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Can Robo Advisors Expedite Carbon Transitions? Evidence from Automated Funds

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Abstract

When it comes to making comparisons with traditional funds, it has been observed that Robo advisers have emerged as a viable alternative that imposes a substantially lesser load on the investors. As a result, they are capable of playing a crucial role in supporting low-carbon transitions - a phenomenon that has never been investigated prior to this. In this study, we assess the performance of automated funds, after categorizing them into different groups, based on their investment exposure to carbon-emitting enterprises. Our findings reveal that automated funds that invest in low-carbon funds tend to outperform their competitors. Moreover, when we compare the absolute returns, the return to value at risk, the adjusted Sharpe ratio, and Jensen's alpha, these results remain consistent. In addition to this, we also found that Robo funds with less exposure to polluting companies have better market timing. Therefore, we conclude that these technology-enabled investment vehicles can help with low-carbon transitions and are instrumental in achieving sustainable development goals.

Keywords: Carbon Transitions, Robo Advisors, Technological Investments

JEL Classifications: Q35, Q43, Q55, G11, G23

1. Introduction

Climatic degradation is an alarming phenomenon that requires immediate attention and responsiveness from all spheres. The last ten years have been considered to be the warmest decade to be recorded thus far, with greenhouse emissions peaking in the year 2019. Although, it must be noted that there was a certain level of relief on the climatic front during the Covid-19 outbreak, due to the economic slowdown and the significant reduction experienced in the global travel activity. Still, the impact has been temporary, and substantial efforts are still needed to combat climate change on a long-term basis. One possible course of action is to effectively promote technological changes that can foster the transition into low-carbon energy regimes.

The nexus between technology and investments has emerged strongly in the last decade (Tsai et al., 2020). this combination has aided in the ultimate optimization of the investing process (Brammertz & Mendelowitz, 2018), and has therefore resulted in limiting the emissions that are usually associated with operational procedures (Yan et al., 2021). Consequently, there is also a favourable behavioural bias that has come into play for the automation in financial services (Dorfleitner and Scheckenbach, 2022). Therefore, it is not surprising that technology-based products can very well substitute conventional asset classes (Karim et al., 2022), and also support effective and efficient investment goals (Schellinger, 2020).

Following the same context, when we shed light on mutual funds, we can effectively affirm that mutual funds are investment vehicles that provide access to portfolio investments for retail and institutional investors (Koutsokostas et al., 2019). In this regard, Robo advisors act as technology-aided alternatives for mutual funds (Jiao et al., 2021) that provide more flexibility and have limited transaction costs. From a sustainability viewpoint, recent studies such as (Guo et al., 2022), and (Ielasi et al., 2018) have argued that mutual funds are deemed to be viable options for environmentally conscious investors. However, to the best of our knowledge, no evidence exists which can indicate how technology-driven green Robo advisors perform vis-à-vis their peers and, therefore, if they can expedite the transition to low carbon business models. In this paper, we have thus attempted to fill this gap by evaluating the risk-adjusted performance of automated funds after differentiating them, based on the ecological-sensitive investment styles.

For this purpose, we have employed an exhaustive pool of automated funds, and have sorted them into various categories, based on their exposure to firms which have a high emission rate. Our assessment of these funds has shown that those funds that have a low frequency of exposure to environment polluting firms tend to outperform their counterparts. Moreover, this evaluation has remained consistent even when we compare the absolute returns, the adjusted Sharpe ratio, return to value at risk, and Jensen's Alpha. In the study, we have also demonstrated that the automated platforms which come with fewer carbon firms tend to exhibit market timing that partly explains their superior performance.

It can be affirmed that this paper addresses a very critical research gap. When it comes to Robo advisors, investment management is undertaken with minimal human intervention, thus resulting in negligible transaction costs. In addition to this, the load on the investors is also less than that in case of conventional funds, and hence these can be considered to be the optimal vehicles for retail and small investors. In this regard, our results provide primary evidence that there are incentives for ecological conscious participants that resort to the usage of automated platforms. The findings of this study are unique, as no prior study has evaluated Robo advisors in the context of sustainable investments styles. Therefore, there are important implications for low-carbon transitions, via alternative modes of investing.

The rest of the paper is organized as follows. Section 2 summarizes some recent literature, section 3 details our data and methodology. Results are presented in section 4, while section 5 concludes.

