

Introduction

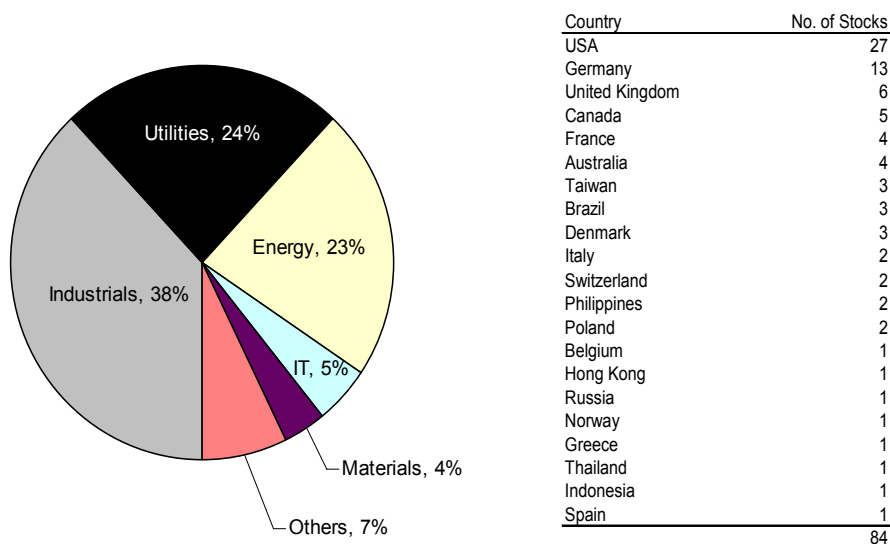
Recently, there has been increasing worldwide awareness of environmental degradation, and a growing sense of urgency toward environmental preservation. This is reflected in new policies and regulations intended to reduce the ecologically damaging effects of production processes. The Kyoto Protocol, the European Emissions Trading Scheme and the US Environmental Protection Agency Clean Air Act are examples of policies aimed at protecting the environment. As the cost of pollution increases, companies are finding ways to mitigate the potential financial risk by adapting to a low carbon operating environment. At the same time, greater environmental awareness is gradually transforming consumers' behavior and spawning new industries to focus on the provision of alternative solutions that are ecologically friendly.

Climate change has far-reaching implications for the global economy and it is being recognized as a long-term investment theme. As more investors take note of companies that are well-positioned to handle climate change, a common factor may account, in part, for the share prices of these companies. This note addresses the question of whether returns to firms that are beneficiaries of climate change display common properties that are not captured by risk factors in use today. In other words, is there a green factor?

The Renewable Energy Sample Portfolio

Given the exploratory nature of this study, we focus our analysis on companies whose businesses are directly or indirectly involved in the provision of renewable energy. We choose renewable energy firms because they are direct beneficiaries of climate change and represent pure plays of climate change investing.

Figure 1: GICS Sector and Country for Selected Firms with Renewable Energy Activities



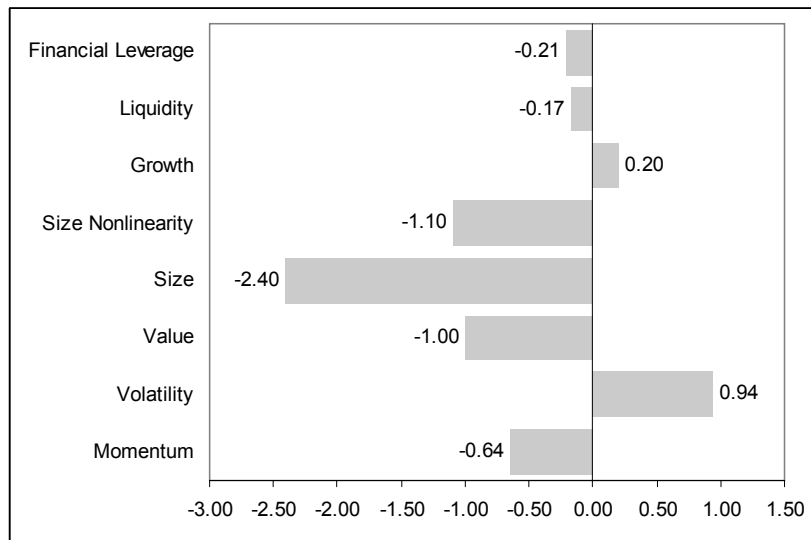
The sample consists of 84 stocks sourced from 21 countries and are drawn mainly from the industrial, utility, energy, information technology and materials sectors. Firms in the industrial

