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Social responsible mutual funds and low-carbon economy

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Abstract

Sustainable investment responds to claims for carbon and climate-neutral societies. To addresses the urgency around climate change and provide more qualified information to investors, Morningstar has developed the Low Carbon Designation (LCD), an indicator that the companies held in a portfolio are in general alignment with the transition to a low-carbon economy. It is assigned to portfolios that have low carbon-risk and fossil-fuel exposure scores. This study takes this a step further by examining the relationship between these scores and financial performance. With this aim, we analyse 3,920 socially responsible mutual funds in the world. Results show differences in financial performance, according scores and investment areas. We find evidence that funds characterized with higher levels of sustainability achieved better performance than funds more exposed to carbon and fossil fuel involved companies. Therefore, we provide insights on the informativeness of these new scores for fund selection by investors, for a fairer comparison between socially responsible and conventional funds -since that sustainability improves performance- and for developing low carbon economies.

Keywords: environmental, low-carbon, mutual fund, performance, sustainability

JEL classification: G11, G17, G23, G2, N20, Q56

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1. Introduction

For decades, the mutual fund industry has experienced a continuous growth worldwide and, more recently, an unprecedented development of social responsible (SR) funds is noticeable in line with the growing interest in sustainable investing. According to the Global Sustainable Investment Review,[1] in 2018 sustainable investing in the United States reached an increase of thirty-eight percent of the total assets under management using sustainable strategies, and considering the past two years. In Europe, the total assets committed to sustainable and responsible investment strategies grew by eleven percent between 2016 and 2018. This is more acute in the case of Canada, with an increase of forty-two percent for the same period. Therefore, SR investment is consolidating its leading position as a preferred investment alternative for investors interested in sustainability and environmental protection.

Although there are differentiating nuances, the so-called sustainable investment is indistinctly recognized sometimes as "social responsible", "ethical", "environmental" or "green" investment. Its importance has been established in relatively recent years, since the societies' beliefs are pushing in pro of environmentally conscious business practices—such as the conservation of natural resources, the production of alternative energy sources, or the implementation of clean air and water projects, among other green-based initiatives. In this context, sustainable investing constitutes an opportunity for managers and well-diversified investors who play a central role in taking action on a real threat, and combat the dramatic consequences of global warming, climate change and environmental pollution. Therefore, many financial investment strategies are centered in allocating capital to exploit the climate-resilient opportunities, i.e., to handle the portfolio risk while capitalizing on the transition towards a lower carbon economy. Specifically, Louche et al. (2019) argue that financial markets play a major role in favoring this transition, while Ceccarelli et al. (2019) address the linkage between the climate preferences of investors and the importance of climate responsibility for the financial intermediaries willing to keep competitiveness dealing with eco-labelling schemes and redirecting, if necessary, capital flows towards the transition to a low carbon economy (Galaz et al., 2015; Linnenluecke et al., 2016; Scholtens, 2017).

Undoubtedly, investors and financial market participants alike ratify the increased in-

[1] Available at www.gsi-alliance.org/.

terest that questions related to the carbon emissions raised along with the carbon reporting and the proliferation of climate conscious investment products worldwide—an interest that peaked with the 2015 Paris Agreement. Among other premises, questions related to transparency and the availability of climate-relevant information are both gaining importance to support the global agreement (Ceccarelli et al., 2019). Since then, some initiatives have been taking place, such as the European Comission's action plan for sustainable finance in 2018 which proposes the introduction of eco-labels schemes on the market to facilitate the environmentally-aware investors to express their preferences. Furthermore, under this scenario, investment institutions are adapting their businesses towards an eco-label system. For instance, the reputed company Morningstar, which is specialized in financial information, has recently adopted an eco-label classification of mutual funds, developing the *Low Carbon Designation* (LCD), which is assigned to portfolios with both low carbon-risk scores and low levels of fossil-fuel exposure (Morningstar, 2018).

Therefore, the introduction of the LCD represents a significant milestone to the sustainable investment field in general and, in particular, to investor's investment decisions, as they have increased the access to relevant climate information. Specifically, the Morningstar's LCD classification offers levels of scores to assess the exposure of the funds in terms of carbon risk and this tool mainly aims to help investors by integrating their preferences into global sustainable investment. To the best of our knowledge, and because this metric is only recently available, the literature on this specific subject is still scarce, with a few number of studies dealing with the LCD scores. A prominent exception is Ceccarelli et al. (2019), who contribute to this particular topic, analyzing mutual funds' flows and finding that investors valued LCD. Thus mutual funds labeled as low-carbon increased assets under management relative to funds that were not labeled as low-carbon. As a contribution, we find that the LCD indicator is very informative not only to evaluate environmental funds according to their low-carbon score but also to compare them by conducting a performance diagnosis.

Previous literature has considered the effect of sustainability on performance but considering as main variables other scores defined prior to the LCD. For instance, similarly to Ceccarelli et al. (2019), Ammann et al. (2019) put the emphasis on the analysis of fund flows, finding that retail investors are sensitive to sustainability scores. Other authors are focused on the relationship between scores and financial performance, finding mixed results. For instance, Durán-Santomil et al. (2019) find that investing in companies with better sustain-

ability scores improves fund's performance. Matallín-Sáez et al. (2019a) explore the effect of idiosyncratic SR features and find that performance improves for environmental funds and those with high scores. In a multinational study, Matallín-Sáez et al. (2019b) show that the negative relationship between scores and performance is driven by worst-performing funds and how is necessary to pay special attention to mutual fund selection when portfolio is restricted. So far the number of scientific articles approaching the performance of environmental funds in a diverse manner is remarkable and researchers interest on this topic has greatly increased over the last decade (Climent and Soriano, 2011; Muñoz et al., 2014; Ibikunle and Steffen, 2017; López-Arceiz et al., 2018; Alda et al., 2020; Allevi et al., 2019).