2. Literature Review

A variety of investment paradigms can also help facilitate such transitions and encourage sustainable business models. Many studies in the past have assessed this phenomenon, and have also reported encouraging findings. It must be noteworthy that Green financial intermediation is essential to transition into a zero-carbon environment. It is evident from the findings and the extant literature that there are potential benefits for the climate-conscious banking system credit portfolios (Umar et al., 2021a). This is critical because the financial system is in a dire need of incentives in order to promote a particular phenomenon. Hence, the transition is believed to be quicker if the bottom line has been supported and is built around a firm base. In the same context, (Ji et al., 2021) assessed the relevance of carbon neutrality on the investment performance, and suggested that green investors tend to yield higher returns than their counterparts who are investing in firms that add to the pollution and deterioration of the environment. This distinction in performance can stem due to many reasons. For example, it could be due to the unique structure of the systematic risks (Dorfleitner and Grebler, 2022), implied volatility (Lobato et al., 2021), and the overall growth in sustainable assets (Ferrat et al., 2021). In this particular study, we believe that these results are rather encouraging from a sustainable perspective, since higher returns will tend to push investors to consider environment-related factors in their investment rationale.

In the case of emerging markets, the relationship between investment and carbon transitions is still unpredictable. Investors who are conscious of climatic concerns pay a premium for their choice of green investments in most emerging markets (Naqvi et al., 2021).

Given that green investments tend to yield lower than the other alternatives, it would most likely discourage investors in such markets. In the same context, similar findings were confirmed by (Reboredo et al., 2017), that could regress the progress towards a pro-environmentally conscious investment landscape. While several studies explore the investment performance of conventional vehicles, to the best of our knowledge, no research has evaluated the role of Robo advisors in promoting a transition towards low carbon investments.

In the recent years, Robo advisors have emerged as a viable alternative to mutual fund investments. In this regard, (Brenner and Meyll, 2020) noted a clientele effect in the use of Robo advisors, especially among those investors who are conscious about the risks associated with the conflict of interest amongst human advisors. Similar findings were also reported by (Amaral and Kolsarici, 2020). In another study, (Shanmuganathan, 2020) highlighted that automated funds tend to incorporate behavioural biases better than conventional managers. Based on these arguments (Bhatia et al., 2020) concluded that a wideset awareness of Robo advisors would increase, and pose a real challenge to conventional funds. From a sustainable investment viewpoint, (Brunen and Laubach, 2021) provided early evidence that automated fund investors already consider the factor of sustainability in their strategy. However, despite the success of these funds, it is still unclear if, based on the investment styles related to high or low carbon firms, there is a performance differential in these two types of funds. Therefore, in this paper, we have attempted to fill this void.

3. Data and Methodology

The paper aims to assess US-based Robo advisors' performance, particularly after classifying them into five categories, based on their exposure to carbon-emitting firms. For this, we have selected all the Robo funds in the United States that have been in existence since the year 2015, and have daily net asset values (NAV) readily available. The choice of the country directly relates to the fact that most of the Robo advisor industry is concentrated in the United States. Also, we chose the year 2015 as the base year primarily because, as noted by (Tao et al., 2021), the Robo advisory industry started gaining strength starting from the beginning of the year 2015. Based on these primary criteria that were used to filter out the noise, we gained access to a total of 103 automated funds, with varying levels of investments in firms that contributed towards pollution. In order to distinguish between their performances, we have thus created five investment sorts. The first one of these is classified as high (H), which signify the funds where investment in carbon firms is more than 60% of the total asset under management. Then, the low class (L) are considered to be the funds with a total investment of less than 10% in non-renewable firms. Between the high and low funds, we have created three more classes (4, 3, and 2), which are also based on their respective exposure to carbon emitting firms. Table 1 presents the details of the sorting criteria and sample funds found in each category.

[Insert Table 1 here]

For each of the selected funds across the five categories that have been defined, the daily NAV based returns from January 1, 2015, to December 31, 2020, are calculated as follows

$$R_{jt} = LN\left[\frac{NAV_{jt}}{NAV_{j,t-1}}\right] \ldots (1)$$

Once the individual daily NAV has been estimated, we can calculate a time series portfolio equivalent for each class, using the market capitalization-based value weights. As contended by (Naqvi et al., 2021), (Naqvi et al., 2018), and (Nawazish et al., 2013), value-weighted portfolios are better suited for performance evaluation, as compared to alternate specifications.

