Investing in Dynamic Green Portfolios

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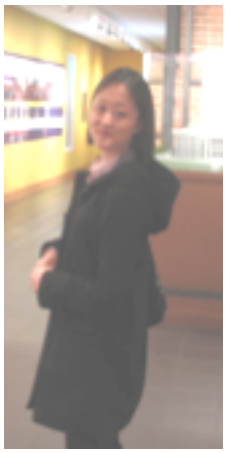

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Abstract

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In this paper, we initially define two types of stocks, green and non-green, in terms of their Kinder, Lydenberg, Domini Research & Analytics (KLD) environmental ratings. We then assemble a dynamic green portfolio with green stocks and a dynamic non-green portfolio with non-green stocks. The portfolios are dynamic in that they are rebalanced annually. By comparing the performance of the green portfolio to that of the non-green portfolio, we find that the green portfolio overwhelmingly outperformed the non-green portfolio over a medium or long term (for example, a five-year term), especially when the two portfolios are mean-variance optimal. We also prove that the better risk-adjusted performance of the green portfolio is robust to various portfolio-assembling techniques. We thus conclude that a company's financial performance is positively correlated to its involvement in environment-friendly activities. In other words, our findings support green investing.

Investing in Dynamic Green Portfolios

In recent years, as people have become more environmentally conscious, green investing has received considerable attention from private investors, mutual funds, and researchers. For example, in an article discussing "Why 'Green' Investing Has Gained Focus" by Jilian Mincer (WSJ 2007), Holly Isdale, once the managing director at Lehman Brothers, trumpets that "green investing is an investment opportunity, 'there is money to be made, and people want to know how to make it.'" Some researchers at Citigroup Inc. and UBS AG argue that global warming can no longer be ignored as a factor in investing. Mincer found that socially responsible mutual-fund firms, such as Calvert, had placed more and more green funds onboard. Investors, especially environment-conscious investors, have increased their portfolio holdings of green assets, such as stocks. Karnani (2010), however, contends that it is fundamentally flawed reasoning to think that companies have a responsibility to act in the public interest and will profit from doing so. He also argues that oftentimes companies will lose profits if they pursue their social responsibilities; therefore, only in some situations can companies do well by doing good (Karnani 2010).

Green investing can be defined as choosing investments in companies that have a positive environmental record. Green investing is also a special category of social investing. Green mutual funds, for instance, pertain to the larger category of socially responsible investment (SRI) mutual funds. Since the 1970s, environmental issues have increasingly caused concern throughout the world. Green investing, consequently, has long been in the lead in the SRI market and will likely continue to be so in the future (Little 2008; Uldrich 2008).

Investors' behavior immediately influences stock prices, and their preferences, therefore, could be the force that drives a company to go green. The motivation for investors to buy green stocks is not limited to profitability. Heinkel, Kraus, and Zechner (2001), for instance, hold that exclusionary ethical investing leads to polluting firms being held by fewer investors since green investors eschew the stock of polluting firms, thus leading to lower stock prices and a higher cost of capital for the polluting firms. If so, investing in green stocks must be a preferred strategy for all security investors (not just environment-conscious investors). The research we have undertaken is aimed at proving this point.

Related Literature

Since the 1980s, quite a few papers have examined the difference in performance between green mutual funds and non-green mutual funds, between green portfolios and non-green portfolios, and between green stocks and non-green stocks. The findings can be summarized as: 1) green investing outperforms non-green investing; 2) the difference in performance between green investing and non-green investing is not significant; and 3) subject to abnormal negative returns, green investing underperforms non-green investing.

