthoff (2008). SRI funds: Nomen est omen. Journal of Business Finance and Accounting, 35(9), 1276-1294.

Khorana, A. and E. Nelling (1997). The performance, risk and diversification of sector funds. Financial Analysts Journal, May/June, 62-74.

King, A. A. and M J. Lenox (2000). Industry self-regulation without sanctions: the chemical industry's responsible care program. The Academy of Management Journal, 43(4), 698-716.

King, A. A. and M J. Lenox (2002). Exploring the locus of profitable pollution reduction. Management Science, 48(2), 289-299.

Klassen, R. D. and C. P. McLaughlin (1996). The impact of environmental management on firm performance. Management Science, 42(8), 1199-1214.

Klassen, R.D. and D. C. Whybark (1999). The Impact of Environmental Technologies on Manufacturing Performance, Academy of Management Journal, 42(6), 599-615.

Konar, S. and M. Cohen (2001). Does the market value environmental performance? The Review of Economics and Statistics, 83(2), 281-289.

Le Maux, J. and E. Le Saout (2004). The performance of sustainability indexes. Finance India 18, 737-750.

Lee, D. D., J. E. Humphrey, K. L. Benson, and J. Y. K. Ahn (2010). Socially responsible investment fund performance: The impact of screening intensity. Accounting and Finance, 50, 351-370.

Luther, R.G., J. Matatko, and D. C. Corner (1992). The investment performance of UK ethical unit trusts. Accounting, Auditing and Accountability Journal, 5(4), 57-70.

Morales, A. (2015). The climate talks in Paris might actually work this time. Bloomberg Business. URL: http://www.bloomberg.com/news/articles/2015-11-25/how-the-rise-of-renewables-brings-a-fix-for-climate-ever-closer, accessed on 2016-01-22.

Morningstar (2007). The Morningstar Guide to "Green" and Socially Responsible Investing. URL: http://retirement.newtonfreelibrary.net/finra/Green_SRI.pdf, accessed on 2016-03-07.

Morningstar (2016). Morningstar glossary: Green fund. URL: https://www.youinvest.co.uk/1c6qh1t6k9/glossary/default.aspx?LanguageId=en-GB&group=G, accessed on 2016-03-01.

MSCI (2016). MSCI ACWI ex fossil fuels index (GBP). URL: https://www.msci.com/resources/factsheets/index_fact_sheet/msci-acwi-ex-fossil-fuels-index-gbp-gross.pdf, accessed on 2016-03-30.

Muñoz, F., M. Vargas, and I. Marco (2014). Environmental Mutual Funds: Financial Performance and Managerial Abilities. Journal of Business Ethics, 124, 551-569.

Nagy, Z., D. Cogan, D. Sinnreich (2013). Optimizing Environmental, Social, and Governance Factors in Portfolio Construction: An Analysis of Three ESG- tilted Strategies. MSCI Research Insight.

Newell, R. G., A. B. Jaffee, and R. N. Stavins (1999). The induced innovation hypothesis and energy-saving technological change. Quarterly Journal of Economics, 114(3), 941–75.

Novethic SRI Research Center (2012). Green funds: A sluggish market. Survey April 2012. URL: http://www.novethic.com/fileadmin/user_upload/tx_ausynovethicetudes/pdf_complets/green_funds_2012.pdf, accessed on 2016-01-30.

Perrow, C. (1984). Normal accidents: living with high risk technologies. Princeton University Press, 1st edition, Princeton, New Jersey, USA.

Popp, D. (2002). Induced innovation and energy prices. American Economic Review, 92, 160-80.

Porter, M. E. and C. van der Linde (1995). Green and Competitive, Ending the Stalemate. Harvard Business Review (September-October), 120-135.

Posnikoff, J. F. (1997). Divestment from South Africa: They did well by doing good. Contemporary Economic Policy, 15, 76-86.

Prior, A. (2009). The Price of Green, The Wall Street Journal. URL: http://www.wsj.com/articles/SB10001424052970204518504574418683155971954, accessed on 2016-01-22.

Rees, W. E. (1994). Hostages of Each Other: The transformation of nuclear safety since three mile island. University of Chicago Press, 1st edition, Chicago, Illinois, USA.