Moving on, we have resorted to the use of four measures on the value-weighted returns, in order to assess the performance across different categories. The first one is the adjusted Sharpe ratio based on the portfolio assessment methodology of (Sharpe, 1966) and (Sharpe, 1994). However, the conventional Sharpe ratio is often criticized for its inability to be a robust estimate, particularly when the underlying returns are non-normal or idiosyncratic. Therefore, since the automated funds use algorithmic trading very frequently, assuming that the underlying returns are normally distributed can be problematic (Umar et al., 2021b). Therefore, as proposed by (Rizvi et al., 2020), we have employed the Adjusted Sharpe Ratio (ASR) that accounts for the skewness (skew) and kurtosis (k) in the returns. Thus, the functional form is presented below:

$$aSR_{jt} = SR(1 + \frac{skew}{6} \times SR - \frac{k-3}{24})) \times SR^2 \ldots (2)$$

The second measure that we have used is the excess returns to Value at Risk (VaR). While the standard risk-return models employ the standard deviation methodology, the presence of excess kurtosis or skewness will leave the standard deviation as a useless estimate. Moreover, (Assaf, 2015), (Yarovaya et al., 2020) and (Reddy et al., 2017) noted that VaR estimates are superior to the standard deviation method, as they are largely not influenced by the underlying distribution. Therefore, we have resorted to the evaluation of the risk-adjusted performance using the following form:

$$RaP_{jt} = \frac{R_{jt} - R_f}{VaR_{jt}} \ldots (3)$$

The third estimate that we have employed is the Jensen's alpha that was proposed by (Jensen, 1968). This estimate measures the excess portfolio returns in comparison to the expected returns that can be predicted through an asset pricing framework. While there are many predictive models, we have preferred resorting to the Carhart four-factor proposition. As highlighted by (Mirza et al., 2020) and (Hasnaoui et al., 2021), the momentum factor is a vital aspect to consider in the context of mutual funds, thus making the specifications highlighted by (Carhart, 1997) more desirable. Therefore, we have estimated Jensen's alpha (α_j) in the following manner:

$$R_{jt} - R_f = \alpha_j + \beta_j(R_{mt} - R_f) + \beta_s SMB_t + \beta_H HML_t + \beta_m MoM_t + u_j \ldots (4)$$

In equation 4, ($R_m - R_f$) refers to market risk premium, while *SMB*, *HML* and *MoM* are the size, value, and momentum factors.

The fourth measure relates to the market timing ability of the fund managers. The market timing refers to the ability of the funds to benefit from the constantly changing market dynamics, and the increasing exposure to high-yielding investments. In the case of Robo advisors, the rebalancing of the portfolios is automated, and therefore, the market timing tends to reflect on both the automation and the investment styles. Following the findings of (Mirza et al., 2020) and (Hasnaoui et al., 2021), we have assessed the market timing ability by adding a dummy variable to equation 4 in the following manner:

$$R_{jt} - R_f = \alpha_j + \beta_j(R_{mt} - R_f) + \beta_s SMB_t + \beta_H HML_t + \beta_m MoM_t + \tau_t D_t + u_j \;...\;(5)$$

In equation 5, D_t will be zero if the market return exceeds the risk-free rate, and zero otherwise. Once the relationship has been estimated, a positive and significant τ_t will indicate the market timing ability. The data for this study has been extracted from multiple sources; Morningstar, DataStream, Kenneth French Data repository, and finally, the individual disclosures of the Robo advisors.

4. Results and Discussion

The descriptive statistics for the sorted funds, as well as certain benchmarks have been presented in table 2. It can be observed that the average return for the portfolios with high carbon emission firms is 0.19%, as compared to 0.15% for low emission portfolios. These values represent a valid case for our research, primarily due to the reason that if investors are not incentivized, they would not opt for climate-friendly investments. Consequently, there would also be a delay in the expected transition into low carbon initiatives and options. In this regard, we have observed that all Robo advisors tend to outperform the benchmarks on absolute returns. It is also affirmed that this is in line with the findings of (Tao et al., 2021). In terms of the standard deviation, we can also report a maximum total risk for high emitting portfolios as well. It has also been observed that low carbon portfolios yield the minimum risk. This can be attributed to the sustainable business model of low-carbon firms. Moreover, a similar trend prevails for the value at risk, which presents the worst-case scenario. That is to say that the maximum VaR is for high category funds, while the minimum is for the ones in the lower class. It is not surprising that the benchmarks depict a lower standard deviation and VaR, owing to their diversified composition.