A vast amount of literature documents that green and/or socially responsible stocks outperform alternative stocks. In particular, Herremans, Akathaporn, and McInnes (1993) examine firms in different industries and insist that only stocks of clean firms in industries having social conflict (including conflicts with the community and the environment) have higher returns but lower stock market risk. White (1995) and Cohen, Fenn, and Konar (1997) find that green firms have positive abnormal stock returns while brown firms do not. Heal (2005) trumpets that firms with higher environmental ranks perform better financially than their low-rated peers. Hart and Ahuja (1996) find that the two or three years following firms' emission reductions are associated with higher returns on equity, but they fail to prove that the association is causality. Dowell, Hart, and Yeung (2000) find a positive correlation between stock market performance and environmental standards as measured by Tobin's q (the ratio of the market value of a company to the replacement costs of its assets). King and Lenox (2001) examine a different and larger sample of firms and their findings are consistent with those of Dowell, Hart, and Yeung (2000). Plantinga and Scholtens (2001) used style analysis to assess fund performance in Belgium, France, and the Netherlands for over 800 investment funds during the 1990s. They contend that funds that to some extent mirror well-known social responsibility indices tend to perform better than funds that have no relationship with socially responsible investment strategies. Bello (2005) and Rudd (1981) have done several empirical studies to testify whether socially responsible stocks outperform alternative stocks.

Many investigations show no significant difference in relative performance between green stocks (funds) and non-green stocks (funds). Cai and Branch (2012) argue that the exclusion of socially irresponsible stocks from an index-tracking portfolio has little influence on the efficiency of the portfolio in delivering market performance; for example, Hamilton et al. (1993) examine the monthly performance of U.S. equity mutual funds and find no difference between the performance of conventional and green funds. Diltz (1995)

investigates the daily returns of 14 portfolios formed by ethical screens over three years and finds abnormal positive returns in only 3 portfolios (Heinkel, Kraus, and Zechner 2001). Renneboog, ter Horst, and Zhang (2007) claim that the risk-adjusted returns of SRI funds in the United States and the United Kingdom are not significantly different from those of conventional funds.

Previous empirical work also demonstrates that green funds may have negative abnormal performance. White (1995), for instance, examines the performances of six U.S. and five German green mutual funds from 1990 to 1993. He finds negative abnormal returns for most of the green funds. Geczy, Stambaugh, and Levin (2005) argue that SRI funds must always underperform funds that are not constrained by ethical considerations. The ground is that a fund manager cannot improve his performance or even worsen it if the universe from which stocks can be picked is restricted. Renneboog, ter Horst, and Zhang (2007) reveal that while corporate social responsibility (CSR) may create value for shareholders, participating in other social and ethical issues is likely to destroy shareholder value.

Other research on SRI include the following: 1) Hallerbach et al. (2004), who introduce a framework for managing an investment portfolio in which the investment opportunities are described in terms of a set of attributes. Part of this set is intended to capture the effects on society. 2) Mackey, Mackey, and Barney (2002) propose a theoretical model in which the supply and demand for SRI opportunities determines whether these activities will improve, reduce, or have no impact on a firm's market value. The theory shows that a publicly traded firm's socially responsible activities will maximize the market value of their firm even if such activities do not maximize the present value of the firm's future cash flows. 3) Renneboog, ter Horst, and Zhang (2007) argue that even though SRI funds underperform conventional funds in profitability, the volatility of money-flows is lower in SRI funds than in conventional funds, and SRI investors' decisions to invest in an SRI fund are less affected by management fees than the decisions by conventional fund investors.

This work complements a vast literature on green investing and SRI. Unlike Little (2008), who excludes environment-unfriendly stocks, we investigate all stocks carried in the KLD database, which will be detailed in the data section. We select stocks by some predefined environmental criteria. Different from those in the current literature, the screening criteria in this work are based upon companies' KLD environmental ratings as they are reflected in a number of environmental strengths. Companies with the largest number of

environmental strengths are perceived as the greenest. Without loss of generality, we simply define two types of stocks—green and non-green. Green stocks constitute the green portfolio and non-green stocks constitute the non-green portfolio. Both portfolios are rebalanced annually, so they are actively managed and the stocks in each of the two portfolios vary over time. In lieu of examining a short time horizon, we observe the performance of stocks during the period from 1994 through 2010 to enhance our results. In addition, our research is based on rolling periods, thus making our work robust to biases in selecting time horizons.

