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Does sustainability pay off? A multi-factor analysis on regional DJSI and renewable stock indices

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ABSTRACT
The private sector arguably plays a greater role in sustainability transitions through private investment. The authors apply the four- and five-factor Fama-French models to the Dow Jones Sustainability Index (DJSI) and a range of renewable energy indices to evaluate the financial attractiveness of sustainability in general, relative to alternative investments. They find both overperformance and underperformance in the regional DJSIs over the period 2006–2016. In contrast, renewable energy indices have high betas and negative alphas, which makes them financially unattractive. These results imply the need for public support in sustainability transitions, as high risk and low return deter private investment.

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1. Introduction

Renewable energy and socially responsible investing are becoming increasingly important. Ever more financial institutions have started publishing corporate social responsibility reports. The topic is also becoming progressively more relevant for investors, due to the policy measures announced to green the economy, although sustainable investment principles are not binding for investors. This has contributed to greater interest in the link between environmental and financial performance. In this paper we study the financial performance (risk and return) of sustainable indices and renewable energy indices over the period 2006–2016, using the multi-factor (Fama & French, 2015) models. Socially responsible and renewable energy indices should be assessed separately, since the latter may be exposed to more risk due to the nature of the sector. This is relevant from both financial investors' and policy makers' perspectives, as negative financial performance implies a greater role for the public sector in the greening of the economy.

Most of the work done on the relationship between environmental and financial performance is not unanimous, and it remains unclear whether the relationship is positive or negative. This is due to differences in methodology, time periods and the choice of variables (on both the environmental and financial sides). In general,

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environmental performance can be described by purely environmental criteria or it can be considered as an integral part within a broader sustainability score. Thus, this is another aspect that explains the difference and inconclusiveness of the results so far. For example, Brammer, Brooks, and Pavelin (2006) find a negative link between social performance and stock returns, but the effect is attributable to the social aspect and companies' record in employment rather than their environmental aspects.

In addition, studies differ in the financial performance aspect they choose to analyse. Most studies analyse the effect of sustainability (environmental or social or both) on returns (Belghitar, Clark, & Deshmukh, 2014; Derwall, Guenster, Bauer, & Koedijk, 2005; Kempf & Osthoff, 2007; Reboredo, Quintela, & Otero, 2017; Xiao, Faff, Gharghori, & Min, 2015), but there are studies that analyse the effect on financial variables such as return on assets or the firm's value through Tobin's Q (Cai & He, 2013; Guenster, Bauer, Derwall, & Koedijk, 2011; Miroshnychenko, Barontini, & Testa, 2017; Ruggiero & Lehkonen, 2017). Another aspect of financial performance is risk. One way of studying this is through the multi-factor models described by Fama and French (1992) who provide a measure of excess return (alpha) and the riskiness of the stock or portfolio (through the beta coefficient). The results are not uniform in their claims as they depend on the index and region analysed.

In this respect, we aim to make a contribution by studying the financial performance of environmentally friendly or sustainable portfolios by employing the multi-factor models as described by Fama and French (1992) for various regions, extending the sample beyond the crisis. In addition, we provide estimates for both the general sustainability indices and the sector for clean energy. We believe the latter is particularly relevant for the renewable energy sector as the demand for the sector's output is reliant on public policy measures such as subsidies. Once those are phased out, the sector's prospects will depend ever more on private sector perceptions that, in turn, depend on its financial performance.

The latter is thus relevant for policy in terms of the speed of subsidy phase-out, and the general level of governmental intervention in driving the green energy transition. Namely, if the private sector has valid financial reasons to orient itself towards sustainability or green energy, the public sector's role and financial support may decrease at a faster rate than otherwise. Furthermore, since sustainability encompasses three aspects (environmental, social and economic), it is difficult to attribute the source of the effect to either one of the three components, which is why it is preferable to analyse the relationship between environmental and financial performance. The remainder of this paper is laid out as follows: Section 2 reviews the literature on environmental and financial performance; Section 3 describes the data and methodology; and results and related discussion are presented in Section 4. The last section concludes.

2. Literature review

The importance of research on the link between environmental and financial performance has been increasing throughout the past decade. As there is no one uniform description of environmental performance, there are several approaches to the research problem. The general research approach differs as well, as it depends on which aspect of financial performance one is interested in. In general, the results have not been conclusive, which can be explained with the varying approaches.

The inconclusiveness in results on whether environmental performance matters for financial performance is to be expected. Namely, both an underperformance and an overperformance hypothesis can be expected (Chan & Walter, 2014). Underperformance stems from mathematical optimisation. Namely, an investor cannot achieve better returns if he is faced with constrained optimisation. A Socially Responsible Investment (SRI) screening will therefore reduce returns, since it restricts an investor's choice set (Markowitz, 1959). Furthermore, investments into environmentally friendly technology are believed to raise operating costs for companies and they may put a significant strain on a company's financial resources. This is difficult to justify as the benefits only appear in the longer term (Guenster et al., 2011).