Rees, W.E. and M. Wackernagel (1994). Ecological footprints and appropriated carrying capacity: measuring the natural capital requirements of the human economy. In: Investing in Natural Capital: The Ecological Economics Approach to Sustainability. Island Press, 1st edition, 1994, Washington, DC, USA.

Renneboog, L., J. Ter Horst, and C. Zhang (2005). Is ethical money financially smart? Working Paper No. 117, ECGI.

Renneboog, L., J. Ter Horst, and C. Zhang (2008a). Socially responsible investments: Institutional aspects, performance, and investor behavior. Journal of Banking & Finance, 32, 1723-1742.

Renneboog, L., J. Ter Horst, and C. Zhang (2008b). The price of ethics and stakeholder governance: Evidence from socially responsible mutual funds. Journal of Corporate Finance, 14, 302-322.

Renneboog, L., J. Ter Horst, and C. Zhang (2011). Is ethical money financially smart? Nonfinancial attributes and money flows of socially responsible investment funds. Journal of Financial Intermediation, 20, 562-588.

Revelli, C. and J.-L. Viviani (2015). Financial performance of socially responsible investing (SRI): what have we learned? A meta-analysis. Business Ethics: A European Review, 24(2), 158-185.

Rudd, A. (1979). Divestment of South African equities: how risky? Journal of Portfolio Management, 5(3), 5-10.

Russo, M. V. and P. A. Fouts (1997). A resource-based perspective on corporate environmental performance and profitability. Academy of Management Journal, 40(3), 534-559.

Scheck, J. (2016). After years of growth, renewable energy investors pull back from Europe. The Wall Street Journal, URL: http://www.wsj.com/articles/after-years-of-growth-green-energy-investors-pull-back-from-europe-1454591209, accessed on 2016-04-09.

Shane, P. B. and B. H. Spicer (1983). Market Response to Environmental Information Produces Outside the Firm, The Accounting Review, 58(3), 521-538.

Sharpe, W. F. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk. Journal of Finance 19 (3), 425-42.

Sharpe, W. F. (1966). Mutual Fund Performance. Journal of Business, 119-138.

Speckbacher, G. and P. Wentges (2009). A note on stakeholder theory and risk: Implications for corporate cash holdings and dividend policy. Frontiers in Finance and Economics, 6(1), 51-72.

Statman, M. (2000). Socially responsible mutual funds. Financial Analysts Journal 56(3), 30-39.

Statman, M. and D. Glushkov (2009). The wages of social responsibility. Financial Analysts Journal 65(4), 33-46.

Sullivan, R. (2011). Investment-grade Climate Change Policy: Financing the Transition to the Low-carbon Economy. IIGCC, INCR, IGCC, UNEP FI. URL: http://www.ceres.org/files/press-files/2011-global-investor-statement-on-climate-change/investment-grade-climate-change-policy-investment-grade-climate-change-policy, accessed on 2016-01-23.

Teper, J. (1992). Evaluating the cost of socially responsible investing. In: The Social Investment Almanac. Kinder, P., A. Domini, and S. Lydenberg, 1st edition, 1992, New York City, USA, 340-349.

The Guardian (2015). Fossil fuel divestment: A brief history. URL: http://www.theguardian.com/environment/2014/oct/08/fossil-fuel-divestment-a-brief-history, accessed on 2016-02-23.

The Social Investment Forum (SIF) (2015). SRI resources and information. URL: http://www.ussif.org/, accessed on 2016-01-22.

Tiwari, A. and A. M. Vijh (2004). Sector fund performance: Analysis of cash flow volatility and returns. Working Paper, University of Iowa, USA. URL: http://www.biz.uiowa.edu/faculty/atiwari/SectorFunds.pdf, accessed on 2016-04-04.

UNEP Finance Initiative (2009). Annual report of the PRI Initiative 2009. URL: http://www.unpri.org/wp-content/uploads/PRIAnnualReport09.pdf, accessed on 2016-03-29.

UNFCCC (2015). Adoption of the Paris agreement. URL: https://unfccc.int/resource/docs/2015/cop21/eng/l09.pdf, accessed on 2016-03-24.

UNIDO (2015). Global green growth report. URL: https://www.unido.org/fileadmin/user_media/Services/PSD/GLOBAL_GREEN_GROWTH_REPORT_vol1_final.pdf, accessed on 2016-04-01.

