Are Green Investment funds really that bad compared to conventional funds?

Author: Paul Glasmacher
University of Twente
PO. Box 217, 7500AE Enschede
The Netherlands

ABSTRACT,
This thesis aims to provide an answer whether green investment or conventional investment Funds outperform the other in terms of risk-adjusted returns. The measures employed include the Treynor ratio, the Sharpe ratio and the Jensen's alpha. The technique employed uses a matched-pair approach over a ten-year period, to identify statistically significant out/-underperformance. The results provide mixed indications for which type of fund outperforms. Even though, some risk-adjusted-performance medians where differing, the majority of those measures did not differ to a statistically significant degree. However, green funds tend to be less exposed to market-risk, but bear higher fund specific-risk, compared to conventional funds.

Graduation Committee members: Dr. X. Huang and Prof. dr. M.R. Kabir

Keywords
Green Investment performance, Risk-adjusted Return,Green Funds, performance measures

1. INTRODUCTION

Investments of institutional and private investors are traditionally focused on return primarily. Ethical correct investments in green, sustainable technologies, moral standards were rare and only seen as marketing Add-Ons. An article by Eccles et al. (2019), published in the Harvard Business Review stresses the importance of Environmental, Social and Governance (ESG) in investment decision-making. The article is answering to what extend ESG is regarded in top management and why. They do that by presenting results of 70 interviews with executives from 43 global institutional investing firms. The

results show, the institutional investors look specifically for ESG scores during the analysis of companies. Additionally, they forecast raising importance of ESG for companies and sectors in the future.

On the other hand, the current trends in social as well as academic research concerning sustainable and green technology are present in the media and daily life. Movements like Fridays For Future as well as political efforts, for example, The European Green Deal Investment Plan reveals a high degree of importance for professionals and academics (Fridays For Future, 2020; Financial Services and Capital Markets Union, 2020). Climate change and ethical treatment of workers are present in the Newspapers as well as in the academic community (Schmidt et al.,2014; Arnold et al., 2007).

When analysing the search entries at https://www.google.com, in march 2020 using the keywords given in Figure 1.1, one can see that responsible investing is a growing field of interest across the globe, even in a non-professional context.

Figure 1.1: Worldwide interest per region[1]

Figure 1.1 shows the distribution of interest in the topics concerning ethical investments, and even databases like Scopus.com for professional researchers indicate an increase in importance (Figure1.2).

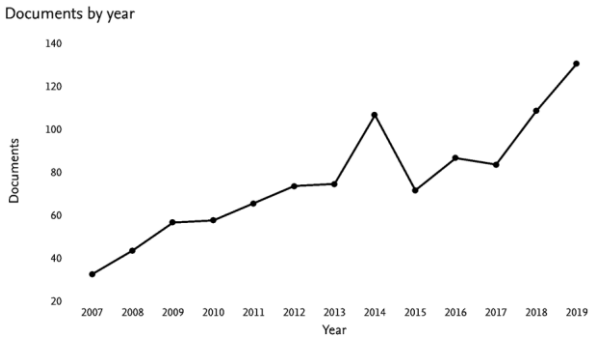

Figure 1.2: Published Journal Articles (2007-2019)[2]

The academic research already provided an in-depth view of Socially Responsible Investments (SRI), covering a variety of subjects. In figure 1.2 the published documents in the online database Scopus.com per year are shown using the search string" TITLE-ABS-
KEY (socially AND responsible AND investment)".

This thesis will borrow from the SRI literature, as SRI can be seen as an umbrella term for several different dimensions targeting a more socially responsible way of investing. One dimension is green investing, therefore literature concerning SRI might as well cover aspects of GI, but not necessarily vice versa.

The concept of SRI lays in the field of Ethical Finance and incorporates the field of Green Investment (Figure 1.3).

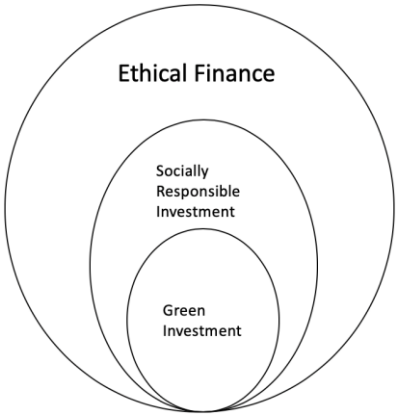

Figure 1.3: Conceptual Classification

The field of Green Investment (GI) appears to be rather unstudied. Specifically, in the context of finance, empirical studies are rather few. Despite, Researchers in the field of SRI already covered a variety of different aspects within that domain. This study emphasizes the relative performance of green investment funds compared to conventional peers. Further information about SRI and GI performance can be found in sections 2.2 and 2.3.

Anticipating the increasing interest in SRI and GI, this thesis aims to give an overview of GI fund performance and the risks associated with this class of investment. The unit of observation are green investment funds located in the EU, and conventional Investment funds without green objectives, located in the European union.

As a result of this study, the reader should obtain an insightful presentation of the difference and similarities in Green and conventional fund performance, as well as, the associated risk-characteristics of each type of fund.

2. LITERATURE REVIEW AND HYPOTHESIS

Ethical finance or the ethical/moral awareness of financiers what their investment can influence has been a widely discussed topic within the finance community. Socially Responsible Investment appears to be a new label explicitly targeting the social responsibility of investments, originated from ethical finance. green investment is a topic within the SRI field, following a more specific approach, targeting the environmental implications of investments.

2.1 Terminology

As stated earlier, Ethical finance can be seen as an umbrella term for several concepts targeting the ethical implementations or challenges connected to the finance industry. Fair treatment of workers, pollution, human rights, industry standards can all be fit into that field and studied from an ethical perspective (Schueth, 2003).

[1] Google Trends, 2020
[2] Scopus, 2020

Socially Responsible Investment introduces several different factors concerned with the social implications of an investment.