On the other hand, overperformance is to be expected as well. This stems from cost savings from investment in pollution-reducing and more energy-efficient technologies (Porter & Van Der Linde, 1995; Spicer, 1978). Furthermore, being an environmentally responsible firm might increase performance due to better strategic alignment with stakeholders and reputational advantages (Fombrun, Gardberg, & Barnett, 2000). Finally, corporate social responsibility might also serve as a proxy for management skills (Bowman & Haire, 1975). In addition, environmentally friendly firms are exposed to less risk with fewer lawsuits expected in the long run.

Chava (2014) finds that loan syndicates consist of fewer banks for borrowers with environmental concerns. Moreover, environmentally irresponsible firms tend to have higher financing costs. This finding is corroborated by El Ghoul, Guedhami, Kim, & Park (2016). Indeed, it is to be expected since such firms are exposed to higher risk and a narrower investor base (El Ghoul et al., 2016). Attig, El Ghoul, Guedhami, & Suh (2013) also find that high-CSR firms exhibit higher credit ratings, which reflects lower risk.

Thus, there are two key perspectives in the proposition of superior financial performance of environmentally friendly companies. The first is that they are superior in terms of financial ratios or financial variables such as stock returns for reasons listed earlier, for example cost-cutting or superior brand value and stakeholder engagement. The second is that they are less risky. We aim to add to the literature from both perspectives, by using the multifactor Fama-French models. In the Fama-French Capital Asset Pricing Model (CAPM), the first proposition of superior return shows as a positive alpha, whereas the second of lower risk shows as a positive beta lower than 1 (see Equation 1).

Most studies on the link between environmental performance and financial performance focus on their returns. Some authors choose to analyse the basic three-factor CAPM model that posits that excess return is a function of risk, size and value. The CAPM can be applied to both stocks and indices. The basic three-factor CAPM model can be extended to a five-factor CAPM that includes profitability and investment, as in Fama and French (2015). Carhart (1997) extends the basic three-factor CAPM to a four-factor CAPM that also includes momentum.

An alternative is to compile a portfolio of environmentally friendly companies and compare its performance to the performance of the broader market or a similar portfolio, which requires matching. Another alternative is to apply event studies and long-term studies. However, event studies are plagued by the drawback that an environmental disaster might take time in showing its negative effects, especially if it is related to lawsuits. In addition, when it comes to long-term studies it is challenging to pin down long-term causality (Ruggiero & Lehkonen, 2017).

Derwall et al. (2005) employ the Carhart four-factor model based on eco-efficiency scores and find that a portfolio of firms with high relative environmental scores outperformed a portfolio of companies with low scores by 6% p.a. over 1997–2003. The strategy of buying high SRI scores and selling low SRI scores has been shown to produce an abnormal return of 8.7% p.a. (Kempf & Osthoff, 2007).

Cai and He (2013) use the Carhart model as well on several seven-year intervals from 1992 to 2011 and find that an equal-weighted environmentally responsible portfolio outperforms in the fourth to seventh year after the first screening year. Chan and Walter (2014) studied 748 environmentally friendly firms listed on U.S. stock exchanges for the period from 1990 to 2012, and find that there is a green premium. Positive abnormal stock returns have also been found by Dixon-Fowler, Slater, Johnson, Ellstrand, & Romi (2012).

Others have compared portfolios including sin stocks (stocks belonging to the tobacco or nuclear industry for example) and conventional portfolios. Humphrey and Tan (2014) find no outperformance for portfolios that include sin stocks, whereas Hong and Kacperczyk (2009) find that a portfolio composed of sin stocks outperforms similar stocks. Geczy, Stambaugh, & Levin (2005) compare SRI portfolios to conventional portfolios and find that there is a cost to imposing an SRI constraint, which is consistent with the Markowitz portfolio theory. This finding is corroborated by Renneboog, Horst, & Zhang (2008) who document that SRI funds in the U.S., U.K. and several European and Asian-Pacific nations underperform their domestic benchmarks substantially. Xiao et al. (2015) find that a portfolio of SRI funds in the U.S. has no significant financial impact. Another study by Lean, Ang, & Smyth (2015) finds outperformance for North American and European SRI funds.

The literature is thus inconclusive as regards the financial impact of socially responsible investing. A caveat in these studies is that differences in performance may arise due to other factors such as fund size, age, investment universe and so on. Some authors (Schroder, 2007; Statman, 2006) circumvent this problem by directly using SRI indices that should be immune to biases associated with specific funds such as management quality, operating costs, size, age and so on.

Statman (2000) finds that the Domini Social Index performed as well as or better than the Standard & Poor 500 (S&P 500) in the period 1990–1998. In a later study, Statman (2006) compared the performance of four popular SRI such as the Domini Social Index, Calvert's Social Index, Citizen's Index and DJSI with the S&P 500 Index and found some evidence of overperformance, which varied with the period studied. Another study by Statman and Glushkov (2009) applies the four-factor Fama-French model and finds no statistically significant results of overperformance. We extend this analysis by also estimating the five-factor Fama-French model for a range of sustainable and renewable energy indices.