Wagner, M. (2001). A Review of empirical studies concerning the relation between environmental and economic performance: What does the evidence tell us?" Center for Sustainability Management, Lüneburg, Germany. URL: http://www2.leuphana.de/umanagement/csm/content/nama/downloads/download_publikationen/01-6_Wagner_A_Review_of_Empirical_%20Studies_Concerning.pdf, accessed on 2016-04-01.

Weber, O., M. Mansfeld, and E. Schirmann (2010). Financial Performance of SRI funds between 2002 and 2009. Working paper, University of Waterloo, USA. URL: http://ssrn.com/abstract=1630502, accessed on 2016-03-01.

White, M. A. (1995) The performance of environmental mutual funds in the United States and Germany: Is there economic hope for green investors? In: Post, J., D. Collins, and M. Starik. Research in corporate social performance and policy. 1st edition, Greenwich, CT: JAI Press, 323-344.

White, M. A. (1996). Corporate Environmental Performance and Shareholder Value. Working Paper WHI002, McIntire School of Commerce.

World Economic Forum (2011). Green Investing 2011, Reducing the Cost of Financing. URL: http://www3.weforum.org/docs/WEF_IV_GreenInvesting_Report_2011.pdf, accessed on 2016-04-06.

Yamashita, M., S. Sen, and M. C. Roberts (1999). The Rewards for Environmental Conscientiousness in the U.S. Capital Markets. Journal of Financial and Strategic Decisions, 12(1), 73-82.

Yi, J. and K. Cho (2015). Performance of Technology sector hedge funds in emerging markets. Emerging Markets Finance & Trade, 51, 985-1000.

Appendix

TABLE A1: Correlation matrix for the full sample

	Size (log)	Age (log)	Tenure (log)	TER	Focus Region	Focus Sector	Green	Europe	Asia	Others	Europe & Green	Asia & Green	Tech-nology	Technology & Green
Size (log)	1													
Age (log)	0,13	1												
Tenure (log)	-0,11	0,20	1											
TER	-0,39	-0,18	0,00	1										
Focus region	-0,06	0,04	0,03	-0,05	1									
Focus sector	-0,03	0,03	0,03	-0,10	-0,07	1								
Green	-0,15	-0,17	0,03	0,18	0,00	0,11	1							
Europe	-0,18	0,11	0,07	0,07	0,12	-0,18	0,00	1						
Asia	-0,06	-0,02	-0,04	0,23	0,00	-0,02	0,07	-0,16	1					
Others	-0,04	0,01	-0,06	-0,02	0,02	0,30	-0,16	-0,12	-0,03	1				
Europe & Green	-0,21	-0,04	0,00	0,15	0,17	-0,08	0,46	0,63	-0,10	-0,07	1			
Asia & Green	-0,11	-0,02	-0,01	0,26	-0,06	0,01	0,17	-0,13	0,81	-0,03	-0,08	1		
Technology	0,05	-0,15	0,01	0,00	0,06	-0,12	0,07	-0,32	0,05	-0,09	-0,20	0,11	1	
Technology & Green	-0,11	-0,11	0,03	0,13	0,00	-0,03	0,39	-0,23	0,13	-0,06	-0,11	0,19	0,70	1

This table presents a pairwise correlation matrix between all control variables and variables of interest available for the full sample. The general control variables are fund size (log), age (log), management tenure (log), total expense ratio (TER) and the green dummy variable for the performance analysis as well as a dummy for regional and sectoral focus for the risk analysis. Other variables of interest are regional dummy variables for top holdings in Europe, top holdings in Asia and top holdings in other world regions as well as an interaction term for top holdings in Europe and the fund characteristic green (Europe & Green) and for top holdings in Asia and the fund characteristic green (Asia & Green). Moreover, the sectoral variables of interest, namely a dummy for major holdings in the technology sector as well as a dummy for major holdings in the technology sector and being green (Technology & Green) are included.