The majority of works in the current literature are based on short-term performance of stocks, mutual funds, and ETFs. Hart and Ahuja (1996), however, find that firms' emission reductions are associated with higher returns on equity two or three years after the reductions take place. In accordance with Hart and Ahuja (1996), we believe that the performance of stocks should be examined in a medium- or long-term range since it takes time for an investor to become acquainted with a company and its stock. Our findings show that the performance of green investing should be investigated over a relatively longer run, that is, three to five years. In this research, we set the span of each rolling window to be five years. Several methods have been used in previous empirical studies to measure performance, such as return, Tobin's q, firm's market value, present value of the firm's future cash flows, and volatility of money-flows, and so on. However, we compare the expected return and Sharpe ratio between the green portfolio and the non-green portfolio.

Heal (2005) studies only the firms with different environmental ranks in the same sector, while we examine cross-industry firms at different level of greenness. Herremans, Akathaporn, and McInnes examine firms in different industries and insist that only stocks of clean firms in industries having social conflict have higher returns but lower stock market risk. Rather than study only industries having social conflict (Herremans, Akathaporn, and McInnes), we investigate all industries but concentrate on environmental issues only. In addition, we examine stocks within the environment of a (dynamic) portfolio rather than on an individual basis, as is done in most of the above works.

The remainder of the paper is organized as follows: we describe the data and define two types of portfolios—green and non-green; in the next section, methodologies are introduced; then the performance and risk characteristics of the green portfolio is compared to that of the non-green portfolio; and in the last section, present the conclusions.

Data Description

The main data sources of this research are the KLD Social Ratings data, CRSP data, and Fama-French data. The KLD Social Rating, published by Kinder, Lydenberg, Domini Research & Analytics, is a very influential measure of corporate social performance. KLD data cover approximately 80 qualitative indicators in seven major social issue domains: community, corporate governance, diversity, employee relations, environment, human rights, and product. Each indicator is assigned with a dummy value "1" or "0." In particular, "1" represents presence and "0" represents the absence. The domain of environment encompasses seven strength indicators (beneficial products and services, pollution prevention, recycling, clean energy, communications, property, plant, and equipment (PPE), and other strengths). Same as above, the dummy value "1" indicates the presence and "0" indicates the absence of an environment strength indicator. In this work, the time horizon of environmental ratings in the KLD dataset is from 1991 through 2010, over which the number of stocks carried in the KLD dataset has been increasing. Currently, the KLD database carries more than 3,100 stocks from a rich index universe: S&P500 Index, Domini 400 Social Index, Russell 1000 Index, Large Cap Social Index, Russell 2000 Index, and Broad market Social Index. The KLD data is published once a year, thus the same rating is valid throughout the year.

In the KLD, the total number of environmental strengths is the summation of the (dummy) values assigned to the seven strength indicators. We use the total number of environmental strengths to filter stocks and fit them into corresponding portfolios. In particular, a green stock is defined as having at least one environmental strength; a non-green stock is defined as having no environmental strengths. The definitions (or screening criteria) for green and non-green stocks are summarized in Figure 1: A stock is perceived as green if it enjoys at least one environmental strength, and as non-green if it has none. In particular, a green stock is defined as $N_{str} \geq 1$, while a non-green stock is defined as: $N_{str} = 0$. N_{str} denotes the number of environment strengths.

Figure 1: Definition of Green and Non-green Stocks (Companies)

Type	Green	Non-green
N_{str}	≥ 1	0

Source: The authors.