A limitation of previous studies is that they were focused on the U.S. Schroder (2007) extended the same approach to funds outside the United States and found no significant effect of overperformance or underperformance. Other authors have also reported no statistical significance in the SRI performance and conventional funds (Ameenc & Sourd, 2008; Munoz, Vargas, & Marco, 2013).

One aspect in which studies differ is the variable chosen for financial performance, such as returns or accounting variables, for example ROA or Tobin's Q. Some authors prefer returns, as they will reflect changes to the overall financial performance of a company in a more timely manner than traditional financial ratios (Cai & He, 2013). We use stock returns as the main financial variable as we analyse a range of indices. However, Tobin's Q is also suitable in the case of a firm-level analysis, as it is a forward-looking variable that reflects intangible value (Guenster et al., 2011).

Another key aspect in which studies differ is the actual environmental variable chosen. Several authors use environmental scores or rankings from various institutions such as the KLD Research and Analytics rankings (Cai & He, 2013; Guenster et al., 2011). Others use environmental cost data such as the Trucost database (El Ghoul et al., 2016). Miroshnychenko et al. (2017) use environmental, social and governance scores from the Asset4 database from Thomson & Reuters. Chan and Walter (2014) construct a portfolio from companies appearing in some of the green indices from established financial institutions. The lack of clear criteria for environmental performance implies that there is a trade-off between the transparency of the set of environmental indicators and its breadth.

In addition, portfolio analysis has typically dealt with the broader sustainability aspect. Although useful for the broader sustainability discourse, these studies are informative for the effect of environmental responsibility as long as we assume that environmental responsibility is a prerequisite for listing in socially responsible funds. However, we could extend the analysis to make the environmental dimension more comprehensive by focusing on the renewable energy sector. This is one research niche that is yet to be filled. Although there is substantial research on the link between oil prices and the general economy (Arouri, 2011; Basher & Sadorsky, 2006; Elyasiani, Mansur, & Odusami, 2011; Hammoudeh, Yuan, Chiang, & Nandha, 2010), there is comparatively less research on the renewable energy sector. Of this research, the majority analyses the relationship between renewable energy stocks and oil prices.

Managi and Okimoto (2013) study the WilderHill clean energy index and its relationship to the oil price, and find a significant relationship between renewable energy stocks and the oil price. Others find that fossil fuel and renewables are viewed as competing assets (Wen, Guo, Wei, & Huang, 2014). Another finding from the literature is that technology stocks correlate with renewable energy stocks. Henriques and Sadorsky (2008) find that technology shocks and oil price shocks cause alternative energy stock prices. Other studies corroborate this finding (Inchauspe, Ripple, & Trück, 2015; Sadorsky, 2012).

Other studies analyse renewables through the CAPM model. Bohl, Kaufmann, & Stephan (2013) analyse a sample of German renewable energy stocks between 2004 and 2011. They find that the four-factor alpha turned negative after the 2008 crisis and document a bubble in renewable energy stocks in the mid-2000s. Other studies have also applied the CAPM model to renewable energy stocks. For example, Sadorsky (2012) finds that U.S. listed renewable energy stocks have substantial market risk as they have a high beta, typically higher than 1, in the period between 2001 and 2007. A high beta is corroborated by Henriques and Sadorsky (2008).

Most of the existing literature has analysed the performance of the broader sustainability aspect by analysing the financial performance of socially responsible firms, funds or indices. The methodological approach can include portfolio construction (Cai & He, 2013; Chan & Walter, 2014; Humphrey & Tan, 2014), mutual fund comparison that requires matching (Belghitar et al., 2014; Lean et al., 2015; Renneboog et al., 2008; Xiao, et al., 2015) or event studies. Typically, the financial variable is return, but there are approaches which also analyse the link between environmental and financial performance at the firm level by analysing Tobin's Q or ROA (Cai & He, 2013; Guenster et al., 2011; Miroshnychenko et al., 2017). This approach assumes a homogeneous risk and return profile for sustainable investing and clean energy investing. The latter is inherently exposed to more risk, which is why it should arguably be analysed separately. Reboredo et al. (2017) compare both types of funds, but the sample starts in 2010 and does not distingusih between regions.

We extend the CAPM model to a multi-factor model and apply it to the Dow Jones Sustainability Index (DJSI) by regions (Europe, Asia, the United States and the global index), as well as the indices on renewable energy. Extending the analysis towards renewables is important for policy and for information on the link between environmental and financial performance, as the renewable energy sector is exposed to more risk. We apply the CAPM to both sustainability and clean energy (renewables) indices, which enables us to gauge the riskiness and return of both the overall sustainability aspect and the specific environmental one by focusing on renewables. Riskiness follows from the relationship with the market, or the beta coefficient, and return follows from the alpha coefficient in the basic CAPM model.