A study by Steven P. Ferris and Karl P. Rykaczewski published in spring 1986 mentions the importance of American pension fund managers to regard the social implications of their investments and formed the cornerstone for SRI. They argue that the moral implications of a pension fund need to be aligned with the interest of the community, to grant responsibility for their clients. Typically, fund managers or general asset managers following the SRI philosophy use screening techniques to identify assets that violate SRI factors and then exclude them from the selection process (Sauer, 1997). SRI is concerned about whether businesses include ESG factors or reasoning into the decision-making process and how well or bad they perform in those disciplines. ESG refers to the Environmental, Social consequences, as well as the implications or consequences for Governance in business practices.

- ***Environmental factors*** may include the carbon footprint or carbon dioxide compensation plans, waste, pollution in general, factors that might harm the ecological environment.
- The ***Social factor*** refers to the impact on the social community such as supplier-relationships, prevention of child labour, whether or not they benefit the community/general public.
- The ***Governance factor*** includes the extend in which the company is governed in an honourable, transparent manner. Measures may consist of accounting standards or no conflicting interests at projects or the board, which might influence decision-making.

Before making an investment decision, SRI fund managers need to screen for such factors ensuring good scores and an alignment with the SRI goal. Those screens and the corresponding factors are usually not standardised, which means they are chosen by the decision-makers individually (Renneboog et al., 2008).

Green investments are investments targeting the environmental impact specifically. Eyraud et al., (2011) defined Green Investments using three criteria which are:

- ***Low-emission energy supply***
- ***Energy efficiency***
- ***Carbon sequestration***

However, a widely accepted definition is not established yet. For the scope of this report, those screening criteria will hold.

2.2 Socially Responsible Investment Literature

The literature about SRI holds several analyses of performance with varying results. Interestingly, the research about SRI funds' performance draws different conclusions about the question of whether SRI funds outperform conventional funds.

Renneboog et al., (2008) conducted a literature review about SRI funds, including performance, institutional aspects and investors behaviour. The investors' behaviour and the institutional aspects shall not be regarded in detail, since the focus of this study is on performance.

The performance of SRI funds will be discussed, and theories are used and applied in the subfield of GI. Renneboog et al., (2008) shows extensive results of performance evaluations conducted by different authors within different countries. They compare the results based on the Jensen's alpha measure of risk-adjusted excess return to the CAPM-prediction of a portfolio or investment (Jensen, 1969). They found that SRI funds **do not out- or underperform** their conventional peers in a statistically significant manner. However, they also introduce several theories why that is the case. Market (in-)efficiencies, for example could play a role, which means that the efficient market theory, given by Eugene Fama and Paul A. Samuelson in the 1960s, cannot hold. This theory states that prices always reflect all available information. If that is accurate, screening for securities on public information cannot produce abnormal returns. Thus, scanning for ESG factors can not produce abnormal returns for SRI funds.

Arguments **in favour** of **outperformance** say that having good Corporate Social Responsibility (CSR) indicates excellent managerial performance and therefore, potentially greater financial success. The other argument is that good CSR scores show companies that are less exposed to the risk connected to social crisis or environmental disasters. Behavioural finance supports the outperformance hypothesis as well, stating that investors might be willing to sacrifice performance for good SRI scores.
Arguments **against** the **outperformance** theory can be found in the traditional portfolio theory by Markowitz (1959). He states that a restriction in the investment universe always leads to a sacrifice of performance compared to an unrestricted universe. In the case of SRI funds, the restriction of the investment universe is done by excluding investment opportunities based on weak SRI scores.

The presented evidence based on 16 different empirical studies conducted around the world show that SRI funds were not able to out- or underperform conventional funds, in a statistically significant manner (Renneboog et al., 2008).

Another, more recent, study conducted by Yu et al., (2014) finds different results about SRI fund performance. She claims that the earlier studies used wrong conventional benchmarks and if a propensity-score-matching is introduced, the SRI funds produce superior returns. A propensity-score-matching is a technique used in social science, biology, medicine, and engineering (among others) to find or construct the most suitable control group for non-experimental studies. The goal of this method is to eliminate the effect of potential confounding variables on a relation between the tested variables.

The factors used to calculate the propensity score are total monthly net asset value, fund flow, management fee, and return variance using a Logit model. The database for SRI and conventional funds is then screened for matching scores, which then are employed as a benchmark.

The conclusion is that, when the benchmarks are selected, using a matching propensity score, SRI funds show a statistically significant outperformance. Interestingly, fund flows still appear to be higher in conventional than SRI funds.

Kemp and Osthoff (2007) find that using a Total-Return[3] trading strategy based on an SRI philosophy can find abnormal returns up to 8.7% p.a. They screened the stocks included in the S&P500 and the DS400 index for SRI criteria. The screen than gives an SRI score, which is used to decide whether to short sell or buy a

[3] Total-Return describes a strategy combining short selling and long investments. It aims to achieve abnormal returns by participating in financial security price increase, as well as, decrease. In this case, short selling weak performing securities on the basis of SRI-scores and long-investments for good scoring securities resp. the underlying stock/bond/index et cetera.

stock. After the actual performance, they included the transaction costs and found the expected annual return presented above.

Nakai et al., (2016) argue that SRI funds tend to outperform their conventional peers, especially in times of financial distress. They conducted a study in the Tokyo stock market using the following indices, Russell–Nomura Large-Cap Growth Index, Russell–Nomura Large-Cap Value Index, Russell– Nomura Small Cap Growth Index and the Russell–Nomura Small Cap Value Index, to investigate if the bankruptcy of Lehman Brothers, the bust of the bubble on toxic-subprime credits, and the following financial crisis does have a positive influence on SRI fund performances. They found that the crisis had a significant positive influence using an alpha level of 1%.

In contrast, Renneboog et al. (2008) find an increase of SRI securities during times of catastrophic events. Renneboog et al., (2008) further state that the amount of SRI funds rises across the globe. Several factors explain this rise in SRI funds that range from regulatory, like the German Renewable Energy Sources Act, (2017) or raising demand in consequence of catastrophic events.

2.3 Green Investment

The literature concerning Green Investments is somewhat limited compared to the research about SRI. Some efforts however, have been made, which will be presented in this section.