[Insert Table 2 here]

The results for the adjusted Sharpe ratio and return to VaR have been presented in table 3. These statistics account for the risk-adjusted returns, and are more relevant from a portfolio perspective as well. Moreover, the adjusted Sharpe ratio suggests that high carbon emitting firms are ranked below the firms with lower emission portfolios. In fact, the Sharpe ratio tends to improve as we move down the sorted portfolios, demonstrating that a lower exposure to carbon firms improves the investment performance. A similar trend has also been observed for the returns and value at risk matrices. The investment transition from high carbon to low carbon portfolios results in an improved return to value at risk. Therefore, even if we consider the extreme risk metric, the portfolio performance for low carbon funds remains in a dominant position. This evidence is encouraging for the climatic concerns as the potential investors can transition into possibilities that come with low emissions, without compromising on the returns. What is more encouraging is that while all Robo funds cannot outperform the benchmarks, the portfolios with the minimum exposure to carbon firms have performed better than the S&P500, NASDAQ, and DJIA. Hence, investors can reap the benefits of active investing, while also supporting the ecological goals.

[Insert Table 3 here]

The results for portfolio alpha from Carhart's four factors model have been presented in table 4. Our findings based on the investment alpha concur with the risk-adjusted returns. In this regard, we have observed a maximum alpha dedicated to the funds, with a minimum investment in the carbon-emitting firms. The alpha tends to experience a reduction as we move towards the high emission portfolios. All the results are significant at a 1% level, which also implies that the overall Robo funds are deemed to be attractive, and within the sorting, the best-performing funds are the ones that have leave a minimal environmental impact. Moreover, the results also demonstrate that automated funds have an exposure to the market, size, value and the momentum risk factors. In addition to this, the superior performance of climate-friendly portfolios is also considered to be encouraging as it would help in supporting the investment sustainability as well. It is noteworthy that these findings have important implications as they are vital in transitioning to a green financial system, and ultimately the effective development of circular economies.

[Insert Table 4 here]

The evidence that is available on market timing has been provided in table 5. The market timing is an essential factor to consider as it contributes to the performance of the funds. In this regard, the results that are based on the factor of market timing for automated funds are exhilarating. We have observed that the timing coefficient is significant for the five portfolios that have previously been sorted. That is to affirm that the significance is at a 5% level across the sorting levels. However, the sign of the coefficients for two high emission funds is negative. The negative sign demonstrates that funds rebalanced the particular portfolio against the market. In other words, the funds were able to time the market in a reverse order. Furthermore, the positive coefficient also suggests the appropriate market timing for low emission funds. The differences in the market timing ability also explain as to why low carbon funds tend to perform better than their counterparts. Therefore, the market timing can be attributed to the sustainable business model of the constituents, and represent the factor of investment attractiveness of green investments.

[Insert Table 4 here]

In general, our results are aligned with most of the literature exploring the responsible nature of mutual funds. However, the fundamental difference is that mutual funds require constant human intervention, while Robo advisors are fully automated in nature. Consequently, the extant literature does not reflect on the plausible possibility of responsible investment through automation that will be the future of asset management. The lower transaction costs and the investment load mean that there would be an execution of pro-ecological investment styles that would be undertaken through Robo advisors, which are more cost-effective and provide inclusive opportunities for retail and small investors. In addition to this, we have also demonstrated that the performance of Robo advisors can be differentiated on the basis of their exposure to high and low carbon funds. Funds that frequently invest in greener companies, tend to provide better investment yields to investors, thus giving necessary incentives for the participants with environmentally critical goals. Similarly, the low carbon funds' market timing ability also ensures that automated funds are robust, and their results would continue to be persistent over time. Consequently, Robo Advisors should be considered a pragmatic and viable investment vehicle, with lower transaction costs and environmentally friendly returns.

5. Conclusion and Policy Suggestions

The increase in greenhouse gas emissions poses a significant threat to the environment, which requires immediate attention from environmentalists as well as other stakeholders. The Paris agreement and other sustainable development goals are unprecedented steps that can be used to combat climate change in this context. However, achieving low carbon targets requires a consolidated effort from all the relevant stakeholders, including the investing public. Given that the transition from conventional energy sources to more sustainable options requires massive investment, the financial channels to do so are of the utmost importance. Therefore, The

Robo advisors that have emerged as an alternative to traditional funds could become instrumental in achieving this transition.

Our results show that low-carbon automated funds tend to dominate their counterparts. Not only do they have robust absolute returns, they also exhibit a higher Sharpe ratio, better return to value at risk, and an exuberant portfolio's alpha. Such funds also exhibit superior market timing that could plausibly explain their excellent performance. It is also imperative to note that the performance of these funds tends to improve as we move from high carbon constituents to low carbon funds. This can be attributed to sustainable firms' more robust business models, complete with high and stable cash flows resulting in better investor yields.