In examining the relationship between environmental funds and their conventional peers attending to their performance, the literature, suggests that no difference in the performance appears. For instance, Muñoz et al. (2014) compare a sample of US and European green funds with a set of conventional and other kinds of SR mutual funds and after discriminating the data into crisis and non-crisis periods, they find that during the crisis all the analyzed funds perform similarly. In addition, Chang et al. (2012) suggest that green mutual funds report lower returns and similar risk when compared to traditional funds. Moreover, Mallett and Michelson (2010) find no differences in performance when US green funds, SR funds and index funds are scrutinized. This question makes the analysis even more attractive from the point of view of the sustainable growth and the boom being experienced for the green funds in the world lately. At the center of the controversy, the vast majority of authors advocate that green funds achieved adjusted returns not significantly different from the rest of SR and conventional funds (Climent and Soriano, 2011; Renneboog et al., 2008; Matallín-Sáez et al., 2019a). However, some contributions postulate that investors in environmental mutual funds earned inferior risk-adjusted returns (White, 1995; Ibikunle and Steffen, 2017; Silva and Cortez, 2016). We contribute to this debate on the impact of the environmental preferences on fund performance.

More specifically, our study analyzes the behavior of SR mutual funds by examining the implications of managerial decisions for financial performance and by taking levels of scores regarding the geographical scope of the Morningstar's LCD indicator. Using a sample of 3,920 SR mutual funds from Europe, the United States and Canada, and "other" zones (including emerging countries), we examine the following: (i) the measurement of performance according to environmental scores; and (ii) the relation between SR fund per-

formance and the level of carbon risk and fossil fuel portfolio involvements. Then, we cover the core LCD fund's region-specific characteristics (carbon risk and fossil fuel involvement) by establishing levels of scores and subsequently, we undertake a multi-regional analysis for comparative purposes. We find that an inverse relationship between scores and performance exists, noting that the lower scores achieve a better performance. Recall that in the case of the LCD, the lower (higher) the scores, the higher (lower) is the intensity in terms of environmental sustainability. Consequently, funds which are more highly ranked by the LCD achieve in general a poorest abnormal performance. This effect is strongly identified for European SI and with less impact for the United States case. These results are in line with the evidence found by Hunt and Weber (2019). They showed how fossil fuel disinvesting strategies in the stock market provide both, lower carbon intensity and also higher risk-adjusted returns. Therefore also mutual funds presenting the lowest carbon risk and fossil fuel portfolio involvements experienced the greatest returns. Thus, the existing dichotomy between performance and low carbon intensity might justify the need to address inherent financial risks caused by the climate change involvement and, simultaneously, the claim to reduce the carbon exposure of investment portfolios.

Our study is based on the novel Morningstar LCD scores and contributes to the literature in several ways. First, we provide new evidence on the added value that environmental investments may provide in the context of SR mutual funds. This is an issue that urges to be addressed since the environmental debate is currently gaining momentum and deserves special attention from a rigorous financial perspective. In this line, our study includes the call for a better understanding to investors of the specific SR scores that may be considered in order to make economically sound decisions. To our knowledge, this is the first study to show that SR scoring by using Morningstar LCD matters for mutual fund assessment and also from a multi-regional perspective.

Second, the study makes a contribution on the existing connections between the environmental strategies when selecting funds and its potential outcomes materialized in financial performance. This is highly valuable information to investors, managers and financial markets participants alike, as they should be aware of the specific risks of each constructed portfolio—in particular for the sustainable investments case.

Third, this analysis underlines, in an objective manner, the motives and investors' existing pro-environmental preferences that have been previously documented in the literature (see Zerbib, 2019, among others). We provide strictly economic and financial arguments

in favor of the sustainable development and the transition to a lower-carbon economy as a global claim which is popularly strongly based on beliefs and good intentions; ultimately, we demonstrate that there is a premium from the financial system for those green investors, but this is conditioned by the geographical investment area.

Fourth, policy-makers should be aware of the impact the environmental policies may have in all its extension, understanding that this shall not preclude the adoption of new environmental regulations, if necessary, in order to mitigate distortions in the green behavior, to favor the proper transition towards a low carbon economy and for a sustainable future.

The remainder of the paper is organized as follows. Section 3 defines the performance methodology and data employed in this study. Section 4 presents the overall results deriving from the empirical analyses. Finally, section 5 provides some concluding remarks.

2. Hypotheses development

Socially responsible (SR) mutual funds are investment vehicles following high standard ethical criteria in their investment decisions (Benson et al., 2006). These criteria are not homogeneous and differ among funds with different SR investment strategies (Hamilton et al., 1993), entailing different levels of sustainability in their investments.

Along these lines, we should note that most of the assets held in SR fund portfolios are subject to the activities of the companies that are connected to. For instance, several SR funds do not invest in the equity of companies that obtain earnings from weapons manufacturing, tobacco or gambling promotion operations. Other SR funds, in contrast, pursue 'green' or ecological principles, and selectively invest in companies engaged in renewable energies or reporting good pollution-control management (Gil-Bazo et al., 2010; Joliet and Titova, 2018; Lee et al., 2010; Renneboog et al., 2011, among others). Funds following different SR investment strategies should present different ratios of sustainability in relation to the business activities of the companies they target, therefore.

Previous studies comparing the returns of funds with different SR investment strategies (e.g. Mallett and Michelson, 2010; Muñoz et al., 2014) do not observe statistically significant differences in the performance of environmental and other SR funds. Nonetheless, these studies mainly focus on the performance of funds reporting similar ethical strategies, and do not address the environmental extent these funds (self-considered green or not) reach in their portfolios.

In this study, we are interested in assessing the relationship between sustainability and performance in the socially responsible fund industry worldwide, considering Morningstar's eco-label for mutual funds, the Low Carbon Designation (LCD). To do this, we analyze the behavior of socially responsible funds with different portfolio exposures to environmental issues. These exposures are estimated through the carbon risk and fossil fuel involvement scores (available through Morningstar's Low Carbon Designation) assigned to the companies each fund invests in. Hence, greater portfolio exposures involve lower levels of sustainability in the fund assets.

The main hypotheses of this study is then posited as follows:

Hypothesis 1: *There are no statistically significant differences in the performance of funds with different exposures to environmental issues.*

To test this hypothesis, we evaluate and compare the risk-adjusted returns of funds with different exposures to companies that obtain part of their revenue from carbon or fossil fuel-based activities. In analyzing a large sample of SR funds around the world, we are able to apply the performance comparison in different regions.