Hafner et al., (2020) identified a so-called "Green finance gap," describing a lack of investment in green technologies. They introduced several variables based on prior research including the following "Lack of suitable financial vehicles/financial instruments,"" Perceptions that returns of renewable infrastructure investments are too low and require high initial capital investment" or "Limited projects with acceptable risk-return profiles or lack of liquidity in markets." These variables are given based on an analysis of policy reports of the finance industry.

The findings go in line with the conclusion of Yu et al., (2014) about SRI funds, presented earlier.

Mūnoz et al., (2016) compared the performance of European and US American SRI, GI funds, and conventional funds. The performance of SRI and GI funds appeared to be comparable. US global green funds, showed underperformance compared to the conventional ones. According to them, US domestic and European green funds do not perform differently than conventional ones. Moreover, they analysed the effect of periods of crisis on the performance of GI funds. They found that US green funds perform better and European GI funds perform in the opposite way.

Silva et al., (2016) conducted research comparing the performance of European and US American green funds in different market conditions. They do this by allowing alphas and betas to vary over time, and compare the results to conventional benchmark and SRI benchmark indices. Additionally, they group green funds based on whether they have a "green" label or not. Another condition is the introduction of different time periods. They found mixed results. European green funds and some US American funds tend to underperform the benchmarks.

Moreover, they found evidence for time verifying performance and risk. Particularly in times of low short-term interest or non-crisis, green funds underperform the benchmark. Also, the investment style plays a role stating that European funds are more exposed to value stocks. The label, on the other hand, appeared to not have a significant impact on performance. Concluding, that green investment funds do not harm performance over time and that even US American green funds can be seen as a "safe haven" in times of financial distress.

Chang et al., (2012) conducted a study investigating whether green investments perform better or worse than a benchmark. They found that the conclusion if GI funds are performing better or worse is bound to the market capitalization of the underlying fund. That means better-capitalized funds tend to outperform the benchmark, but securities with small capitalization tend to underperform. They try to explain that phenomenon by a resistance of investors for new technology. Interestingly that is also what Hafner et al., (2020) found investigating the "Green-finance Gap.".

2.4 Summary

Summing it up, the theories given in the SRI literature can be used for green investments first and foremost because GI is a part of SRI investing. As a consequence, the theories applied in SRI studies will also apply for green investments, to an extent.

Reviewing the theories of why SRI funds perform as they do, one sees that older theories like those of Makowitzs that restriction of the investment universe lead to a sacrifice in performance or the efficient market theory by Fama appear not to be supported by empirical research in the SRI field.

Newer studies found that the influence of time, especially times of distress or capitalisation of the fund, play a role. Additionally, the more scientific theory describes the effect of not suitable benchmarks. Those benchmarks are the foundation for models used to identify out or underperformance, logically selecting the inadequate benchmark will result in differing results.

The reasoning behind that difference of performance, some researchers say that SRI investors are willing to sacrifice performance for having peace of conscience or a balanced ethical scorecard. The resistance of investors for the new technology might also be a reason. Others argue, that the SRI criteria for fund selection minimise the risk-exposure of investors to downfalls, because of environmental or social scandals. Interestingly, that could also be a valid reasoning behind the finding that SRI funds tend to outperform in times of crisis (Renneboog et al., 2008).

Renneboog et al., (2008) prepared a literature review showing SRI performance related studies and their findings. They find that even though SRI funds can outperform their benchmarks, the majority of studies do not find sufficient evidence to say that the overall performance of conventional and green funds differ significantly. For that reason, the thesis will follow up, investigating whether the risk-adjusted performance measures differ.

2.5 Hypothesis

When referring back to the literature provided in the field of SRI it can be seen that the dominating field of interest is performance and risk. Moreover, researchers present differing results. Some argue SRI funds out-/underperform conventional funds, or they perform relatively equal. The risks of SRI funds are analysed using predominantly risk-adjusted returns as a measurement. Therefore, the primary hypothesis is about whether green and conventional funds risk-adjusted performance differs significantly. For a better understanding of the nature and the exposure to risk, the risk factors, the different measures (Chapter 3) adjusting for, will be analysed for statistically differing results.

The primary hypothesis, based on premier SRI fund performance literature, is:

- H_0: *There is no significant risk-adjusted performance difference between European green and conventional European funds*
- H_A: *There is a significant risk-adjusted performance difference between European green and conventional European funds*

The secondary hypothesis, based on risk-adjusting measurements, is:

- H_0: *There is no significant risk difference between European green and conventional European funds*
- H_A: *There is a significant risk difference between European green and conventional European funds*

3. DATA AND METHODOLOGY

A literature review prepared by von Wallis and Klein in 2015, shows different measures for performance evaluation employed by researchers and their frequency in studies concerning performance of SRI-funds. The top four performance measures include Jensen's alpha, Treynor ratio, average return and the Sharpe ratio. For that reason, the methodology will be based around average scores in terms of the risk-adjusted performance measures presented. The majority of studies use statistical tests to evaluate if the performance of each set of funds (SRI or conventional) differ significantly or are relatively equal from a statistical point of view.

Other researchers state the importance to use a matched-pair analysis, because of potential confounding variables influencing the relationship between the two sets of funds analysed. (Kreander et al., 2005; Mallin et al., 1995; Yu et al.,2014; Chang et al., 2012) For SRI funds the most prominent factors are location, size and currency.

Mallin et al., (1995) conducted a study comparing the performance of ethical a non-ethical UK investment funds. They obtained data from the Finstat database screening the strategic orientation, given in the fund prospectuses, of investment funds, for ethical behaviour. After that they formed a matched- sample for the conventional funds based on the funds size and registration date. Then, they employed three performance measures adjusting for risk, namely, the Jensen's alpha, the Treynor ratio and the Sharpe ratio. The return data is obtained by the mean annualized returns on a monthly basis. The obtained yearly data sets were than tested for statistically significant difference using a T-test. As a result, he provides the frequencies when which investment fund type outperformed the other in terms of the performance measure, giving an indication about what kind of investment fund tends to outperform the other.