sector are mainly involved in the production of electrical equipments associated with the generation of renewable energy. Those in the utility sector are directly involved in the generation of renewable energy. The companies in the IT sector manufacture hardware and software that are used in solar and other types of alternative energy applications. In the material sector, relevant firms provide inputs to renewable energy production (e.g., chemical reagents for the synthetic fuels industry) and outputs from renewable sources. In terms of geographical distribution, the US has the biggest share at 32%, while the Eurozone accounts for 26%. The emerging markets (including Russia) have a significant share at 15%.

Risk Characteristics of the Renewable Energy Portfolio

We begin the analysis by examining the risk characteristics of an equal-weighted renewable energy portfolio using the new and enhanced Barra Global Equity Model (GEM2). The exposures to the Barra style factors yield information on how these stocks compare with the rest of the global equity universe. There are eight style factors¹ in the Barra GEM2 model: value, growth, momentum, volatility, size, size nonlinearity, financial leverage and liquidity. By construction, a portfolio's exposure to a factor represents the sensitivity of its value to that factor. Exposures are normalized over the GEM2 estimation universe so that the average is 0, and an exposure of -2.0 is two standard deviations below average, for example.

Figure 2: Exposures to Barra Risk Factors In Barra GEM2 Model (averages of monthly exposures from Sep 2007 to Aug 2008)



The results in Figure 2 show that the renewable energy stocks are notably below average in size, size nonlinearity, value and momentum, while they are above average in terms of volatility. These stocks, therefore, tend to be relatively small and tend to be non-value stocks, but are relatively more volatile relative to the market as compared to others. These characteristics appear to be

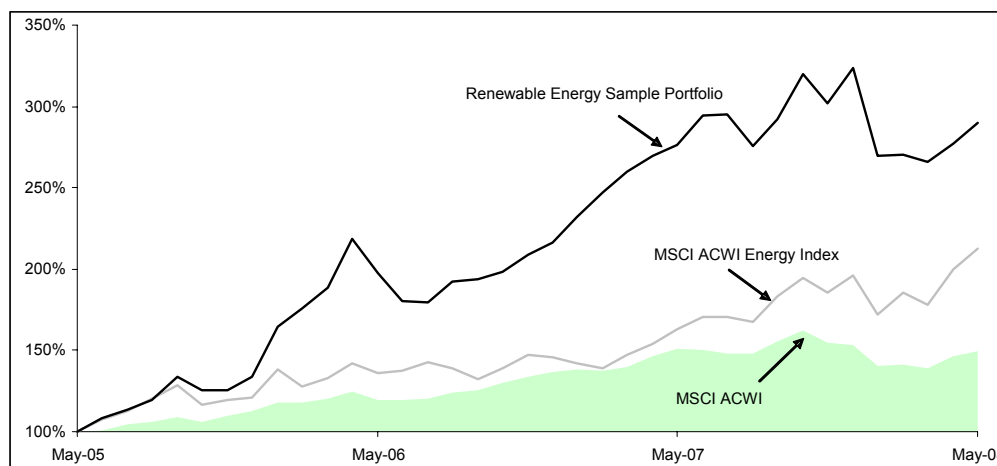
¹ The value factor is based on earnings to price, forecast earnings to price, book to price, cash earnings to price and dividend yield. The growth factor, which differentiates stocks based on their prospects for sales or earnings growth, is computed from various measures of earnings or sales growth. The momentum factor identifies recently successful stocks using price behavior in the market as measured by relative strength and historical alpha. The volatility factor differentiates stocks according to their relative volatility, as determined by their historical sigma, historical beta, cumulative range and daily standard deviation. The size factor values companies according to their market capitalization, differentiating between large and small companies. The nonlinear size factor captures non-linearities in the payoff to the size factor across the market-cap spectrum. The financial leverage factor differentiates between highly leveraged stocks with those having low leverage, and is based on various liability ratios. Lastly, the liquidity factor captures differences in stock return due to variation in trading activity, as determined by turnover measured over various time scales.

consistent over time as well as with our understanding of renewable energy firms, which tend to be young growth companies with volatile stock prices.