3. Data and performance methodology

3.1. Methods: measuring performance

Similarly to previous studies focusing on mutual funds (Gruber, 1996; Carhart, 1997; Fama and French, 2015), we apply a multifactor model to estimate the performance experienced by SR mutual funds. Multifactor models extend the Capital Asset Pricing Model in considering other potential systematic risk-factors or additional benchmarks to the market portfolio. These additional factors represent the asset classes in which the fund invests and define its style (Sharpe, 1992). This way we avoid the bias derived from omitting relevant benchmarks (Pastor and Stambaugh, 2002; Matallín-Sáez, 2006). Therefore, in this study, and given the characteristics of the broad sample under analysis, we employ a multifactor model that firstly includes a global stock market index (FTSE World Index); a sustainability index to represent the SR investment (DJ Sustain World Index), and considering that some SR funds invest in emerging markets, we employ the FTSE Emerging Index representing the investment in these markets.

Specifically, we propose the following linear model to capture the abnormal performance of SR funds:

$$r_{p,t} = \alpha_p + \beta_{p,w} r_{w,t} + \beta_{p,s} r_{s,t} + \beta_{p,m} r_{m,t} + \varepsilon_{p,t} \quad (1)$$

where $r_{p,t}$ is the return of the SR mutual fund p in excess of the risk free asset in period t, $r_{w,t}$ is the return of a global benchmark (FTSE World index) during the same period, $r_{s,t}$ is the return of a benchmark related to socially responsible investment (DJ Sustain World index) corresponding to the same period t, and $r_{m,t}$ is the return of an index related to the investment in emerging markets (FTSE Emerging index). The performance of the socially responsible portfolio is therefore estimated as the intercept of the model, or alpha (α_p).

3.2. Data

3.2.1. Data description and sources

Our sample consists of 3,920 SR equity mutual funds around the world. The sample period under analysis runs from January, 2000, to March, 2018. There is no survivorship bias in the sample since we consider all the funds that existed during that period (i.e., terminated funds and surviving funds).

Data on mutual funds is obtained from Morningstar. Specifically, we obtain the funds' total net assets under management, inception date, investment area, and fund daily return index. Funds' daily returns are derived from the latter variable, and are expressed on net terms.

Additionally, and since we are interested in comparing the performance of socially responsible funds with different environmental scores, we also obtain from Morningstar the information related to carbon risk and fossil fuel portfolio involvements for each mutual fund. On the one hand, the carbon risk of a portfolio equals the sum of the asset-weighted carbon-risk score of each company the fund invests in—either through equities or corporate bonds. The carbon-risk score indicates the risk that a company would face from the transition to a low-carbon economy. Therefore, greater portfolio carbon risks imply higher exposures to companies focusing on (and working with) thermal coal, tar sands, Arctic oil and gas, etc. On the other hand, fossil fuel involvement is measured as the portfolio's percentage exposures to companies obtaining part of their revenue from fossil fuel activities, such as thermal coal extraction, thermal coal power generation, oil and gas production,

and oil and gas power generation. Companies with at least 50% of their revenue obtained from oil and gas products are also included in this group.[2]

3.2.2. Multilevel classification

We also split the sample of socially responsible funds into several groups, or levels, as follows. Firstly, we consider three main investment zones to avoid any distortion in the results related to different geographical areas. Those zones are categorized as Europe, US and Canada, and other investment areas. Funds investing mainly in a country or region are grouped into the subsample corresponding to the investment zone that country or region belongs to.

Funds in each subsample are subsequently sorted again in another level (or several additional groups), according to the the environmental scores assigned to their portfolio. To do this, we consider one of the two variables related to the portfolio environmental dimension—Carbon Risk Score or Fossil Fuel Involvement—and the following four categories:

High: funds whose carbon risk/fossil fuel involvement levels (scores) are greater than 70% of their investment area peers' scores.

Low: funds whose carbon risk/fossil fuel involvement levels (scores) are below 30% of their investment area peers' scores.

Medium: funds whose carbon risk/fossil fuel involvement levels (scores) range between 30% and 70% of their investment area peers' scores.

Undefined: funds with non-assigned environmental scores.

Table 1 reports the overall financial results experienced by socially responsible funds in each group. Specifically, the upper panel shows the average return and risk experienced by funds investing in Europe for different levels of carbon risk and fossil fuel portfolio involvements. The central and lower panels report analogous characteristics in relation to the funds grouped in the US and Canada and other investment areas, respectively. The number of funds in each group, along with the average of their total net assets are also included in Table 1.

[2]See Morningstar (2018) for more details.

As shown in the last row of Table 1, socially responsible funds experienced, on average, an annualized net return of 7.97% during the period considered. The related standard deviation of the returns (i.e., the risk borne in fund portfolios) was on average 16.70%.

Nonetheless, Table 1 also shows some differences in fund characteristics among the different investment zones considered. For instance, SR mutual funds investing in Europe show in average the greatest size, measured by the amount of total assets (more than US$80 million) while experiencing, simultaneously, lower overall net returns (6.31%) and greater variability in their results (17.34%) than funds investing either in US/Canada or "Other" areas. In contrast, funds investing in "Other" areas managed in average smaller amounts of assets (US$32 million) and achieved higher net returns in the sample (10.96%, in annualized terms).

Table 1 also reports interesting differences among the characteristics of comparable SR funds with different levels of environmental portfolio involvement (carbon risk/fossil fuel). For instance, funds corresponding to the "High" categories managed in average larger portfolios than other funds in the sample (e.g., US$117.40 million and US$104.59 million under the management of funds with high levels of fossil fuel portfolio involvement in Europe and in US and Canada, respectively). Also, and regarding funds investing in Europe, portfolios with High-carbon risk levels obtained similar net returns but also experienced greater returns' volatility (annualized standard deviation of 17.02%) compared to their low-carbon risk peers (15.23%).