3.1 Data

3.1.1 Fund Selection

Following the Methodology given in Mallin et al., (1995), the funds needed for the analysis are taken in march 2020 from htttps://www.sustainable-investment.org and https://www.yourSRI.com. These websites employ mutual fund screeners targeted explicitly to the SRI strategy. As been stated in the terminology section, Green investment or the environmental impact is one of the three dimensions of SRI. The results were then filtered to funds registered in the European Union only. Unfortunately, a widely accepted definition of Green investment appears to be missing. Validating whether funds are green, the selected environmental funds were checked using the three criteria of Eyraud et al., (2011). The requirements are: Low-emission energy supply, Energy Efficiency, and Carbon sequestration. The websites, as mentioned above, do not use such measures; that is why the funds strategy and the restriction were checked using their prospectuses.

In order to obtain historical data, the https://www.ariva.de website was used. Arriva provides historical prices for financial securities on a daily basis, in addition to other financial information.

After doing that, the sample of 33 funds with data of at least 10 years of historical price data is set.

3.1.2 Benchmark Selection

Using the European Central Bank (ECB) list of registered funds, the conventional funds were selected. The selection process is based on a matched pair approach, which means the conventional funds are matched with the fund's registered destinations and the Net Asset Value of the green funds. Funds, meeting these restrictions, with price data (in euro) of at least 10 years is then selected. They are providing a total sample of 66 funds, 33 green funds, and 33 conventional funds.

3.2 Methodology

3.2.1 Performance/Risk Measures

The performance measured employed are ***Jensen's alpha***, ***Treynor ratio***, and the ***Sharpe ratio***, to adjust for different measures of risk.

The equation for the Jensen's alpha is:

$$\alpha = R_F - (R_f + \beta_F(R_M - R_f))$$

Where:

R_F= Return of the fund

R_f= Risk-free rate

β_F= Beta of the fund

R_M= Return of the Market-portfolio

Jensen's alpha is a measure of excess return, relative to the predicted return of the CAPM model, adjusted for risk. The risk is measured using Beta.

The equation for the Treynor-ratio is:

$$TREYNOR\ RATIO = \frac{R_F - R_f}{\beta_F}$$

Where:

R_F= Return of the fund

R_f= Risk-free rate

β_F= Beta of the fund

The Treynor Ratio is similar to the Jensen's alpha, adjusting the fund performance by the risk-free return, relative to the beta risk of the fund.

The equation for the Sharpe ratio is:

$$SHARPE\ RATIO = \frac{R_F - R_f}{\sigma_F}$$

Where:

R_F= Return of the fund

R_f= Risk-free rate

σ_F= Standard deviation of fund

Similar to the aforementioned measures, Sharpe adjusts for risk, but this risk is measuring the risk associated with the specific fund, the unsystematic risk. In other words, the variation in prices associated with the specific fund.

The equation for Beta is:

$$\beta_F = \frac{cov(R_{F,R_M})}{\sigma_M^2}$$

Where:

$cov(R_{F,R_M})$= Covariance of fund returns and market return

σ_M^2= Variance of market return

The data for the market portfolio and risk-free rates is taken from Kenneth Frenches webpage at the Tuck School of Business at Dartmouth University, US (French, 2020). He builds a portfolio of every stock of which he could obtain equity data and calculates the return. That is to have an estimate for a market portfolio return as precisely as possible. The risk-free rate is the rate of a risk-free investment within the same timeframe. He used the treasury-bill-rate of European countries. The funds returns are calculated using the adjusted closing price on a daily basis.

The means of those measures are then taken on a yearly basis. In the ***first step*** the historical adjusted close prices were taken over the timeframe of 1st of January 2010 until the 11th of June of 2020, to calculate the daily return.

In a ***second step,*** the yearly average returns per day are calculated. The same holds for the factors incorporated in the Jensen's alpha, Sharpe-ratio, Treynor-ratio and the risk-factors beta and standard deviation, to calculate the risk-adjusted performance measures, as well as, the risk factors described.

That leaves 33 data points for green investment funds and 33 data points for conventional funds, each year from 2010 and 2020, per performance/risk measure.

The ***third step***, an analysis of statistically significant difference is conducted based on the distribution or the data points obtained. So, there are 5 different statistical tests, one for each performance measure and risk-factor in a given year.

3.2.2 Statistical Tests

Statistical tests are used when researchers want to compare two samples, in this case, the comparison in this report is between one sample of green funds and one sample of conventional funds. Each sample has 33 data points per year and performance/risk measure. That leaves us with ten statistical test which have to be performed.

In order to select the appropriate test for the given sample, one has to consider the underlying assumptions and principles the test is relying on. Two important assumptions are targeting the distribution and the variances of each sample. The distribution of the samples (in this specific setting) can either be approximately normal or skewed (t-distribution). The selection of the relevant test is bound to those assumptions. On the one hand, non-parametric tests are not bound to samples following the normal distribution and do not have restrictions concerning variance. Parametric tests require samples which are approximately normal distributed and take variance into account. To attain the knowledge about distribution and variance several tests are introduced. (Verma et al., 2019)

That means the samples of the measures for conventional and green funds are tested for normality and equal variances.

The test for normality used is the Shapiro-Wilk test, with the test statistic:

$$W = \frac{(\sum_{i=1}^{n} a_1 x_i)^2}{\sum_{i=1}^{n}(x_i - \overline{x})^2}$$

The next condition is variance, a test for the equality of variances is used, namely the F-test. The test statistic is:

$$F_{STAT} = \frac{\sigma_2^2}{\sigma_2^2}$$

The statistical test is then chosen based on the requirements it needs. Using either non-parametric tests, when normal distribution cannot be assumed or parametric tests, when it can be expected. Those conditions are tested based on the data set obtained from the measures given earlier. The non-parametric. (not assuming normality) test used is the Mann-Whitney U test; the parametric tests (assuming normality) are dependent on the equality of variance, Welch's t-test for equal variances or independent-two-sample t-test for unequal variances.