Do Common Risk Factors Explain the Performance of Renewable Energy Portfolio?

Figure 3 plots the cumulative total returns of the sample portfolio against the MSCI AC World Index (MSCI ACWI Index) and the MSCI AC World Energy Index (MSCI ACWI Energy Index) for the past three years. The figure shows that the sample portfolio recorded significant performance differential compared to the broader benchmark indices.

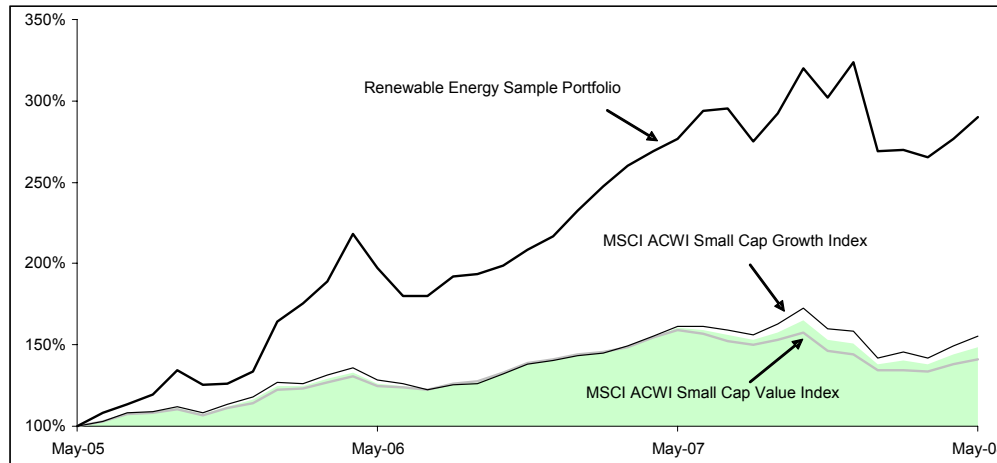
Figure 3: Performance of Sample Portfolio and MSCI Indices



Before we proceed to test for the existence of a green factor, it is useful to examine whether existing common risk factors sufficiently explain the performance of the renewable energy portfolio. Based on the portfolio risk attribution using GEM2, the renewable energy firms in the sample tend to be below average in size. This leads to the question of whether the small cap characteristic may explain their superior performance. One simple way to control for this effect is to replace the MSCI ACWI Index shown in Figure 3 with the MSCI ACWI Small Cap Index. We also consider other aspects of style by examining the performances of small cap value and growth indices.

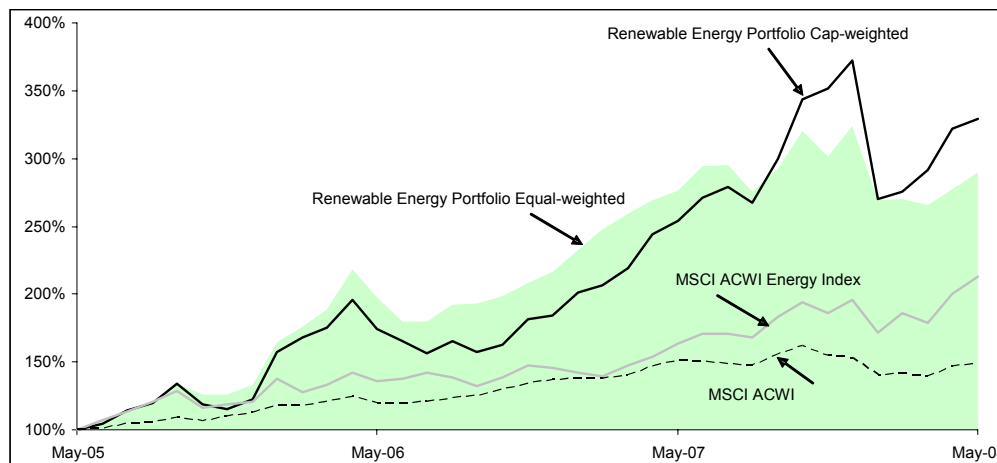
Figure 4 compares the performance of the sample portfolio with the various small cap versions of the MSCI ACWI Index. The shaded curve represents the MSCI ACWI Small Cap Index, which is sandwiched between the MSCI ACWI Small Cap Value and Growth Indices. These three small-cap indices did not differ significantly from one another, which implies that the style effects considered are limited compared to the performance differential with the sample portfolio of renewable energy stocks.