In contrast, for funds investing in US and Canada, those presenting the lowest carbon risk and fossil fuel portfolio involvements experienced the highest returns—on average, 11.79% and 11.36% per year, respectively. These returns were higher than those yielded by High-carbon risk (7.69%) or High-fossil fuel involvement funds (9.01%). These patterns hold for "Other" investment areas, where Low-carbon risk and Low-fossil fuel SR funds experienced net returns of 11.74% and 12.58% per year, respectively. Finally, funds with no information on these environmental attributes, classified as "Undefined", experienced the worst behavior in each sub-sample (i.e., the lowest average returns and the greatest levels of risk).

Additionally, Table 2 shows the main statistics describing the returns of the benchmarks employed in Model (1). It should be noted that the FTSE World Index shows a better combination of return and risk than the DJ Sustain World Index, a representative benchmark of sustainable investment. On the other hand, the benchmark corresponding to emerging

countries, FTSE Emerging Index, represents the combination with the highest return and risk.

4. Results

4.1. Performance according to environmental scores

We now estimate the overall performance of socially responsible mutual funds with similar levels of environmental attributes. To do this, we regress the excess-risk free net returns of each fund on the factors included in Model (1), and report results on performance (alpha and significance) in the different groups in the Table 3. More specifically, Table 3 reports the number of funds in each group and the percentage of funds with positive and negative (and significant) performance. The mean and standard deviation of the alphas in each group are also included in the last two columns of the table.

Table 3 shows some interesting results. Firstly, the percentage of socially responsible funds with negative alphas (53.34%, as shown in the last row of Table 3), is higher than the percentage of funds experiencing positive alphas (46.66%). The evidence is similar if we take into account significant risk-adjusted returns, as only 5.46% of the funds experienced significantly negative alphas during the period considered, while 3.27% of the sample achieved positive and statistically significant alphas. This evidence holds when the analysis is focused on funds investing in Europe and, particularly, those investing in the US and Canada, for which the risk-adjusted returns lower than zero is found for 60.48% of the funds—7.97% statistically significant.

These results are mainly driven by the performance of socially responsible funds with high relative levels or undefined on the aforementioned environmental attributes (i.e., carbon risk and fossil fuel involvement). Along these lines, it should be noted that almost 70% of US and Canadian High-level funds experienced negative alphas. Most of the funds with no information on these scores also obtained negative alphas. In contrast, funds investing mainly in this area with low scores of carbon risk (56.99% with positive alphas) or fossil fuel portfolio involvements (50.90%) obtained risk-adjusted returns greater than zero. Furthermore, and if we compare the overall performance of the funds with different levels of environmental attributes, we observe that the alphas achieved by Low-level socially responsible funds are greater than the alphas experienced by their High-level counterparts.

This result contributes to the knowledge about the connection between multi-levels of

environmental attributes strategies and risk-adjusted financial returns. Our results show that environmental performance increases financial performance and this evidence agrees with previous literature. In this sense, there are two strands of literature explaining the importance of investments focused on the low environmental impact. The first one depend on preferences and values of the investors, in a sense that, although investment decisions are primarily centered on seeking risk-adjusted returns there is also a real motive of embedding environmental concerns into their portfolios; it is evidenced that financial performance is strongly linked to the environmental performance perceived by investors. For instance, Riedl and Smeets (2017) and Hartzmark and Sussman (2019) devote attention to mutual fund investors displaying pro-social preferences being translated into investment. Similarly, Zerbib (2019) identify the effect of non-pecuniary motives (so-called pro-environmental preferences) behind the investor preferences towards green bonds. A second stream of the literature builds upon purely financial motives, under the tenet of achieving higher financial performance. In this vein, Galema et al. (2008), Allevi et al. (2019) and Lins et al. (2017) identify the expectation of better financial performance as main argument whereas Nilsson (2008) and Hartzmark and Sussman (2019), among others, find that both financial perceptions and pro-social attitudes are connected to drive SR investment.

Regarding the last row of Table 3, the average alpha of the funds is negative (-0.164%). US and Canadian funds performed worse (average alpha of -0.849% per year) than the rest of the funds, while the best-performing funds were funds investing in "Other" areas (annualized alpha of 1.577%, on average). There is, however, an average effect, since High-level funds underperform their Low-level peers—regardless of the area considered. For instance, for funds investing in US and Canada, those with the highest levels of carbon risk (overall alpha of -2.005%) or fossil fuel portfolio involvements (-1.212%) performed much worse than funds with the lowest scores (average alphas of 1.755% and 1.156% for low-carbon risk and low-fossil fuel portfolios, respectively).

The main performance differences among the group of funds with Low and High scores of each environmental score, along with p-values for statistical significance, are reported in Table 4. These differences are expressed in annualized terms. We also report the results for the main differences between the Low and the Undefined group of funds in each geographical zone.

As shown in the Table 4, Low-level funds of carbon risk and fossil fuel portfolio involvements performed better than their High-level counterparts in US and Canada (differences

in alpha between Low- and High-level funds are 3.76% and 2.37%, respectively), in Europe (0.67% and 3.15%) and in Other investment areas (0.84% and 1.94%). These differences were statistically significant in most of the cases.

Low-level funds also experienced higher annualized performances than funds with "no scores" in those environmental attributes (i.e., in the "Undefined" category), especially in relation to US and Canada (statistically significant performance differences between Low and Undefined groups of 4.40% and 4.20%, respectively) and Europe (3.35% and 4.84%).

Up to this Section, our results imply that Low-funds (i.e., funds with lower carbon risk and fossil fuel exposures) also experienced greater alphas during the sample period under analysis. This is in line with the results reported in recent studies examining portfolio returns and sustainability indicators in the European region. For instance, Ibikunle and Steffen (2017) show a notable improvement of environmental fund performance during the last years, especially in relation to those funds that invest in carbon-intensive companies' equity. In the same vein, Durán-Santomil et al. (2019) illustrate a positive relationship between ESG involvement (adjusted to controversy) and equity fund performance.

Our study, however, does not only evaluate the performance of European funds, but also considers different regions in the analyses and also considering a new methodology (Morningstar's LCD) that enables different levels of scores. Hence, and as shown in Table 3 and Table 4, the greater performance of funds presenting higher sustainability ratings remains in any of the areas considered. Therefore Hypothesis 1 would be rejected.