3. Data and methodology

Following the literature review, we build on the approach by Schroder (2007) and Statman (2006). We apply the Fama and French (1992) models to data on returns of the Dow Jones Sustainability Index (available regionally as well). The basic model is the initial Capital Asset Pricing model that specifies that the excess return (ER) (stock return minus the risk-free rate) depends on the idiosyncratic risk (alpha) and the systematic risk. The systematic risk is captured through the MRP term, i.e., the market risk premium (MRP) that stands for the difference between the market index return and the risk-free rate.

Thus, in the simplest specification, alpha (α) is the excess return of the stock/index beyond the market, whereas the beta (β) reflects the relationship between the stock or index's return beyond the risk-free rate and the market return over the risk-free rate. A positive alpha indicates positive excess return that cannot be attributed to general movements in the market, as this is controlled for with the inclusion of the MRP term. Thus, the alpha term reflects idiosyncratic risk that gives a positive return in case of a positive alpha. The beta term reflects systematic risk. A risky stock or index would have a beta higher than 1, since it indicates that it moves more than the market.

The basic CAPM model, although useful, has been extended to incorporate other factors such as value or quality, size or momentum.

Namely, in addition to stocks' or indices' excess returns being driven by broader movements in the market, there are other variables which could explain the presence of a positive alpha. The idea behind the inclusion of the three factors above exploits several empirical relationships. The first is that small firms tend to have a premium over big firms. Thus, the alpha might be driven by the size of the premium that arises from the difference in size, small minus big (SMB). This is the size factor, or the difference between the returns of portfolios made up of small and big firms, respectively – small minus big (SMB).

The second is that high-value firms will have higher stock returns. Thus, the difference in return between high- and low-value firms (or growth firms) could be what is driving the alpha. This is the value factor, or the difference between the returns of high and low value portfolios – high minus low (HML).

In addition to the three factors for market risk premium, size and value (MRP, SMB, HML), Carhart (1997) proposes to extend the model to account for trend. Namely, the alpha, if present, might be a consequence of the momentum on the market. Thus, he proposes to extend the model by including the return of a portfolio composed of the best performing stocks over the past 12 months, i.e., the stocks with the best trend or momentum (MOM).

$$ER_t = \alpha + \beta_1 MRP_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \varepsilon_t \tag{1}$$

Recently, Fama and French have extended their analysis to five factors as well (Fama & French, 2015), thus specifying the following equation:

$$ER_t = \alpha + \beta_1 MRP_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 CMA_t + \beta_5 RMW_t + \varepsilon_t \tag{2}$$

Equation 2 states that returns should be analysed not only in relation to the market risk premium, size or value, but also in relation to investment and profitability. Namely, firms with slow growth in total assets (conservative) should have higher returns.

The fourth factor captures the difference in returns between a portfolio composed of conservative investment firms and aggressive investment firms – conservative minus aggressive (CMA).

The fifth factor captures the profitability of firms, as the more profitable a firm is, the higher its returns should be. This is the profitability factor which reflects the difference between a portfolio composed of robust firms (profitable) and weak firms (less profitable) – robust minus weak (RMW).

The inclusion of factors is useful because it allows controlling for market-wide influences. We estimate the four and five-factor models by Ordinary Least Squares (OLS) for the DJSI regional indices and a range of renewable indices. We use daily returns over the period 25 October 2006–30 June 2016, amounting to 2436 observations. We follow the literature and use total return indexes (thus including dividends). All returns are in USD dollars.

The clean energy indices used are the WilderHill indices: WilderHill clean energy index (ECO); WilderHill New Energy Global Innovation Index (NEX); and the WilderHill Progressive Energy index (WHPRO). The difference between the WilderHill ECO and the WilderHill NEX is that the ECO covers only firms listed in the U.S., whereas the NEX also covers firms listed outside the U.S. The criteria for both, however, is that they are companies focusing on the generation and use of cleaner energy, conservation, efficiency and advancing renewable energy.

The difference between the ECO, NEX and the WHPRO is that the WHPRO focuses on transitional technologies, while the former two are focused on clean technologies. The WHPRO includes companies that provide an energy bridge, 'improving near-term use of fossil fuel resources by progressively reducing carbon and other pollution reflecting transitional technologies'. Thus, both belong to the renewable energy sector, albeit at a different pace to reflect the variety of firms operating in the sector, where not all are 100% renewable as it is an on-going transition.

In addition to the WilderHill indices, we also use indices from other providers, for comparability and robustness of results. The other indices are from the S-Network Global Indexes that include the Ardour Global Alternative Energy index (AGIGL) that includes only companies that are principally engaged in the field of alternative energy. Thus, it is closer in construction to the ECO and the NEX, but the latter have the advantage of differentiating between regions. Thus, we analyse the broader sustainability dimension and then move to the environmental dimension through renewable indices.