We observe the environmental ratings for a stock for three years in a row before allocating the stock to a portfolio. Only the stocks that are characterized as green or non-green throughout the three-year screening period will be selected to form the green or non-green portfolio. The performance of the green and non-green portfolios will be examined for the

following five years. In other words, we design a three-year window for screening stocks and a five-year window for examining the performance of the two selected stock portfolios. The three-year screening window, starting from 1991, rolls annually. If we start observing stock ratings from 1991, for instance, only stocks that are categorized as green in 1991, 1992, and 1993 will be selected to build the green portfolio, and the performance of that portfolio will be examined in the following five years: 1994, 1995, 1996, 1997, and 1998. Next, the three-year screening window rolls one year forward and we select stocks labeled as green in 1992, 1993, and 1994 to assemble the green portfolio. The performance of the portfolio is examined in the following five years: 1995, 1996, 1997, 1998, and 1999, and so on. The number of stocks in the green portfolio and its counterparty are illustrated in each screening and performance window in Figure 2. The screening column contains three-year rolling periods for selecting stocks. The performance column contains five-year rolling periods over which the performance of the selected stocks is examined. N_{stk} represents the number of stocks. The green and non-green columns represent the green portfolio and the non-green portfolio, respectively. The number of stocks in both portfolios is larger than 30 in any period, implying that the two portfolios are well diversified. Note that we have eliminated the stocks that are missing environmental ratings in the screening window or missing return data in the performance window.

Figure 2: Stocks in the Green (Non-green) Portfolio over Rolling Periods

Window		N_{stk}	
Screening	**Performance**	**Green**	**Non-green**
1991–1993	1994–1998	78	44
1992–1994	1995–1999	76	51
1993–1995	1996–2000	71	43
1994–1996	1997–2001	75	36
1995–1997	1998–2002	79	32
1996–1998	1999–2003	84	37
1997–1999	2000–2004	85	37
1998–2000	2001–2005	75	37
1999–2001	2002–2006	74	42
2000–2002	2003–2007	72	46
2001–2003	2004–2008	73	58
2002–2004	2005–2009	70	67
2003–2005	2006–2010	69	92

Source: The authors.

Another major data source is CRSP (the Center for Research in Security Prices), which has been an integral part of the academic and commercial world of financial and economic research (see the CRSP Programmer's Guide at http://www.crsp.com/). We retrieve the data of returns and stock IDs ("PERMNO") from CRSP for all the stocks satisfying the screening criteria. PERMNO is a unique permanent security identification number assigned by CRSP to each security. We use PERMNO rather than CUSIP, Ticker, or company name to identify a stock because only PERMNO does not change during an issue's trading history or even if the issue ceases trading. PERMNOs and stock returns can be found in CRSP and the environmental ratings in KLD, thus incentivizing us to merge CRSP and KLD into a larger dataset so that the data of stock returns, PERMNOs, and KLD environmental ratings are together. CRSP contains both monthly and daily data. To compare the performance and risk characteristics between the green portfolio and its counterparty, we examine daily returns in lieu of monthly returns. The reason is that in the stock market, daily returns give us a richer picture of the market than monthly returns do. KLD starts issuing environmental ratings from 1991, and since three successive years of ratings are required for the screening purpose (1991, 1992, and 1993), the CSRP stock return data needed for examining performance in this research is no earlier than Jan 1994.

In addition to information from KLD and CRSP, the data of the daily risk-free rate is also indispensible to our analysis. We use 17 years, from 1994 to 2010, of daily risk-free rates (this data is available from Professor Kenneth French's website, http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/). We incorporate risk-free rates into CRSP in order to calculate the excess return (R_P - R_f) as well as the Sharpe ratio (the Sharpe ratio is developed by Nobel laureate William F. Sharpe to measure risk-adjusted performance. The Sharpe ratio can be expressed as: S = R - Rf / s. That is, the Sharpe ratio is the expected excess return divided by the standard deviation of the excess return).