TABLE A2: Correlation matrix for the subsample

	Size (log)	Age (log)	Tenure (log)	TER	Focus Region	Focus Sector	Green	Fossil	Fossil & Green
Size (log)	1								
Age (log)	0,12	1							
Tenure (log)	-0,20	0,17	1						
TER	-0,33	-0,14	-0,02	1					
Focus region	-0,06	0,04	0,06	-0,02	1				
Focus sector	-0,13	0,06	0,07	-0,01	-0,03	1			
Green	-0,21	-0,17	0,17	0,14	-0,02	0,16	1		
Fossil	0,20	-0,05	-0,11	-0,20	0,01	-0,38	-0,41	1	
Fossil & Green	-0,07	-0,23	0,06	-0,09	0,01	-0,10	0,48	0,40	1

This table presents a pairwise correlation matrix between all control variables and variables of interest available for the sub sample. The general control variables are fund size (log), age (log), management tenure (log), total expense ratio (TER) and the green dummy variable for the performance analysis as well as a dummy for regional and sectoral focus for the risk analysis. Other variables of interest are fossil fuel dummy variables for funds with fossil fuel holdings (Fossil) and an interaction term for funds that have fossil fuel holdings and are green (Fossil & Green).

TABLE A3: Robustness check for the general cross-sectional model on fund performance

	Constant	Size (log)	Age (log)	Tenure (log)	TER	Green
Excess return	-0,0094	0,0043***	0,0026	0,0002	0,0006	-0,0021
t-statistic	-1,0925	4,5284	1,1962	0,2263	0,3326	-0,7706
p-value	0,2760	0,0000	0,2331	0,8212	0,7398	0,4418
R-squared	0,1282					

This table presents the results from testing the effect of fund size, age, tenure of current management, total expense ratio (TER) and being green on fund performance measured by average excess returns. Size is the natural logarithm of total assets under management of fund i at the end of 2015; Age is the natural logarithm of a fund's age at the end of 2015 since inception date in years; Tenure is the natural logarithm of current management tenure at the end of 2015 in years; TER is the total expense ratio at the end of 2015; dummy Green is 1 if fund i is a green fund and 0 otherwise. T-statistics, p-values and the R-squared of the regression are presented as well. The sample period is January 2, 2002-December 31, 2015. *, **, *** denote significance at 10, 5 and 1%, respectively.

TABLE A4: Robustness check for changes in factors determining excess returns over time

	Constant	Size (log)	Age (log)	Tenure (log)	TER	Green
2002	0,0279	0,7742***	-0,0107**	-0,0052	-0,0019	-0,0054
2003	0,0946***	0,1096*	0,0073**	-0,0055	0,0054	-0,0175
2004	0,0801***	0,1977***	-0,0043	0,0034	0,0051	-0,0030
2005	0,0445**	0,1182**	-0,0036	0,0028	0,0052	-0,0046
2006	0,0604**	0,1513**	-0,0021	-0,0034	0,0147	0,0170
2007	0,0505	0,2060**	-0,0070	-0,0113	0,0128	0,0457***
2008	-0,236***	-0,1355*	0,0095**	0,0008	-0,0247**	0,0119
2009	0,1207***	0,1803***	0,0024	0,0018	0,0147*	-0,0308***
2010	0,0203	0,0766**	0,0081*	0,0009	0,0020	-0,0433***
2011	0,0203	0,0766**	0,0081***	0,0009	0,0020	-0,0433***
2012	0,0624***	0,0006	0,0012	-0,0003	-0,0067	-0,0047
2013	0,0574***	-0,0023**	0,0010	0,0037	0,0062	0,0200***
2014	-0,049***	-0,0010	0,0069***	-0,0004	0,0008	0,0071
2015	-0,0413***	-0,0011	0,0039*	-0,0003	0,0026	0,0136**

This table presents the estimated coefficients for size, age, current management tenure, total expense ratio (TER) and the green dummy variable for the cross-sectional regression of the general control variable setting on performance every year. The dependent performance measures are yearly average excess returns. Size is the natural logarithm of total assets under management of fund i; Age is the natural logarithm of a fund's age at the end of year t since inception date measured in years; Tenure is the natural logarithm of current management tenure for each year t in years; TER is the average total expense ratio of year t; Dummy Green is 1 if fund i is a green fund and 0 otherwise. The sample period spans yearly from 2002 to 2015. *, **, *** denote significance at 10, 5 and 1%, respectively.