The test statistics for the Mann-Whitney-U test is:

$$U_1 = R_1 - \frac{n_1(n_1+1)}{2};$$
$$U_2 = R_2 - \frac{n_2(n_2+1)}{2}$$

where:

R_1 =Sum of the ranks of group one

n_1 =The sample size of group one

R_2 =Sum of the ranks of group two

n_2 =The sample size of group two

The test statistic for the Welch's t-test is:

$$t = \frac{\overline{X_1 - X_2}}{\sqrt{\frac{s_1^2}{N_1} - \frac{s_2^2}{N_2}}}$$

The test statistic for the independent-two-sample-t-test is:

$$t = \frac{\overline{X_1 - X_2}}{s_p * \sqrt{\frac{2}{n}}}$$

Where:

$$s_p = \sqrt{\frac{s_{X_1}^2 + s_{X_2}^2}{2}}$$

By choosing this methodology, this report follows the approach of Kreander et al., (2005). However, he did not consider the different requirements for each test, he did both kinds, without differing results between parametric and non-parametric tests. Additionally, he analysed weekly average returns instead of yearly averages. He further introduced additional variables such as timing or management fee, which should be of interest for future research.

4. ANALYSIS AND DISCUSSION

4.1 Analysis

The analysis of the different data sets show that Normal Distribution cannot be assumed in each case and every timespan. The null-hypothesis of the Shapiro-Wilk-test was rejected in each of the samples (given alpha =5%) Therefore, the Mann-Whitney-U test was selected in every year.

The chosen funds and the performance measures provided above are presented in Table 4.1. That shows, already similar outcomes across the two samples and performance/risk measures.

4.1.1 Full sample

	Medians			
Full sample period	**Green**	**Conventional**	**p-value**	**h0-decision**
Jensens alpha	-0,0021	-0,0021	0,088	retain
Sharpe ratio	-0,1819	-0,1730	0,189	retain
Treynor ratio	-0,0050	-0,0037	0,021	reject
Beta	0,4187	0,5131	0,034	reject
Standard deviation	0,0104	0,0113	0,48	retain

* data only obtained until 11.06.2020

h0-hypothesis: The Medians of the two samples out of conventional and green funds do not differ significantly

Figure 4.1: measures full sample

Figure 4.1 shows the results for the statistical analysis for the scope of the full sample. The h0-hypothesis for the Mann-Whitney-U test is that the median of the Green and the conventional sample is equal. Given that, one finds that there is no statistically significant difference in the Jensen's alpha, Sharpe ratio, and Standard deviation, on the other hand, the Beta and as a consequence, the Treynor ratio appear to differ from each other. (alpha = 5%) That means, in simpler terms, that the average medians of the two kinds of funds of each sample does not have statistically different intrinsic risk or statistically significant different returns. The sensitivity to the market and the returns adjusted for that differ in a statistically significant manner. It seems to be the case that green investment funds are less exposed to market risks, thus are less sensitive. The Treynor ratio reflect that, as well. Even though conventional funds are more sensitive to the market, they also tend to achieve higher returns.

4.1.2 2020

The 2020 data analyzed, as mentioned before, does only cover the timeframe from the first trading day in January of 2020 until the 11th of June 2020. It is included to see the implications given by the SARS-CoV-2 pandemic challenging the global economy.

Medians

2020*	Green	Conventional	p-value	h0-decision
Jensens alpha	-0,0067	-0,0071	0,288	retain
Sharpe ratio	-0,3368	-0,3304	0,427	retain
Treynor ratio	-0,0100	-0,0091	0,296	retain
Beta	0,9011	0,9916	0,015	reject
Standard deviation	0,0263	0,0287	0,001	reject

* data only obtained until 11.06.2020

h0-hypothesis: The Medians of the two samples out of conventional and green funds do not differ significantly

Figure 4.2: measures 2020

Figure 4.2 shows that even though the medians of the performance measures adjusted for risk do not differ, the risk indeed does differ significantly at conventional levels (alpha of 5%). To follow up on the reasoning of Silvia et al., (2016) that green investments tend to perform better in periods of crisis. The analysis shows, risk-adjusted returns do not differ, but the risk factors (incorporated in the performance measures) do. A Beta of 0.9011 for green funds is better than 0.9916 for conventional funds. The implied median average daily returns of -0.9% for both groups does not show the security which an investor might expect. As a conclusion, for this crisis, green investment funds appear not to be the "safe haven," which would have been expected.

4.1.3 January 2010 until December 2019

	h0-decision		Outperformance	
Counts of*	retain	reject	Green Funds	Conventional Funds
Jensen's alpha	4	6	3(30%)	3(30%)
Sharpe ratio	6	4	1(10%)	3(30%)
Treynor ratio	8	2	2(20%)	0(0%)
Beta	7	3	3(30%)	0(0%)
Standard deviation	9	1	0(0%)	1(10%)

*01/2010-12/2019

h0-hypothesis: The Medians of the two samples out of conventional and green funds do not differ significantly. Percentages are conditional

Figure 4.3: counts for statistically significant outperformance per measure and fund type

For the remaining years of 2010 until 2019, Figure 4.3 shows the frequency of h0-decisions made and whether green or conventional funds outperformed the other. Table 4.2 provides more detailed information, including medians and p-values.

Given the conditional probabilities, representing the stake of outperformance of the fund type, in counts throughout January 2010 until December 2019, on a yearly basis. It shows when the medians per performance/risk measure of each fund type are (statistically) significantly different from each other. Additionally, the stake of green and conventional funds within that condition.

Outperformance in terms of Jensen's alpha appeared to be the case for 50% green funds and 50% conventional funds. The conclusion should be that a systematic outperformance cannot be proven, generally. The Sharpe ratio shows that conventional funds tend to outperform green funds for 30% of the cases if the difference in medians is statistically different. That could indicate a systematic outperformance.

Standard deviation, the risk factor the Sharpe ratio is adjusting for, on the other hand, does not show differing medians in general. Only one case showed differing medians, and that was the median for conventional fund outperforming green funds. (lower standard deviation). For that reason, one might be arguing that could indicate a lower specific-risk involved when buying conventional funds.

Contrary to the implications given by the Sharpe ratio, the Treynor ratio shows that green funds tend to outperform their conventional alternatives in 20% of the relevant cases, considering the beta (the risk factor Treynor is adjusting for), that indication appears to be the driver of this outperformance, given that in 30% of the cases green investment performed better or are less exposed to market risk.