Within renewable indices, where possible, we estimate the same models for specific types of renewable energy. The indices used are the Bloomberg Global Solar and Wind (BGSOLAR and BGWIND) and the Ardour Solar index (SOLRX) from the renewable indices. For comparison, we also estimate the models for the S&P Global Energy index (SGES). Table 1 shows the summary statistics for each of the indices.

4. Results

4.1. Sustainable indices (DJSI) results

The results indicate substantial risk that differs across regions. We obtain a relative ranking of Asia, Europe, the U.S. and Global in terms of risk (from the least exposed

Table 1. Summary statistics.

WilderHill ECO	−0.036	2.256	−13.469	15.627
WilderHill NEX	−0.002	1.628	−9.954	12.829
WilderHill PROO	0.016	1.912	−19.231	18.088
Ardour Global Alternative Energy	0.001	1.890	−11.673	15.259
Ardour Solar	0.046	4.612	−16.357	175.798
Bloomberg Solar	−0.005	2.144	−11.864	16.407
Bloomberg Wind	0.006	1.612	−13.018	12.960
S&P Global Energy	0.022	1.667	−12.955	14.528
DJSI E.U.	0.014	1.597	−9.283	11.300
DJSI Asia	0.012	1.420	−9.810	11.449
DJSI U.S.	0.029	1.262	−8.441	10.770
DJSI GLOBAL	0.016	1.276	−7.474	9.240

Source: Authors' estimates.

Table 2. Four-factor (Carhart) estimates for the DJSI regional indices.

	(1) E.U.	(2) AP	(3) U.S.	(4) Global
MRP	0.941***	0.819***	0.945***	1.018***
	(0.0126)	(0.0297)	(0.00504)	(0.0171)
SMB	−0.302***	−0.107	−0.181***	−0.184***
	(0.0355)	(0.0715)	(0.00917)	(0.0456)
HML	0.0324	0.0315	0.00600	0.0768
	(0.0382)	(0.0511)	(0.0104)	(0.0490)
MOM	−0.0829***	−0.133***	−0.0138**	−0.0460*
	(0.0243)	(0.0359)	(0.00610)	(0.0237)
α	0.00170	−0.00859	−0.00349	−0.00648
	(0.00890)	(0.0186)	(0.00373)	(0.00900)
R^2	0.926	0.592	0.979	0.880

Source: Authors' estimates.

to systemic risk to the most) (Table 2). Whereas the DJSI Global is the only index with a beta higher than 1, other estimated beta coefficients are close to 1, which implies a relatively high systemic risk. In terms of excess returns, they are negative but not significant. The lowest return is observed for the DJSI Asia, with an annual alpha of −2.14%. The European DJSI has a positive four-factor alpha, but it is not statistically significant. What these results show is that sustainability remains a risky business, and a positive risk–reward relationship is generally not observed. Namely, the DJSI US has a relatively high systemic risk, as well as a negative return. Similarly, low exposure to risk, as evident in the Asian case, is suboptimal, as the estimated returns are negative.

In terms of the other two factors, the results show a negative and significant loading on size across regions, which implies that these stocks belong to the large-cap stocks. The Asian DJSI has a negative coefficient on the size factor, but it is not significant. The overall result for a positive relationship between market capitalisation and sustainable firms is expected, as larger companies are more able to afford sustainability strategies. The value factor coefficient is positive but not statistically significant across all regions, which indicates a value effect. The findings for the fourth factor indicate that a sustainable portfolio is typically composed of contrarian stocks, as the returns load negatively on the momentum factor. The estimated coefficient is negative and statistically significant across all regions. In general, these results imply that the factor models are able to explain a large share of the variation across most regions, as the R^2 is high, excluding Asia.

Table 3 shows the results for the five-factor model. The estimated market risk premium loadings are stable across both regions, and we obtain a similar ranking for exposure to risk as in the four-factor model. All size loadings are negative and statistically significant. The results are comparable for the five-factor excess return as well. The five-factor model gives an annualised alpha of 1.36% p.a. for DJSI EU, but it is not statistically significant. The magnitude of the alpha is substantially smaller than the magnitude reported by Derwall et al. (2005) who apply the four-factor model. This is likely due to the period of observation that includes the global financial crisis.

The annualised excess return is negative and statistically significant for the DJSI US, amounting to −1.47% p.a. The U.S. and global DJSI excess returns decrease in

Table 3. Fama-French five-factor model estimates for the DJSI indices.

	(1) EU	(2) AP	(3) US	(4) Global
MRP	**0.931*****	**0.757*****	**0.963*****	**1.025*****
	(0.0156)	(0.0291)	(0.00518)	(0.0202)
SMB	**−0.339*****	**−0.184*****	**−0.169*****	**−0.182*****
	(0.0345)	(0.0708)	(0.00925)	(0.0459)
HML	**0.0350**	**0.00225**	**0.0111**	**0.211*****
	(0.0546)	(0.0684)	(0.00941)	(0.0571)
RMW	**−0.200****	**−0.0778**	**0.0910*****	**0.253*****
	(0.0939)	(0.0740)	(0.0142)	(0.0813)
CMA	**−0.187*****	**−0.227*****	**0.154*****	**−0.112***
	(0.0595)	(0.0780)	(0.0183)	(0.0609)
α	**0.00537**	**−0.00625**	**−0.00588***	**−0.00991**
	(0.00904)	(0.0186)	(0.00355)	(0.00901)
R^2	0.926	0.593	0.981	0.882

Source: Authors' estimates.

magnitude in the five-factor model, which implies that other factors included account for the excess return obtained in the initial estimation of the four-factor model. The annualised excess returns (alphas) and betas are shown in Table 4. The results from both models indicate that high risk in the DJSI is not necessarily conducive to excess high returns, as the traditional portfolio theory would suggest.