4.2. On the external shape of performance

The results presented in both Table 3 and 4 report relevant information, yet constrained to summary statistics such as the mean or standard deviation. We provide a more comprehensive analysis estimating nonparametrically, via kernel smoothing methods, the densities corresponding to the performance results reported in both Tables 3 and 4.

Densities are displayed in several figures, in order to achieve a fuller view of the heterogeneity found in the results. Figures 1, 2 and 3 report densities for the three investment areas considered. In each figure, the left-hand-side panel contains densities corresponding to carbon risk, whereas fossil fuel involvement environmental focus densities are contained in the right-hand-side panels. Each subfigure contains densities corresponding to three levels of scores being compared, namely, high (solid line), low (dashed line) and undefined (dotted line).

Although some features had already been outlined when describing the results reported in Tables 3 and 4, there are others that were concealed due to focusing on two statistics only—mean and standard deviation. Specifically, although, on average, the funds in the "low" category outperform those in other categories (see Table 4), regardless of the investment zone or environmental category, this behavior is not only driven by few funds only. For instance, in the case of Europe (Figure 1), the probability mass in the upper tail of the distribution confirms this result for funds in the with "low" (dashed line) scores. It is particularly the case for the carbon risk environmental category (Figure 1a), which not only has a clear mode (bump) in the vicinity of 1.7 that pushes the average upwards but, in addition, probability mass is mainly concentrated above zero. These noticeable bumps for the carbon risk category and "low" scores are even more blatant for US/Canada (Figure 2a) and other investment areas (Figure 3a). Therefore, although funds in the "low" category, *on average*, outperform those in either the "high" or "undefined" categories, there are important peculiarities such as the existence of some specific groups of funds (revealed by the existence of multiple modes in the upper tail of distributions in Figures 1a, 2a and 3a) with particularly high performances.

The funds in the "high" category, in contrast, exhibit a less heterogeneous behavior, regardless of the investment zone considered, as shown by tighter densities (solid lines). This relatively homogeneous behavior (compared to the "low" category) is particularly marked for the fossil fuel involvement category (Figures 1b, 2b and 3b). In this case, the relative underperformance (compared to the "low" category) is not driven exclusively by the existence of some bumps (modes) in the lower tail of the distribution, since the upper tail is also bumpy. However, although the lower tails are generally long, the bumps on the left hand side of the distributions are less marked. These findings, together with the fact that the probability mass tends to concentrate more tightly, would suggest that funds in the "high" category exhibit a generally more homogeneous behavior, particularly for fossil fuel involvement.

4.3. Double sorting by environmental scores

In this section, we further explore the relation between SR fund performance and the level of carbon risk and fossil fuel portfolio involvements. To do this, we form two-way tables (Brown et al., 1992; Drago et al., 2010; Ando and Bai, 2016) based on the relative levels of the two categories of environmental portfolio attributes (carbon risk/fossil fuel involvement).

These tables are applied to the sub-sample of funds corresponding to each investment zone.

Specifically, we grouped all the funds with similar investment areas according to the relative level of those characteristics, so each subsample is split into 16 (4×4) different groups. For instance, the High-High group refers to the group of funds with high relative levels of carbon risk and fossil fuel portfolio involvements, while the Low-Low group comprises funds with relative low scores of those environmental characteristics. Table 5, Table 6 and Table 7 present the number of funds and the performance results of each group of funds investing mainly in Europe, US and Canada, and other investment areas, respectively.

Some interesting results arise from this analysis. Firstly, we observe an association between the relative levels of both environmental attributes in the distribution of socially responsible funds (upper Panel of each Table). That is, funds with high (low) relative levels of carbon risk scores are likely to present high (low) relative levels of fossil fuel portfolio involvement. This is in line with the definitions of both variables.

Moreover, and regarding funds presenting information on those environmental attributes, we observe that the worst performance is achieved by funds characterized with the highest level of both carbon risk and fossil fuel involvement. For instance, Table 5 shows that European funds sorted on the High-High group achieved, on average, a negative and statistically significant alpha of -1.28% per year (p-value of 0.000). In contrast, the best performing European funds where those presenting low levels of fossil fuel involvement or carbon risk scores (significantly positive alphas, ranging from 0.86% to 5.41% per year).

A similar evidence is found in the other main areas considered. As shown in Table 6, funds with high relative levels of those characteristics also presented the worst performance results in the US and Canada subsample (annualized alpha of -2.45%, p-value of 0.000), whereas US and Canadian funds reporting the lowest levels of both characteristics (Low-Low group) achieved positive (2.64%) and statistically significant (p-value of 0.000) annualized alphas. In the same vein, those funds investing mainly in Other investment areas different than Europe and US and Canada (Table 7) and characterized with the lowest levels of fossil fuel portfolio involvement also presented higher risk-adjusted returns in their subsample (annualized alphas up to 4.09%).

In sum, we aimed to assess the relationship between sustainability and performance in socially responsible funds. In sorting the funds in the sample in several groups according to the extent to which their portfolios are exposed to carbon risk and fossil fuel-related companies, our results show that funds presenting the lowest scores on fossil fuel portfolio

involvement and carbon risk designations (i.e., those funds characterized with the greatest levels of sustainability in their portfolio) performed better than their comparable counterparts. This evidence is found across different areas around the world (Europe, US and Canada, and Other investment regions).

5. Conclusions

The relevance of sustainable investment in financial markets greatly raised over the previous years. In this way, managers of several investment vehicles pretended to achieve specific levels of sustainability in their portfolios, and acted accordingly. Those strategies contrasted with conventional investments, which mainly aimed to maximize return and minimize risk without taking into account any other non-financial dimensions. Mutual funds fulfilling sustainable goals were labeled as socially responsible (SR) funds, and began to be very popular among fund investors, especially in the US and the European markets. That led to a rapid increase of global investment towards SR assets, representing more than 30 trillion dollar at the beginning of 2018.

Due to this huge development, analyzing the overall performance of SR mutual funds was one of the main interests of both professionals and academics. Researchers showed that those portfolios pursuing SR values, on aggregate, did not experienced significantly different risk-adjusted returns than conventional mutual funds. Nonetheless, most of these studies did not regard to different extents of sustainable characteristics in SR mutual funds' portfolios.