TABLE A5: Robustness check for the general cross-sectional model on fund risk

	Constant	Size (log)	Age (log)	Tenure (log)	TER	Focus region	Focus sector	Green
Standard deviation of excess returns	0,0406***	-0,0007**	-0,0046***	0,0002	0,0009	0,0017*	0,0056***	-0,0016*
t-statistic	13,1432	-2,2638	-6,0111	0,5791	1,3265	1,7955	4,1756	-1,7518
p-value	0,0000	0,0247	0,0000	0,5632	0,1862	0,0742	0,0000	0,0814
R-squared	0,2706							

This table presents the results from testing the effect of fund size, age, tenure of current management, total expense ratio (TER), being regionally focused, being sectorally focused and being green on idiosyncratic fund risk measured by the returns' standard deviation. Size is the natural logarithm of total assets under management of fund i at the end of 2015; Age is the natural logarithm of a fund's age at the end of 2015 since inception date in years; Tenure is the natural logarithm of current management tenure at the end of 2015 in years; TER is the total expense ratio at the end of 2015; dummy Focus region is 1 if fund i holds more than 75% in one region and 0 otherwise; dummy Focus sector is 1 if fund i holds more than 50% in one sector and 0 otherwise; dummy Green is 1 if fund i is a green fund and 0 otherwise. T-statistics, p-values and R-squared of the regression are presented as well. The sample period is January 2, 2002-December 31, 2015. *, **, *** denote significance at 10, 5 and 1%, respectively.

TABLE A6: Robustness check for changes in factors determining risk over time

	Constant	Size (log)	Age (log)	Tenure (log)	TER	Focus region	Focus sector	Green
2002	0,0907***	-0,0284	-0,0007	-0,0004	-0,0038	0,0129	0,0069	0,0000
2003	0,0638***	-0,0473*	0,0002	-0,0031	0,0016	0,0040	-0,0012	-0,0031
2004	0,0740***	0,0647***	-0,0021**	-0,0016	-0,0009	-0,0035	0,0077	-0,0043
2005	0,0596***	0,0658***	-0,0016*	0,0017	-0,0018	-0,0019	0,0129***	-0,0052*
2006	0,0859***	0,0817***	-0,0035***	0,0004	-0,0017	-0,0078*	0,0196***	-0,0056
2007	0,0864***	0,0462**	-0,0021*	-0,0003	-0,0014	-0,0027	0,0227***	-0,0101**
2008	0,1546***	0,0860**	-0,0028	-0,0002	0,0053	0,0017	0,0371***	-0,0008
2009	0,1099***	0,0580**	-0,0006	0,0015	0,0012	0,0042	0,0175***	-0,0142***
2010	0,0901***	0,0334*	-0,0023**	0,0009	0,0006	0,0025	0,0041	-0,0049
2011	0,0978***	-0,0004	-0,0012	0,0014	0,0022	0,0041	0,0092*	-0,0073*
2012	0,0765***	-0,0003	-0,0025***	0,0005	-0,0012	0,0011	0,0086**	-0,0042
2013	0,0588***	0,0002	-0,0016**	0,0003	0,0010	0,0014	0,0130***	-0,0047**
2014	0,0683***	0,0001	-0,0022***	0,0004	-0,0021	0,0008	0,0145***	-0,0083***
2015	0,0809***	0,0002	-0,003***	-0,0002	0,0000	0,0009	0,0187***	-0,0062**

This table presents the estimated coefficients for size, age, tenure of current management, total expense ratio (TER), the dummy variable for regionally focused, the dummy variable for sectorally focused and the green dummy variable for the cross-sectional regression of the general control variable setting on idiosyncratic risk per year. The dependent risk measures are the yearly calculated standard errors of excess returns. Size is the natural logarithm of total assets under management of fund i at the end of 2015; Age is the natural logarithm of a fund's age at the end of year t since inception date in years; Tenure is the natural logarithm of current management tenure at the end of year t measured in years; TER is the average total expense ratio at the end of year t; dummy Focus region is 1 if fund i holds more than 75% in one region and 0 otherwise; dummy Focus sector is 1 if fund i holds more than 50% in one sector and 0 otherwise; dummy Green is 1 if fund i is a green fund and 0 otherwise. T-statistics, p-values and R-squared of the regression are presented as well. The sample period is 2002-2015. *, **, *** denote significance at 10, 5 and 1%, respectively.