The value and size factor coefficients are consistent with the four-factor model. In terms of other factors, apart from the global and the U.S. portfolios, both Asia and Europe have negative coefficients on the profitability factor in both the original and the DJSI specification. This in turn implies that sustainable stocks encompassed within these indices belong to the less profitable companies. The opposite is true for the U.S. and the global portfolio, which could be a sign of institutional differences. Namely, the U.S. is characterised by higher competition in general and, thus, sustainable companies are more likely to be more profitable as well.

A similar relationship emerges for the investment factor. The coefficient on CMA is positive and significant for the U.S., whereas it is negative and significant for Europe and Asia. The differences in signs between the regions implies that U.S. sustainable companies undertake a more conservative strategy. Although indicative of certain patterns, these are results for the overall sustainability indices. However, the relationship between environmentalism and financial performance could be gauged even better by focusing on renewables stocks, as these are exclusively environmental. The next section shows the results for the renewables stocks.

4.2. Renewable energy indices results

The renewable energy indices results are consistent with the literature, as they all have market risk premiums higher than one. This corroborates the finding by earlier studies (Henriques & Sadorsky, 2008; Sadorsky, 2012) that renewables are more sensitive to systemic risk. The geographic and sectoral dimensions are informative and can be observed in Table 5. The results show that the ECO index, which includes companies at the technological forefront for renewable energy, and one of the solar indices, have the highest betas among all renewable energy indices.

Table 4. Annualised alphas and estimated betas for the four-factor and five-factor portfolios.

	Four-factor alpha p.a. (in %)	Four-factor beta	Five-factor alpha p.a. (in %)	Five-factor beta
DJSI E.U.	0.43	0.941***	1.36	0.931***
DJSI Asia	−2.14	0.819***	−1.56	0.757***
DJSI U.S.	−0.88	0.945***	−1.47*	0.963***
DJSI Global	−1.62	1.018***	−2.47	1.025***

Source: Authors' estimates.

Table 5. Four-factor (Carhart) model estimates for renewable energy stock indices.

Index	(1) *WHPRO*	(2) *ECO*	(3) *NEX*	(4) *SOLRX*	(5) *BGSOLAR*	(6) *AGIGL*	(7) *BGWIND*	(8) *SGES*
MRP	**1.492***	**1.733***	**1.404***	**1.966***	**1.483***	**1.553***	**1.134***	**1.229***
	(0.0375)	(0.0417)	(0.0263)	(0.0742)	(0.0479)	(0.0332)	(0.0436)	(0.0240)
SMB	**0.221**	**0.655***	**0.635***	**0.416**	**0.524***	**0.430***	**0.464***	**−0.452***
	(0.0901)	(0.116)	(0.0751)	(0.282)	(0.138)	(0.103)	(0.112)	(0.0665)
HML	**−0.207***	**−0.637***	**−0.326***	**−0.907***	**−0.636***	**−0.516***	**−0.107**	**−0.0957**
	(0.109)	(0.126)	(0.0646)	(0.243)	(0.125)	(0.0858)	(0.101)	(0.0798)
MOM	**−0.214***	**−0.247***	**−0.142***	**0.224**	**−0.131***	**−0.114***	**−0.00930**	**0.0165**
	(0.0433)	(0.0591)	(0.0378)	(0.455)	(0.0695)	(0.0530)	(0.0542)	(0.0389)
α	**−0.0119**	**−0.0687**	**−0.0292***	**−0.00193**	**−0.0351**	**−0.0313**	**−0.0183**	**−0.00640**
	(0.0197)	(0.0277)	(0.0156)	(0.0772)	(0.0309)	(0.0200)	(0.0230)	(0.0163)
R^2	0.746	0.639	0.781	0.183	0.502	0.733	0.512	0.772

Source: Authors' estimates.

Focusing on the sectoral dimension, it can be observed that wind has a lower beta coefficient than solar energy. The beta coefficient for solar seems sensitive to the index used, as the specification using the Ardour Solar Index shows a substantially higher beta coefficient than the Bloomberg Solar or Bloomberg Wind Indices. However, the R^2 is low in this regression. Finally, if we take the sector as a whole, we observe that the energy sector is still sensitive to systemic risk although comparably less than the other indices.