Figure 4: Performance Compared to MSCI ACWI Small Cap Indices



Another way to analyze the impact of size on performance is to compare the relative performance of small and large cap stocks within the sample portfolio. To do this we compare the equally-weighted renewable energy portfolio with a free float-adjusted cap weighted version. The two versions of the portfolio are shown in Figure 5. The cap weighted version lagged the equal-weighted version from 2006 to 2007, when small caps outperformed large caps. However, beginning with the later stages of the bull market in the latter half of 2007, the large cap stocks fared better, and the cap-weighted portfolio outperformed its equal-weighted counterpart for the three-year period as a whole. These results support the conclusion that firm size cannot account for the superior performance of renewable energy stocks.

Figure 5: Equal-Weighted vs Float-adjusted Cap Weighted

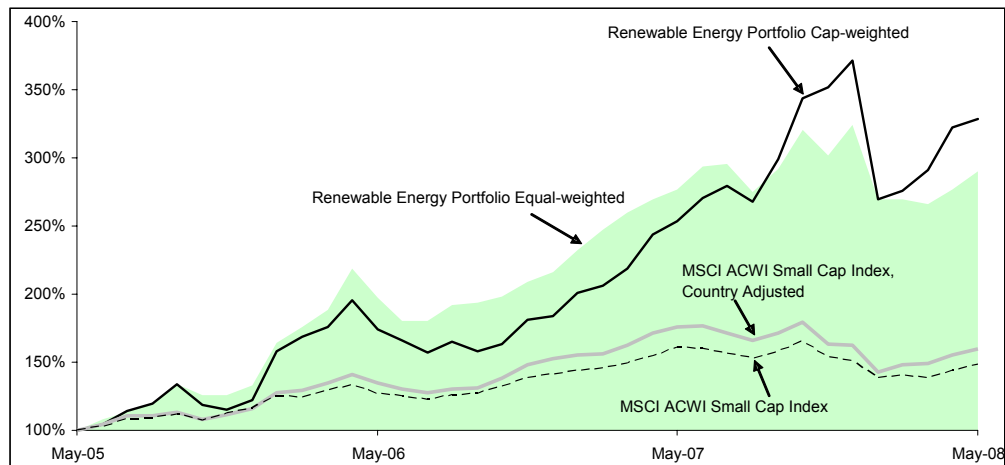


Finally, we investigate whether the difference in country distribution is a major factor in the results. This is a possibility since, for instance, the share of emerging markets in the sample renewable energy portfolio is somewhat higher than that in the MSCI ACWI Index. In addition, the country weights tend to be more variable over time due to the relatively small number of stocks in

the portfolio. To account for this effect, we use composite small cap indices of the countries represented in our sample portfolio, and weigh them according to the actual country weights in the portfolio. This is implemented from the start of the sample period and repeated on a monthly basis. At the monthly rebalancing points, the weights of the composite small cap index are reset to the corresponding country weights in the sample portfolio. This creates a geographically comparable index that accounts for differences in country distribution while still controlling for the size effect through the use of small cap indices.

The country adjusted small cap index and the MSCI ACWI Index are shown in Figure 6, together with the equal-weighted and cap-weighted versions of the sample portfolio. The country adjustment appears to have improved the performance of the MSCI ACWI Small Cap Index, but the effect is not sufficiently large to account for the performance differential with the sample portfolio. Therefore, the above observations suggest that a more rigorous statistical test is warranted.