With the aim of expanding the literature and filling this gap, this study addresses the relationship between sustainability and performance in the SR fund industry. Fund sustainability is measured through the fund's portfolio exposures to companies involved in carbon and fossil fuel activities. In this sense, fund sustainability reaches a greater extent when portfolio exposures to carbon or fossil fuel-based businesses are lower.

In analyzing a large sample of SR mutual funds around the world, we show that funds characterized with higher levels of sustainability achieved better performance than funds more exposed to carbon and fossil fuel involved companies. This evidence remains in considering several major markets, such as Europe, US and Canada, and other investment areas.

This study is therefore of interest for professionals, investors and researchers willing

to determine and to analyze the behavior of sustainable portfolios over time. First, both institutional and retail investors must be vigilant in the selection of funds since significant differences are evidenced within the pool of SR mutual funds. Our evidence indicates that in general, those funds with greater sustainability intensity also provide a better financial performance. The joint fulfillment of this double objective should not go unnoticed by both types of investors. Secondly, it could clarify the results of previous studies on the comparison between SR funds and conventional funds. Thus, just those funds with a greater sustainability vector are the ones that achieve the best results, which would imply tilting the balance in favor of sustainable investment. Finally, it should be taken into consideration that the mutual funds most exposed to carbon and fossil fuel commercial activities also involve additional risks for developing low carbon economies.

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Table 1: Summary statistics of the mutual funds in the sample, 2000–2018

This table reports overall financial results for funds in each level. The upper panel shows the average return and risk experienced by funds investing in Europe for different levels of carbon risk and fossil fuel portfolio involvements, whereas the central and lower panels report analogous characteristics for funds investing in the US and Canada and other investment areas, respectively

Geographical investment zone	Morningstar Low Carbon Designation (LCD)	Morningstar portfolios scores	Number of funds	Average annualized net return (%)	Average annualized s.d. (%)	Average size (US$)
Europe	Carbon risk	High	266	7.75	17.02	90,899,646
		Mid	355	7.97	15.76	93,758,565
		Low	267	7.83	15.23	64,313,730
		Undefined	416	3.01	20.25	70,752,932
	Fossil fuel involvement	High	289	7.73	16.21	117,395,535
		Mid	385	7.47	16.10	50,663,234
		Low	292	7.71	16.12	79,480,543
		Undefined	338	2.58	20.77	83,307,826
		Total category	1,304	6.31	17.34	80,063,077
US and Canada	Carbon risk	High	363	7.69	14.29	66,211,757
		Mid	484	10.30	12.87	77,274,293
		Low	365	11.79	14.22	79,720,542
		Undefined	506	2.17	22.23	29,482,516
	Fossil fuel involvement	High	385	9.01	13.24	104,590,977
		Mid	519	9.10	14.26	61,263,419
		Low	391	11.36	14.28	58,287,276
		Undefined	423	1.28	23.10	22,795,905
		Total category	1,718	7.67	16.21	64,080,875
Other	Carbon risk	High	187	10.31	15.68	27,452,522
		Mid	270	12.37	16.35	33,466,305
		Low	199	11.74	17.31	40,555,988
		Undefined	242	9.25	17.32	26,442,652
	Fossil fuel involvement	High	231	10.98	16.10	37,471,437
		Mid	309	11.29	17.04	26,204,156
		Low	237	12.58	14.85	32,318,919
		Undefined	121	6.89	20.49	37,282,056
		Total category	898	10.96	16.68	32,068,387
		All funds	3,920	7.97	16.70	62,086,961

Table 2: Summary statistics for the benchmarks

This table reports the statistics describing the returns of the benchmarks employed in Model (1)

Factors	Average annualized return (%)	Average annualized s.d. (%)
FTSE World Index	6.04	16.15
DJ Sustain World Index	4.81	17.80
FTSE Emerging Index	9.46	19.22

Table 3: Performance according to environmental scores, 2000–2018

In this table, funds are classified according to two criteria. These criteria relate to the relative levels (High, Medium, Low, and Undefined) of carbon risk and fossil fuel involvement fund portfolios are characterized with. Both criteria are applied to the sub-sample of funds clustered in each geographical investment zone (i.e., Europe, US and Canada, or Other areas). The table reports overall performance for funds classified in these groups, and it is obtained by regressing the excess-risk free net returns of each fund on the factors included in Model (1). Performance results are split into alpha (positive/negative) and significance. The mean and standard deviation of the alphas in each group are also included.

Geographical investment zone	Morningstar Low Carbon Designation (LCD)	Morningstar portfolios scores	Number of funds	Percentage of total number of funds in group (%)				Annualized performance (%)	
				< 0	p-value ≤ 0.05	> 0	p-value ≤ 0.05	Mean	S.D.
Europe	Carbon risk	High	266	51.50	3.76	48.50	4.51	0.244	4.91
		Mid	355	49.01	1.97	50.99	2.82	0.297	3.71
		Low	267	37.08	0.37	62.92	8.24	0.916	4.94
		Undefined	416	65.63	10.10	34.38	2.64	–2.435	7.50
	Fossil fuel involvement	High	289	69.90	4.50	30.10	0.69	–1.193	3.85
		Mid	385	42.34	3.64	57.66	3.38	0.394	4.80
		Low	292	27.05	0.34	72.95	12.67	1.954	5.31
		Undefined	338	70.71	9.47	29.29	0.89	–2.886	7.34
		Total category	1,304	52.38	4.60	47.62	4.22	–0.459	5.78
US and Canada	Carbon risk	High	363	69.97	6.61	30.03	0.83	–2.005	4.86
		Mid	484	59.30	8.68	40.70	1.65	–0.070	3.84
		Low	365	43.01	1.10	56.99	6.58	1.755	5.28
		Undefined	506	67.39	13.24	32.61	1.78	–2.644	7.71
	Fossil fuel involvement	High	385	67.27	8.05	32.73	0.52	–1.212	4.57
		Mid	519	56.07	8.29	43.93	2.31	–0.299	4.18
		Low	391	49.10	1.28	50.90	5.63	1.156	5.84
		Undefined	423	70.21	13.71	29.79	1.89	–3.048	7.93
		Total category	1,718	60.48	7.97	39.52	2.56	–0.849	5.95
Other	Carbon risk	High	187	44.39	2.67	55.61	0.53	0.654	6.52
		Mid	270	40.00	1.11	60.00	2.22	1.320	6.36
		Low	199	47.74	3.52	52.26	8.04	1.492	6.32
		Undefined	242	34.30	0.83	65.70	2.48	2.647	8.09
	Fossil fuel involvement	High	231	35.50	0.87	64.50	0.87	1.193	5.35
		Mid	309	43.69	3.56	56.31	1.29	0.688	5.69
		Low	237	41.35	1.27	58.65	9.28	3.136	7.95
		Undefined	121	44.63	0.83	55.37	0.83	1.527	9.40
		Total category	898	41.09	1.89	58.91	3.23	1.577	6.92
		All funds	3,920	53.34	5.46	46.66	3.27	–0.164	6.21