The results are gloomier for the returns. In all cases, the alpha is negative and in the case of the ECO and the NEX Index, it is significantly negative. This amounts to substantial negative returns on an annualised level, as is evident in Table 6. This differs from the previous findings for the sustainability indices, where the annualised losses (in the case of DJSI Asia for example) amounted to -2.14%. The underperformance is not statistically significant in most indices. This is a similar finding to Schroder (2007) and Statman and Glushkov (2009). However, a key difference is that they use general sustainability indices, for which we do find some statistical evidence depending on the region analysed. A possible explanation for the contrasting results could be that utilising environmentally friendly technologies and thus qualifying for a sustainable index is different from producing environmentally friendly technologies.

Another observation in relation to the excess returns is that the transition technology index (WilderHill) has a less negative alpha in relation to the ECO and NEX indices. This suggests that clean technologies themselves have indeed been a risky business over the past decade. The immediate implication for the private sector involvement is that transitional technologies might be better than the actual clean technologies (absent substantial public support).

Regarding the other factors, the renewable energy stock returns have a positive relationship with the size factor, unlike the DJSI indices. This implies that positive

Table 6. Fama-French five-factor model estimates for renewable energy stock indices.

Index	(1) WHPRO	(2) ECO	(3) NEX	(4) SOLRX	(5) BGSOLAR	(6) AGIGL	(7) BGWIND	(8) SGES
MRP	**1.404*** **	**1.525*** **	**1.280*** **	**1.754*** **	**1.234*** **	**1.391*** **	**1.042*** **	**1.208*** **
	(0.0428)	(0.0524)	(0.0290)	(0.0780)	(0.0496)	(0.0346)	(0.0470)	(0.0278)
SMB	**0.119**	**0.459*** **	**0.556*** **	**0.353* **	**0.407*** **	**0.337*** **	**0.457*** **	**−0.414*** **
	(0.0880)	(0.110)	(0.0728)	(0.187)	(0.125)	(0.0938)	(0.108)	(0.0656)
HML	**−0.0587**	**−0.682*** **	**−0.0246**	**−1.178**	**−0.148**	**−0.263*** **	**0.280** **	**0.294*** **
	(0.103)	(0.143)	(0.0663)	(0.857)	(0.130)	(0.0862)	(0.110)	(0.0845)
RMW	**−0.597*** **	**−1.761*** **	**−0.223** **	**−1.184*** **	**−0.352* **	**−0.458*** **	**0.484*** **	**0.907*** **
	(0.142)	(0.188)	(0.102)	(0.259)	(0.187)	(0.140)	(0.174)	(0.104)
CMA	**−0.640*** **	**−1.066*** **	**−0.984*** **	**−0.798**	**−1.829*** **	**−1.125*** **	**−0.888*** **	**−0.518*** **
	(0.137)	(0.184)	(0.0956)	(1.233)	(0.174)	(0.129)	(0.151)	(0.112)
α	**0.000121**	**−0.0350**	**−0.0174**	**0.0296**	**−0.0113**	**−0.0137**	**−0.0154**	**−0.0136**
	(0.0197)	(0.0268)	(0.0153)	(0.0742)	(0.0299)	(0.0194)	(0.0229)	(0.0154)
R^2	0.750	0.667	0.795	0.186	0.533	0.749	0.530	0.790

Source: Authors' estimates.

returns can be attained for small companies. The contrast with the sustainable indices results is somewhat encouraging for a green economy transition. While qualifying for overall sustainability is more likely for large-cap companies, renewables companies can be small-cap firms as well.

The value factor has a negative coefficient and is significant for half of the specifications. This implies that the stocks in the renewables sector tend to be growth stocks rather than value stocks. This result is to be expected, as the industry is still developing. Finally, the negative and statistically significant factor loadings on the momentum factor indicate that these are contrarian stocks. This implies that stock market momentum is not favourable to investors' perception about renewable energy stocks, a result that is explicable with their volatility and potential sensitivity to oil prices.

We obtain similar findings with the five-factor model estimates. Namely, all indices have betas higher than 1. The estimated excess returns are negative in this case as well, although statistically insignificant. Moreover, the magnitude of the negative return is smaller, as evident in Table 7. For example, the negative alpha in the five-factor model is twice smaller than in the four-factor model. Almost all indices have alphas smaller than -5% p.a. when using the five-factor model. This implies that the loss can be explained by accounting for relevant factors such as investment and profitability.

The coefficients on the size and value factor indicate that renewable stocks are small-cap and growth stocks, as in the four-factor model. The profitability and investment factor loadings imply that the stocks that have done well are not all among the most profitable, as we would expect that a decrease in profitability was associated with a decrease in returns. In addition, the renewable energy stocks that have done well are not among the conservative ones. Namely, the negative coefficients on the investment factor imply that the renewables in this sample, which have done well, are the ones that have higher total assets.

4.3. Discussion

The results indicate that sustainability is a risky business as implied by the high beta globally. Our results indicate that these are likely to be large-cap, value and contrarian stocks. The results on the excess return indicate underperformance which

Table 7. Annualised alphas and estimated betas for the four-factor and five-factor portfolios.