Figure 6: Adjusting for Country Distribution Differences with Benchmark

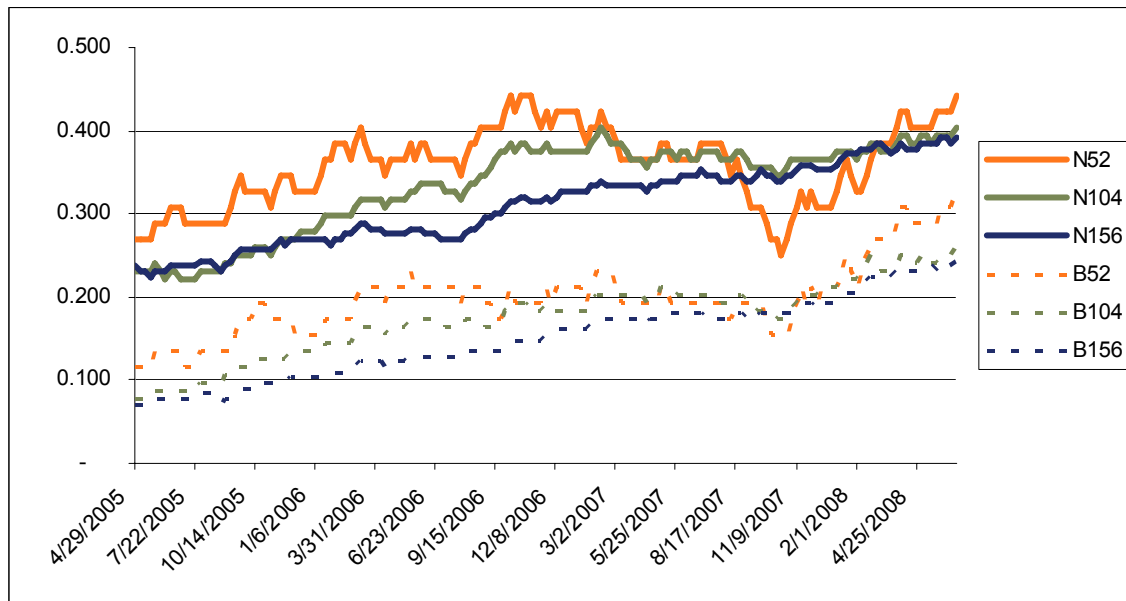


Green Industry Factor Evidence in Risk Models

To test for a green industry factor, we look into the specific returns data of GEM2 to see if any residual information can be extracted. We construct exposures by assigning one to green stocks and zero to the rest of the stocks in the estimation universe. We standardize these exposures to have regression-weighted mean zero. Finally, we regress the weekly specific returns on the exposures to obtain an estimate of the green factor return.

We use the t-ratio (factor return estimate divided by its estimated standard deviation) to evaluate the statistical significance of the green factor return. Under the null hypothesis that there is no green factor, the t-ratio has approximate 2.5% and 97.5% critical values of -2 and 2, under the assumption that GEM2 residuals are normally distributed. Consistently larger t-ratios imply that there is a green factor. To study the significance of the factor returns, we compute the fraction of absolute t-ratios greater than 2 in rolling windows of 52, 104 and 156 weeks. These are shown as solid lines in Figure 7. A value of 0.30 compares favorably with similar statistics of some GEM2 industries

Figure 7: Trailing Ratio of Significant Regressions Using Normal and Bootstrap Distribution



To avoid relying on normality assumptions for the distribution of the t-ratio, we use a bootstrap methodology. The idea is that randomly sampling from the empirical distribution of the specific returns produces a sample with identical noise to the true data set, but washes out any green factor component. The test checks if the t-ratio with the actual data is exceptional relative to the distribution of the t-ratio for the scrambled data.