Table 4: Comparative performance according to environmental scores

This table reports performance differences (in annualized terms) between the different levels of environmental scores (Low/High/Undefined) and Low Carbon Designation (carbon risk/fossil fuel involvement), and for each geographical investment zone. The table also reports results for statistical significance, obtained by bootstrapping one-sided *p*-values.

Geographical investment zone	Morningstar Low Carbon Designation (LCD)	Morningstar scores	Difference in annualized performance (%)	*p*-value
Europe	Carbon risk	Low - High	0.67	(0.057)
	Fossil fuel involvement	Low - High	3.15	(0.000)
	Carbon risk	Low - Undefined	3.35	(0.000)
	Fossil fuel involvement	Low - Undefined	4.84	(0.000)
US and Canada	Carbon risk	Low - High	3.76	(0.000)
	Fossil fuel involvement	Low - High	2.37	(0.000)
	Carbon risk	Low - Undefined	4.40	(0.000)
	Fossil fuel involvement	Low - Undefined	4.20	(0.000)
Other	Carbon risk	Low - High	0.84	(0.107)
	Fossil fuel involvement	Low - High	1.94	(0.000)
	Carbon risk	Low - Undefined	–1.16	(0.037)
	Fossil fuel involvement	Low - Undefined	1.61	(0.038)

Table 5: Performance according to double sorting by environmental scores, Europe

This is a two-way table for funds investing in Europe based on the relative levels of the two categories of environmental portfolio attributes (carbon risk/fossil fuel involvement). Funds investing in Europe are classified according to the relative level of those characteristics, so each subsample is split into 16 (4×4) different groups. For instance, the High-High group refers to the group of funds with high relative levels of carbon risk and fossil fuel portfolio involvements, while the Low-Low group comprises funds with relative low scores of those environmental characteristics. The lower panel represents the mean of the abnormal performance of the funds in each group. *p*-values are for the mean significance test.

		Fossil fuel involvement			
Number of funds		High	Mid	Low	Undefined
Carbon risk score	High	158	70	38	0
	Mid	114	165	76	0
	Low	1	131	135	0
	Undefined	16	19	43	338
Performance					
Carbon risk score	High	–1.28%	0.89%	5.41%	–
		(0.000)	(0.123)	(0.000)	–
	Mid	–0.90%	0.29%	2.10%	–
		(0.002)	(0.253)	(0.000)	–
	Low	–	0.95%	0.86%	–
		–	(0.042)	(0.032)	–
	Undefined	–2.72%	–4.36%	2.06%	–2.89%
		(0.028)	(0.045)	(0.088)	(0.000)

Table 6: Performance according to double sorting by environmental scores, US and Canada

This is a two-way table for funds investing in US and Canada based on the relative levels of the two categories of environmental portfolio attributes (carbon risk/fossil fuel involvement). Funds investing in US and Canada are classified according to the relative level of those characteristics, so each subsample is split into 16 (4×4) different groups. For instance, the High-High group refers to the group of funds with high relative levels of carbon risk and fossil fuel portfolio involvements, while the Low-Low group comprises funds with relative low scores of those environmental characteristics. The lower panel represents the mean of the abnormal performance of the funds in each group. *p*-values are for the mean significance test.

		Fossil fuel involvement			
Number of funds		High	Mid	Low	Undefined
Carbon risk score	High	191	105	67	0
	Mid	168	256	60	0
	Low	0	135	230	0
	Undefined	26	23	34	423
Performance					
Carbon risk score	High	-2.45%	-1.48%	-1.54%	-
		(0.000)	(0.001)	(0.021)	-
	Mid	-0.20%	0.07%	-0.30%	-
		(0.398)	(0.783)	(0.602)	-
	Low	-	0.24%	2.64%	-
		-	(0.373)	(0.000)	-
	Undefined	1.40%	-2.17%	-1.04%	-3.05%
		(0.312)	(0.159)	(0.160)	(0.000)

Table 7: Performance according to double sorting by environmental scores, other investment areas

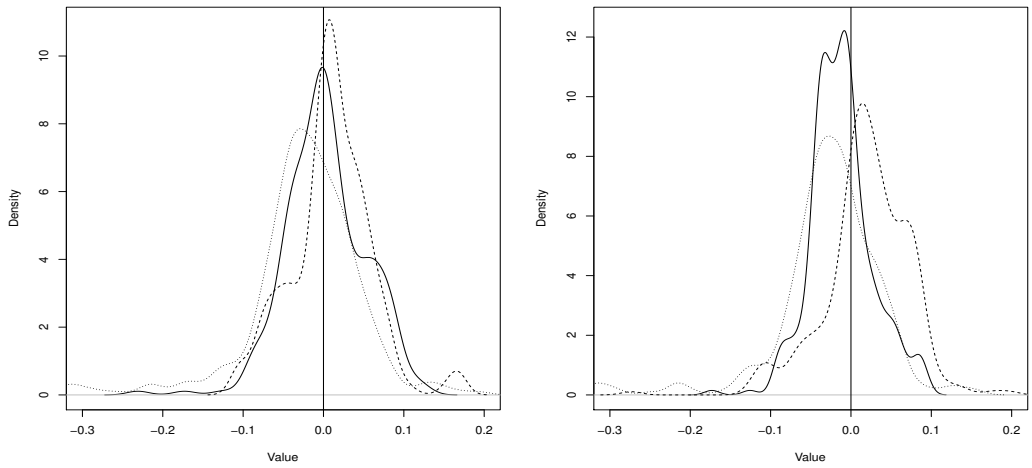
This is a two-way table for funds investing in other areas based on the relative levels of the two categories of environmental portfolio attributes (carbon risk/fossil fuel involvement). Funds investing in other areas are classified according to the relative level of those characteristics, so each subsample is split into 16 (4×4) different groups. For instance, the High-High group refers to the group of funds with high relative levels of carbon risk and fossil fuel portfolio involvements, while the Low-Low group comprises funds with relative low scores of those environmental characteristics. The lower panel represents the overall performance of the funds in each of these 16 groups