These findings have important implications. The digitalization of green finance can gear up the initiatives so as to achieve sustainability goals by supporting low carbon assets. When global efforts are targeted towards the preservation of the overall environmental wellbeing, the capital requirements from the corporate sector become colossal in terms of their importance and role. Therefore, by harnessing disruptive technologies in order to initiate sustainable business models, financial products can go a long way in creating circular economies. Hence as Robo advisors are getting additional traction, their role in promoting environmental-friendly investments will be more and more critical in the years to come. Thus, it would be vital to continue to provide ecological-conscious investors with more innovative possibilities to invest. As the fiscal systems surrounding Robo advisors are evolving over time, some favourable regimes should be introduced in order to facilitate the green investment landscape. Future research on this topic can explore the nature and magnitude of such interventions, and how these can support low carbon transitions.

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Tables

Table 1: Investment Criteria and No of Funds

Category	Investment Criteria	No of Funds
High	More than 60%	23
4	Between 40% and 60%	22
3	Between 25% and 40%	18
2	Between 10% and 25%	19
Low	Less than 10%	21
	Total	**103**

Investment Criteria refers to the proportion of carbon-emitting firms in AUM

Table 2: Descriptive Statistics of Sorted Portfolios and Benchmarks

	Mean R	Std Deviation	VaR 95%
High	0.1939%	1.533%	2.33%
4	0.1263%	0.998%	1.52%
3	0.1445%	1.142%	1.73%
2	0.1124%	0.902%	1.37%
Low	0.1538%	0.889%	1.31%
S&P500	0.0400%	0.13%	0.17%
DJIA	0.0520%	0.09%	0.10%
Nasdaq	0.0500%	0.14%	0.18%

Table 3: ASR and RVaR for Sorted Portfolios & Benchmarks

	ASR		RVAR	
High	0.1562	**	0.0977	**
	1.9958		*2.0013*	
4	0.1836	***	0.1027	**
	3.1703		*2.1437*	
3	0.2340	**	0.1209	**
	2.0936		*2.1522*	
2	0.4163	***	0.1541	***
	3.0990		*3.6015*	
Low	0.7604	***	0.1532	**
	2.9715		*2.1912*	
S&P500	0.1752	**	0.0457	***
	2.1485		*3.0560*	
DJIA	0.0848	**	0.0126	***
	2.0297		*2.6764*	
Nasdaq	0.2932	**	0.0689	**
	1.9960		*1.9804*	

**** represents significance at 1%, ** at 5%, t stats in italics*

Table 4: Portfolios Alpha from Carhart Factor Model

	High		4		3		2		Low	
αj	0.008657	***	0.010797	***	0.109641	***	0.201473	***	0.3079	***
	2.88399		*3.03691*		*3.20874*		*2.70136*		*2.75751*	
βj	0.811295	**	0.278615	**	0.547397	**	0.627503	**	0.528993	***
	2.1794		*1.99101*		*2.06529*		*2.05734*		*3.50845*	
βs	0.190169	**	0.727428	**	0.195545		0.069502		0.4002	**
	2.28494		*2.01132*		*0.27871*		*1.95374*		*2.08931*	
βh	0.876607	*	0.708939		0.801293	**	0.738364	*	0.922855	
	1.85412		*1.59933*		*2.1532*		*1.81315*		*1.29827*	
βm	0.195881		0.482987	*	0.766185		0.151718	**	0.474474	***
	1.63828		*1.89478*		*0.32898*		*2.12658*		*3.01287*	
Adj R2	0.61712		0.66063		0.74425		0.68439		0.71551	

**** represents significance at 1%, ** at 5%, and * at 1%. T stats in italics*

Table 5: Market Timing Ability of Robo Advisors (High to Low Carbon Investments)

	βj		βs		βh		βm		τ		Adj R2
High	0.3267	**	0.2727	**	0.0974	**	0.4136	***	-0.0920	**	0.7081
	2.0496		*2.0787*		*1.9957*		*3.1071*		*-2.0928*		
4	0.6453	*	0.1763	**	0.0380	**	0.4284		-0.0130	**	0.6984
	1.8192		*2.0943*		*2.0336*		*0.3599*		*-2.2165*		
3	0.1146	**	0.1139		0.0387	**	0.3723	**	0.0180	**	0.5178
	1.9917		*0.5132*		*2.0392*		*2.2967*		*1.9718*		
2	0.2863	**	0.4348	**	0.0228	**	0.3979	**	0.0091	**	0.7085
	2.0934		*2.2588*		*2.0863*		*1.9630*		*2.1508*		
Low	0.3826	***	0.0333	**	0.0404	**	0.4503	*	0.0215	**	0.7039
	3.0445		*2.1039*		*2.3165*		*1.7201*		*2.0184*		

**** represents significance at 1%, ** at 5%, and * at 1%. T stats in italics*