4.2 Discussion

The analysis shows differing results, when answering the question of which type of fund outperforms the other in terms of risk-adjusted returns. As usual, the answer seems to be not that clear. The two different kinds of fund strategy are shown to be exposed differently to two major risks involved, namely systematic and unsystematic risk or market- and fund-specific-risk (when matched with fund destination, size and currency).

Although, the informative power of the analysis (more in the limitations section) can be questioned, indications can be provided though.

The full sample period, including 2020, give no clear picture of risk-adjusted returns. If we consider the 2020 period as a separate sample, we see that the two risk dimensions differ from each other. Especially, the abnormally high values for the Beta measure might have skewed the data set. (compared to the other years in Table 4.2)

When analyzing the data obtained from January 2010 until December 2019, we get a clearer picture of risk-adjusted returns.

Investment funds following a conventional strategy appear to be more exposed to market-risk, underperforming funds following a green, environment centric strategy. The reason for that might be found in the field of Behavioral Finance. Different kinds of investors require various investments and investment styles. Long-term oriented investors, like pension-funds or other institutions, might need additional social criteria when selecting an investment, to act in favor of their stakeholders or reduce the risk exposure associated with unethical investments. As a result, those institutional investors do not have/are allowed to behave like the market.

The other implication given is that conventional funds outperform green funds in terms of fund-specific-risks. That means, the yearly volatility of green funds tends to be higher than the annual fluctuations of conventional funds. The reason for that could be that the green Funds are less liquid than their conventional peers, or are traded less often. That might lead to

higher spreads and ultimately to higher volatility or standard deviation.

Another interesting indication is that the actual yearly average returns do not differ significantly (given that only,16 cases out of 50 show statistically significant difference) in recent years. Which leads to a more general question, is outperformance/underperformance the correct way to evaluate green funds, or should we see the ecological impact of our investments as another critical factor not related to pure performance related criteria. Or should we see green investment funds as an ethical alternative to conventional investment Funds, with arguably unique risk-characteristics?

5. LIMITATIONS AND FUTURE RESEARCH

5.1 Limitations

Even though the data was selected with a maximum of care and accuracy, implications about the whole population cannot be guaranteed. The reason for that is, the extensive use of terms such as green, sustainable, or other environmentally responsible connotated keywords. In addition to that, the true populations of green investment funds cannot be assessed correctly, because a widely accepted definition for green investments is not established yet. Another factor is that the assessment of the green investment criteria of Eyraud et al., (2011) read out the prospectuses of the funds checked depends to a high degree of qualitative personal interpretation.

The data collection is very dependent on the providers yourSRI.com, sustainable-investment.org, arriva.de, and the list of registered funds of the ECB. The reliability of those providers does not seem to be in question. However, it is plausible that they did not identify every fund which meets the criteria employed.

The sample size of conventional funds is not big enough to make general statements about the European fund population. There might be different results when the sample size is more substantial.

A more general limitation, when it comes to selecting historical data, is the survival ship bias, that states in this case that historical funds that were closed do not appear in the sample anymore. Which results in a skewed representation of historic developments. Even though the green fund sample has a fund that is closed by now, it is most probably not a good representation of the history.

The timeframe of this survey is only covering a period of 10 years, comparing yearly average medians, based on daily prices. That leaves the analysis with a somewhat limited set of data series to analyze. Especially, the data for 2020 cannot be taken as a realistic representation of the whole year, since data is only obtained until 11th of June 2020 missing out of approximately 5.5 months of data.

A more methodological issue is that even though the sample size is relatively small, using a non-parametric test. There is a risk of Type I errors, which means falsely rejecting the h0- hypothesis, or in simpler terms falsely assuming statistically different performance/risk medians.

5.2 Future Research

This research does not provide insights about monthly returns, that would be an excellent opportunity for future research, because shorter periods may include higher variation.

Additionally, future research should emphasize the definition of green investment funds and employ quantifiable measures to assess the "greenness" of a fund. Moreover, risk-adjusted returns and specific risks should be analyzed, as well as management fees. A question which is more ethical in nature but worth considering is whether it is ethically right to make green investments, as a Pension fund, considering the potential higher volatility. The claims set up in the Discussion section, the reasoning behind the causes of outperformance, cannot be validated by this study, but the premier focus of this study was on accessing the historical performance and risk characteristics of conventional and green funds. These claims could indeed be a starting point for future research. Future research could emphasize that, by analyzing the fund flows for both green and conventional funds, liquidity, as well as the investor-/fund holder structure.

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Secondly, I have to thank M. Krauthausen a fellow student, we spend quite some time during the whole process evaluating different models and methods or even databases, which not always resulted in fruitful results.