		Fossil fuel involvement			
Number of funds		High	Mid	Low	Undefined
Carbon risk score	High	130	57	0	0
	Mid	67	166	37	0
	Low	29	64	106	0
	Undefined	5	22	94	121
Performance					
Carbon risk score	High	1.23%	-0.67%	-	-
		(0.018)	(0.516)	-	-
	Mid	1.21%	0.98%	3.04%	-
		(0.045)	(0.010)	(0.135)	-
	Low	0.85%	0.40%	2.33%	-
		(0.162)	(0.532)	(0.002)	-
	Undefined	1.95%	2.82%	4.09%	1.53%
		(0.654)	(0.049)	(0.000)	(0.077)

Figure 1: Annualized performance, densities, Europe

These figures contain densities estimated using kernel smoothing methods for three levels of Morningstar scores (Low/High/Undefined) for socially responsible funds investing in Europe. Each Low Carbon Designation category is represented in a different figure, with carbon risk on the left hand side, and fossil fuel involvement in the right hand side. All densities were estimated using local likelihood density estimation (Loader, 1996)

(a) Carbon risk **(b)** Fossil fuel involvement

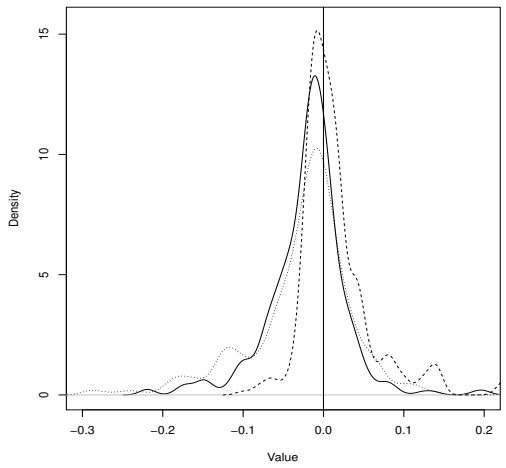


High —— Low ------ Undefined · · · · · ·

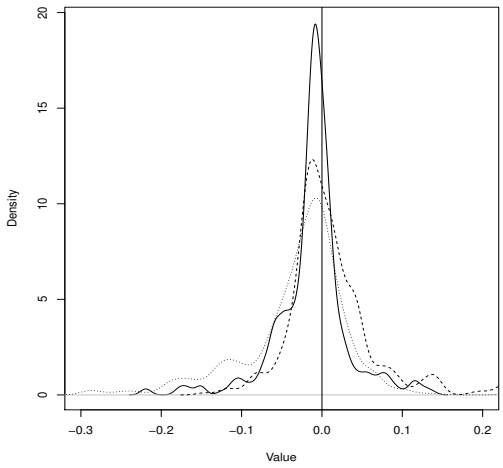
Figure 2: Annualized performance, densities, US and Canada

These figures contain densities estimated using kernel smoothing methods for three levels of Morningstar scores (Low/High/Undefined) for socially responsible funds investing in the US and Canada. Each Low Carbon Designation category is represented in a different figure, with carbon risk on the left hand side, and fossil fuel involvement in the right hand side. All densities were estimated using local likelihood density estimation (Loader, 1996)

(a) Carbon risk



(b) Fossil fuel involvement

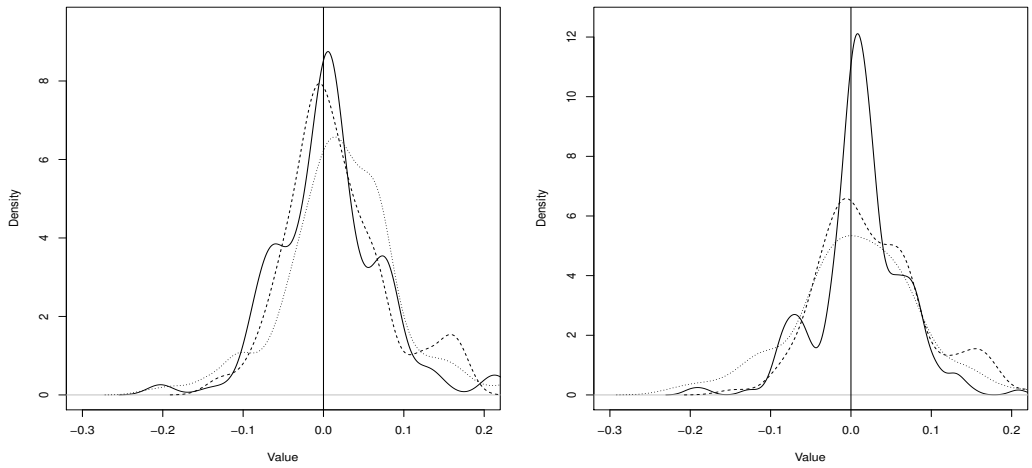


High —— Low ------ Undefined · · · · · ·

Figure 3: Annualized performance, densities, other investment areas

These figures contain densities estimated using kernel smoothing methods for three levels of Morningstar scores (Low/High/Undefined) for socially responsible funds investing in "Other" areas. Each Low Carbon Designation category is represented in a different figure, with carbon risk on the left hand side, and fossil fuel involvement in the right hand side. All densities were estimated using local likelihood density estimation (Loader, 1996)

(a) Carbon risk **(b)** Fossil involvement



High —— Low ------ Undefined · · · · · ·