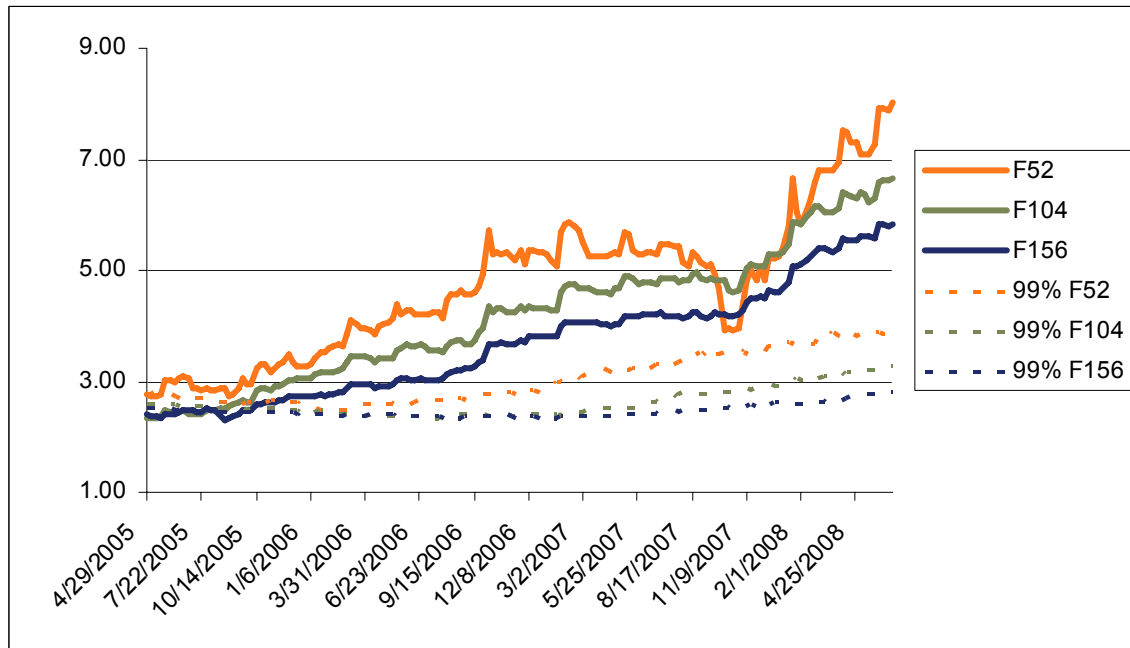
The bootstrap first independently draws specific returns at random (with replacement) for each firm in the estimation universe. Repeating the cross-sectional regressions over 1000 bootstrap runs, we obtain the distribution of the t-ratio for each week. This distribution yields larger critical values than the normal distribution, which makes it harder to reject the null hypothesis of statistical insignificance. This results in a substantial drop in the ratio of significant regressions represented by dotted lines in Figure 7.

However, with more than 20% of t-ratios exceeding these more rigorous critical values, there is statistical evidence showing the emergence of a green factor.

To judge the overall quality of the regressions, we compute 52-, 104- and 156-weeks trailing mean t-squared statistics. Under the assumption of normality, this statistic exceeds four with 95% significance. In addition, we use the bootstrap distribution to compute 99% critical values. Figure 8 shows the three rolling mean t-squared statistics (solid lines) and the bootstrap critical values (dotted lines). We observe an increasing trend in the overall significance, which further supports our conclusion that a green factor exists.

Therefore, even with a higher statistical bar of the bootstrap method, in about a quarter of the weekly returns in the past three years, the green stocks exhibit common behavior. This number is substantially higher than the 5% expected by pure chance with the chosen significance level.

Figure 8: Trailing Mean t-squared Statistic and its 99% Bootstrap Critical Value



Summary

This paper investigates the unique risk and return characteristics of green stocks, with a study of renewable energy companies. Using the GEM2 we find that renewable energy firms are generally smaller and more volatile than the market on average, with a negative value tilt. In addition, the impact of firm size, sector, style and geographical distribution do not fully account for the superior performance of these firms. Finally, controlling for all GEM2 risk factors, we find that a statistically significant green factor seems to have emerged in recent years. These preliminary findings warrant further investigation of the risk and return characteristics of green portfolios.

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