Table 4.1: Fund Overview with Measures over the full period

	Green Fund Portfolio		Full Sample period (2010-2020*)				
	Name	ISIN	Jensen's Alpha	Shape Ratio	Treynor Ratio	Beta	Standart deviatior
1	Parvest Global Environment	LU0347711466	-0,0021	-0,2670	-0,0048	0,4187	0,0075
2	Nordea 1 - Global Climate and Environment Fund BP EUR	LU0348926287	-0,0020	-0,2042	-0,0054	0,3564	0,0095
3	Meridio Funds - Green Balance P	LU0117185156	-0,0019	-0,1587	-0,0245	0,0772	0,0119
4	ERSTE WWF Stock Environment A	AT0000705660	-0,0023	-0,2617	-0,0464	0,0503	0,0089
5	DPAM Invest B Equities World - A	BE0946563377	-0,0022	-0,1537	-0,0045	0,4647	0,0136
6	LBBW Global Warming	DE000A0KEYM	-0,0027	-0,0785	-0,0040	0,6472	0,0326
7	DWS Water Sustainability Fund	DE000DWS0DT	-0,0021	-0,2060	-0,0070	0,2910	0,0099
8	Deka-UmweltInvest CF	DE000DK0ECS:	-0,0020	-0,1987	-0,0062	0,3121	0,0097
9	Lyxor New Energy UCITS ETF	FR0010524777	-0,0019	-0,1845	-0,0189	0,1017	0,0104
10	HSBC RIF Europe Equity Green Transition AC	FR0000982449	-0,0022	-0,4285	-0,0113	0,1882	0,0050
11	Vontobel Fund - Global Clean Technology A EUR	LU0384405519	-0,0020	-0,2048	-0,0067	0,2953	0,0097
12	Parvest Green Tigers	LU0823437925	-0,0021	-0,2094	-0,0079	0,2552	0,0096
13	KBC ECO Fund Climate Change	BE0946844272	-0,0020	-0,1467	-0,0032	0,5970	0,0129
14	KBC ECO Fund Alternative Energy	BE0175280016	-0,0021	-0,2103	-0,0038	0,5234	0,0096
15	TBF SMART POWER EUR R	DE000A0RHHC	-0,0021	-0,1453	-0,0023	0,8189	0,0131
16	Invesco Umwelt und Nachhaltigkeits Fonds	DE0008470477	-0,0021	-0,0901	-0,0081	0,2537	0,0227
17	DWS Zukunftsressourcen	DE0005152466	-0,0019	-0,1284	-0,0028	0,6503	0,0140
18	Fondita Sustainable Europe	FI4000024484	-0,0020	-0,2295	-0,0360	0,0561	0,0088
19	Vontobel Fund - Future Resources A EUR	LU0384406087	-0,0020	-0,1819	-0,0035	0,5385	0,0102
20	Swisscanto (LU) EF Global Climate Invest	LU0275317336	-0,0019	-0,1851	-0,0155	0,1236	0,0104
21	SUNARES - Sustainable Natural Resources	LU0344810915	-0,0021	-0,1985	-0,0036	0,5512	0,0099
22	LSF Solar & Sustainable Energy Fund	LU0405846410	-0,0020	-0,1762	-0,0034	0,5606	0,0109
23	Jupiter Global Ecology Growth	LU0231118026	-0,0021	-0,2188	-0,0072	0,2793	0,0092
24	JSS Sustainable Equity - Europe P EUR acc	LU0484532444	-0,0020	-0,1645	-0,0034	0,5666	0,0116
25	DNB Fund - ECO Absolute Return EUR	LU0547714286	-0,0022	-0,1340	-0,0036	0,5777	0,0155
26	ÖkoWorld Klima	LU0301152442	-0,0027	-0,1413	-0,0050	0,5272	0,0185
27	GreenEffects NAI-Wertefonds	IE0005895655	-0,0022	-0,1815	-0,0033	0,6161	0,0113
28	DNB Fund - Renewable Energy	LU0302296149	-0,0023	-0,1738	-0,0060	0,3754	0,0129
29	DKB Nachhaltigkeitsfonds Klimaschutz AL	LU0117118124	-0,0024	-0,1588	-0,0034	0,6635	0,0143
30	RobecoSAM Smart Materials	LU0175575991	-0,0020	-0,1762	-0,0032	0,5930	0,0108
31	RobecoSAM Smart Energy Fund	LU0175571735	-0,0022	-0,3699	-0,0118	0,1869	0,0059
32	Parvest Climate Impact	LU0406802339	-0,0020	-0,1790	-0,0024	0,7791	0,0105
33	Mirova Europe Environmental Equity Fund R/A (EUR)	LU0914733059	-0,0023	-0,3933	-0,0094	0,2373	0,0057

* data only obtained until 11.06.2020

	Conventional Fund Portfolio		Full Sample period (2010-2020*)				
	Name	ISIN	Jensen's Alpha	Shape Ratio	Treynor Ratio	Beta	Standart deviation
1	UBS-ETF MSCI World	LU0340285161	-0,0020	-0,1680	-0,0034	0,5536	0,0113
2	db x-tr.MSCI USA Index ETF Inhaber-Anteile 1C	LU0274210672	-0,0019	-0,1300	-0,0039	0,4700	0,0141
3	Lyxor STOXX Europe 600 Media UCITS ETF	LU0378436363	-0,0021	-0,1599	-0,0028	0,6919	0,0123
4	All Asia T	DE0009757922	-0,0022	-0,1532	-0,0020	0,9924	0,0129
5	KBC Equity Fund - World Classic Dis	DE0005152623	-0,0017	-0,0592	-0,0008	1,6048	0,0227
6	Deka-Technologie CF	AT0000721436	-0,0025	-0,1874	-0,0100	0,2473	0,0132
7	Deka DAXplus Maximum Dividend UCITS ETF	FR0010149112	-0,0020	-0,2215	-0,0065	0,3004	0,0088
8	Invest Global	FR0010890814	-0,0020	-0,1961	-0,0037	0,5087	0,0097
9	Carmignac Euro-Entrepreneurs A EUR Acc	BE6213776535	-0,0019	-0,2142	-0,0055	0,3423	0,0087
10	NATIXIS EUR.OPP	LU0252634307	-0,0019	-0,1906	-0,0041	0,4300	0,0093
11	UBS ETF - EURO STOXX 50 UCITS ETF (EUR) A-dis	DE000ETFL235	-0,0020	-0,1840	-0,0037	0,5131	0,0102
12	Lyxor Daily LevDAX UCITS ETF	LU0136234068	-0,0017	-0,1651	-0,0042	0,3946	0,0100
13	KBC Equity Fund - Latin America Classic Dis	DE000A1J9BC9	-0,0021	-0,0815	-0,0071	0,2899	0,0253
14	KBC Equity Fund - Utilities Classic Cap	LU0533034632	-0,0021	-0,1524	-0,0026	0,7758	0,0130
15	Fiag Universal Dachfonds	DE0005321038	-0,0023	-0,1554	-0,0020	1,0108	0,0132
16	sentix Fonds Aktien	LU0249326488	-0,0020	-0,1388	-0,0024	0,7775	0,0134
17	Monega Germany	LU0533034046	-0,0021	-0,1464	-0,0022	0,8747	0,0134
18	Fondita Nordic Small Cap	LU0533033071	-0,0019	-0,1546	-0,0022	0,7976	0,0114
19	Market Access ROGERS INTERNATIONAL COMMODITY INE	BE0152246535	-0,0021	-0,1732	-0,0057	0,3465	0,0115
20	Lyxor MSCI World Utilities TR UCITS ETF	BE0169742898	-0,0016	-0,1305	-0,0131	0,1177	0,0118
21	Lyxor MSCI World Materials TR UCITS ETF	DE0009848424	-0,0024	-0,1758	-0,0026	0,8403	0,0126
22	Lyxor MSCI World Telecommunication Services TR UCITS E	FI0008801766	-0,0021	-0,1730	-0,0038	0,5134	0,0113
23	Lyxor MSCI World Industrials TR UCITS ETF	LU0533034392	-0,0021	-0,2923	-0,0091	0,2308	0,0072
24	Lyxor MSCI World Financials TR UCITS ETF	LU0533033584	-0,0022	-0,1587	-0,0032	0,6460	0,0130
25	Lyxor MSCI World Consumer Discretionary TR UCITS ETF	LU0533032180	-0,0021	-0,1868	-0,0030	0,6491	0,0105
26	UBS ETFs plc - MSCI AC Asia ex Japan TRN Index SF (USD) .	IE00B7WK2W2	-0,0021	-0,2195	-0,0034	0,5737	0,0089
27	Market Access NYSE Arca Gold BUGS Index UCITS ETF	LU0259322260	-0,0021	-0,2418	-0,0046	0,4265	0,0082
28	UBS ETF (LU) FTSE 100 UCITS ETF (GBP) A-dis	LU0136242590	-0,0024	-0,1614	-0,0038	0,6054	0,0142
29	UBS-ETF EMU Values	LU0446734369	-0,0021	-0,2338	-0,0059	0,3486	0,0088
30	db x-tr.MSCI EUR.Small C.I.ETF Inhaber-Anteile 1C	LU0322253906	-0,0021	-0,2172	-0,0695	0,0302	0,0097
31	ComStage DAX UCITS ETF	LU0378438732	-0,0021	-0,1892	-0,0033	0,6079	0,0106
32	Lyxor DAX (DR) UCITS ETF	LU0252633754	-0,0018	-0,1501	-0,0033	0,5089	0,0081
33	db x-trackers MSCI Pacific ex Japan Index UCITS ETF (DR) 2(	LU0455009935	-0,0021	-0,2548	-0,0068	0,3015	0,0081