	Four-factor alpha p.a. (in %)	Four-factor beta	Five-factor alpha p.a. (in %)	Five-factor beta
ECO	−15.902**	1.733***	−8.444	1.525***
NEX	−7.095*	1.404***	−4.290	1.280***
WHPRO	−2.954	1.492***	0.030	1.404***
AGIGL	−7.586	1.553***	−3.394	1.391***
SOLRX	−0.485	1.966***	7.743	1.754***
BGSOLAR	−8.467	1.483***	−2.808	1.234***
BGWIND	−4.507	1.134***	−3.807	1.042***
SGES	−1.600	1.229***	−3.369	1.208***

Source: Authors' estimates.

corroborates the findings in the recent literature (Belghitar et al., 2014; El Ghoul & Karoui, 2017), but it is not statistically significant. Statman and Glushkov (2009) report a positive alpha, but the period does not include the crisis. The inclusion of the other two factors that are relatively new theoretically indicate that institutional differences transmit to sustainable firms. Namely, being sustainable does not guarantee profitability per se, as implied by the different signs for the U.S. and the European indices. Moreover, a conservative or aggressive investment strategy does not guarantee a positive alpha per se either. Previous studies have been done on a range of socially responsible indices. Our results on the renewable energy indices indicate that these are high-beta, small-cap, growth and contrarian stocks. These findings corroborate the results in Bohl, Kaufmann, and Siklos (2015) who study a range of renewable indices as well. The coefficients on the two additional factors reveal that renewables need aggressive investment to generate positive returns. In contrast, Reboredo et al. (2017) apply separate time-series regressions to a range of renewable energy indices and report an average beta lower than 1. Regarding the other factors, the authors find that these stocks are likely to be small-cap, value and momentum stocks. Finally, perhaps the most relevant result from an investors' point of view is the under/overperformance. Both Reboredo et al. (2017) and Bohl et al. (2015) report negative alphas. The significance for the negative alpha differs in the latter study, whereas the former only reports average alphas. The lack of significance can be interpreted as no financial effect, as in Xiao et al. (2015). This cannot be claimed for all indices, as is evident in the case of the WilderHill Eco Index.

These results imply that there is a negative effect from sustainability, although it is not significant. This effect is the most pronounced for renewable energy indices, which indicates that in practice renewable energy is not a suitable investment for the risk-averse investor. The results on the general sustainability indices are less gloomy, thus indicating that there is a green premium for renewable energy (Reboredo et al., 2017).

Although our study is one of the first to provide estimates on the performance of both socially responsible and renewable energy indices from the Fama-French multifactor models, the analysis can be extended in several ways. First of all, the over/underperformance can be related to various firm-level characteristics, including specific environmental characteristics. Second, we have used the general market as the benchmark, as this is the classic approach, but it can be extended to other indices. Third, the Fama-French framework is revealing for the first two moments of the distribution of returns: average return (mean) and risk (standard deviation). Future studies could assess their performance by accounting for other characteristics of the return distribution as in (Belghitar et al., 2014). Finally, although renewable energy has had negative performance in the past decade, technological innovation and climate change agreements may change the outlook over the next decade.

5. Conclusion

This paper applies the multi-factor models using the Fama-French factors to various sustainability indices in different regions, and various renewable energy indices, as this is an unfilled research niche, particularly in the case of renewables. The results show that sustainability is risky in general. This is evident from the magnitude of the beta coefficient.

The implications are gloomier when focusing on the environmental dimension within sustainability by analysing renewables. One of the contributions of this paper is the use of a wide range of indices which allow an insight into the heterogeneity of the beta coefficients. We find high market risk betas for renewables in general. Furthermore, our results indicate that wind is less risky than solar and that the U.S. clean energy portfolio is indeed riskier than the global one.

In addition to the systemic risk dimension, these results provide an insight into the excess return that was positive in the European DJSI and negative but statistically insignificant in other DJSI specifications. The renewables' excess returns were negative and significant, which implies that sustainability is a risky business on the one hand, which is not justified by rewarding returns on the other. This gives investors a motive to refrain from clean energy. However, this could be a result of an improper benchmark, as this analysis relied on the market risk premium for the general markets as calculated by Fama and French (2015). Future research could use specific, relatable benchmarks.

The results obtained are informative for policy makers as high betas and low/negative alphas point out there is room for an increasing role of public policy in driving the clean energy transition. In a policy setting where support for renewables is waning, the other option is the private sector. However, a seemingly valid reason for a lack of interest in renewables could be their poor financial performance from an investor's perspective. Thus, public policy, timely development and adoption of transitional technologies become ever more important. Technological development is crucial for this sector and it may change the outlook for renewables in the next decade. Thus, besides methodological improvements such as disaggregated analysis (firm-level), future research should aim to take technological development into account as well.

Disclosure Statement

No potential conflict of interest was reported by the author.

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