* data only obtained until 11.06.2020

Table 4.2: Medians of measures per sample and timeframe

	Medians					Medians			
2019	**Green**	**Convention**	**p-value**	**h0-decision**	**2014**	**Green**	**Convention**	**p-value**	**h0-decision**
Jensens alpha	-0,0094	-0,0096	0,027	reject	Jensens alpha	0,0004	0,0005	0,004	reject
Sharpe ratio	-1,1413	-1,1630	0,993	retain	Sharpe ratio	0,0408	0,0510	0,012	reject
Treynor ratio	-0,0122	-0,0125	0,879	retain	Treynor ratio	0,0006	0,0006	0,192	retain
Beta	0,7102	0,7124	0,15	retain	Beta	0,4634	0,5675	0,122	retain
Standard deviation	0,0078	0,0078	0,623	retain	Standard deviation	0,0084	0,0078	0,979	retain
2018			**p-value**	**h0-decision**	**2013**			p-value	h0-decision
Jensens alpha	-0,0092	-0,0091	0,22	retain	Jensens alpha	0,0005	0,0003	0,048	reject
Sharpe ratio	-1,1222	-1,0928	0,411	retain	Sharpe ratio	0,1082	0,0914	0,056	retain
Treynor ratio	-0,0159	-0,0158	0,538	retain	Treynor ratio	0,0023	0,0014	0	reject
Beta	0,5846	0,6074	0,177	retain	Beta	0,2830	0,4498	0,006	reject
Standard deviation	0,0085	0,0088	0,33	retain	Standard deviation	0,0071	0,0079	0,228	retain
2017			**p-value**	**h0-decision**	**2012**			**p-value**	**h0-decision**
Jensens alpha	0,0001	-0,0001	0,001	reject	Jensens alpha	0,0000	0,0004	0,001	reject
Sharpe ratio	0,0672	0,0538	0,016	reject	Sharpe ratio	0,0033	0,0621	0,003	reject
Treynor ratio	0,0017	0,0007	0,005	reject	Treynor ratio	-0,0003	0,0012	0,084	retain
Beta	0,2658	0,4024	0,005	reject	Beta	0,2317	0,3588	0,03	reject
Standard deviation	0,0060	0,0065	0,11	retain	Standard deviation	0,0103	0,0117	0,35	retain
2016			**p-value**	**h0-decision**	**2011**			**p-value**	**h0-decision**
Jensens alpha	0,0003	0,0004	0,017	reject	Jensens alpha	-0,0003	-0,0002	0,357	retain
Sharpe ratio	0,0340	0,0416	0,044	reject	Sharpe ratio	-0,0239	-0,0116	0,381	retain
Treynor ratio	0,0009	0,0008	0,131	retain	Treynor ratio	-0,0010	0,0001	0,053	retain
Beta	0,4224	0,5091	0,15	retain	Beta	0,2501	0,2491	0,544	retain
Standard deviation	0,0099	0,0105	0,03	reject	Standard deviation	0,0080	0,0082	0,652	retain
2015			**p-value**	**h0-decision**	**2010**			**p-value**	**h0-decision**
Jensens alpha	0,0004	0,0004	0,549	retain	Jensens alpha	-0,0001	-0,0001	0,61	retain
Sharpe ratio	0,0287	0,0337	0,36	retain	Sharpe ratio	-0,0147	-0,0066	0,122	retain
Treynor ratio	0,0007	0,0006	0,237	retain	Treynor ratio	-0,0007	-0,0003	0,524	retain
Beta	0,5191	0,5263	0,114	retain	Beta	0,1963	0,2568	0,299	retain
Standard deviation	0,0113	0,0112	0,28	retain	Standard deviation	0,0123	0,0139	0,61	retain

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