Methodology

We construct two portfolios, green and non-green, in each period for paired comparison analysis. We build up the green and non-green portfolio only with stocks that are defined as green or non-green throughout the three-year screening period and that are missing no return data in the following five-year performance period. A stock is categorized as green or non-green in terms of its total number of environmental strengths assigned by KLD. As previously discussed, a green stock is defined as "$N_{str} \geq 1$" and a non-green stock is defined as "$N_{str} = 0$". KLD publishes social ratings for each company on an annual basis. Both portfolios, therefore, have to be rebalanced annually based on the updated three-year KLD ratings as the screening window rolls. Only the performance of stocks consistently pertaining to a specific type, green or non-green, during the screening period will be

examined within the framework of their portfolios in the following five-year performance period. As the three-year screening window rolls, one year of new ratings are incorporated and one year of the oldest ratings are dropped.

Portfolio rebalancing refers to updates on both the assets (stocks) and the weight of each asset in a portfolio. In this work, the probability for a stock to be selected depends on whether the stock meets the screening criteria and possesses complete return data in the performance period. The weight of each stock is measured in two ways: equal weight and optimal weight. Equal weight indicates that each stock accounts for the same proportion in the portfolio. Optimal weight implies that the weight of each stock in a portfolio has been optimized via Mean-Variance Optimization (MVO).

Modern Portfolio Theory

The MVO approach, which has been well recognized in finance, was first introduced by Harry Markowitz in his Modern Portfolio Theory (Markowitz, 1952). The concept of the equally weighted portfolio is accessible, so we elaborate on only the MVO methodology.

Assumptions:

1. Returns from the portfolio are normally distributed (multivariate normality is assumed).

2. Correlations between the stocks are fixed or constant for a period of time.

3. The investors seek to maximize their overall profit/economic utility.

4. All players in the market are rational and risk averse.

5. Common information is available to all players in the market.

6. All players are price takers.

Symbols:

wi: weight allocation to stock *i* in the portfolio.

ri: return of stock *i* in the portfolio.

RP: return of the portfolio.

σi: volatility of stock i in the portfolio.

ρij: correlation coefficient between stock i and stock j in the portfolio.

σtol: acceptable volatility of portfolio returns.

Rr: required or acceptable rate of return.

B: investment budget (i.e., *100%*).

The expected return of the portfolio:

$$ERP=i=1nwiE(ri)$$

The volatility of the portfolio:

$$\sigma P=i=1nj=1nwiwj\sigma i\sigma j\rho ij$$

Portfolio Optimization

The Modern Portfolio Theory comes up with an efficient way to build and optimize portfolios. The optimal portfolio can be achieved either by minimizing the portfolio volatility at a required rate of reward or by maximizing the portfolio reward while constraining the portfolio volatility. The constraint on volatility is generally reflected as risk tolerance. The problem of optimizing a portfolio can be solved by using quadratic programming. The mechanism behind the programming is as follows:

Model 1:

Objective Function: Minimize σP

Subject to the following constraints:

Constraint 1 (returns constraint): $ERP=i=1nwiE(ri)\geq Rr$

Constraint 2 (budget constraint): $i=1nwi\leq B$

Constraint 3 (allocation constraint): $wi \geq 0$

Model 2:

Objective Function: Maximize ERP

Subject to the following constraints:

Constraint 1 (volatility constraint): $\sigma P \leq \sigma tol$

Constraint 2 (budget constraint): $i=1nwi \leq B$

Constraint 3 (allocation constraint): $wi \geq 0$

Model 1 is to optimize a portfolio by minimizing portfolio volatility given a required rate of return. Model 2 is to optimize a portfolio by maximizing portfolio return while controlling portfolio volatility. Note that all weights are set to be positive in both cases, implying that short sales are not allowed. The constraint $wi \geq 0$ can be removed if short sales are allowed. A short sale is the sale of a security that is not owned by the seller but is promised to be delivered. Therefore, a short sale is a speculative strategy that might be manipulated by investors to profit from the falling price of a stock. Consequently, the Securities & Exchange Commission (SEC) allows investors to sell short only on an uptick or a zero-plus tick (with some exceptions, as explained in the SEC's alternative uptick rule). In other words, an investor cannot sell a stock short if it is already going down. Due to the limitation of short sales, we assume that short sales are not allowed.

Performance Comparisons

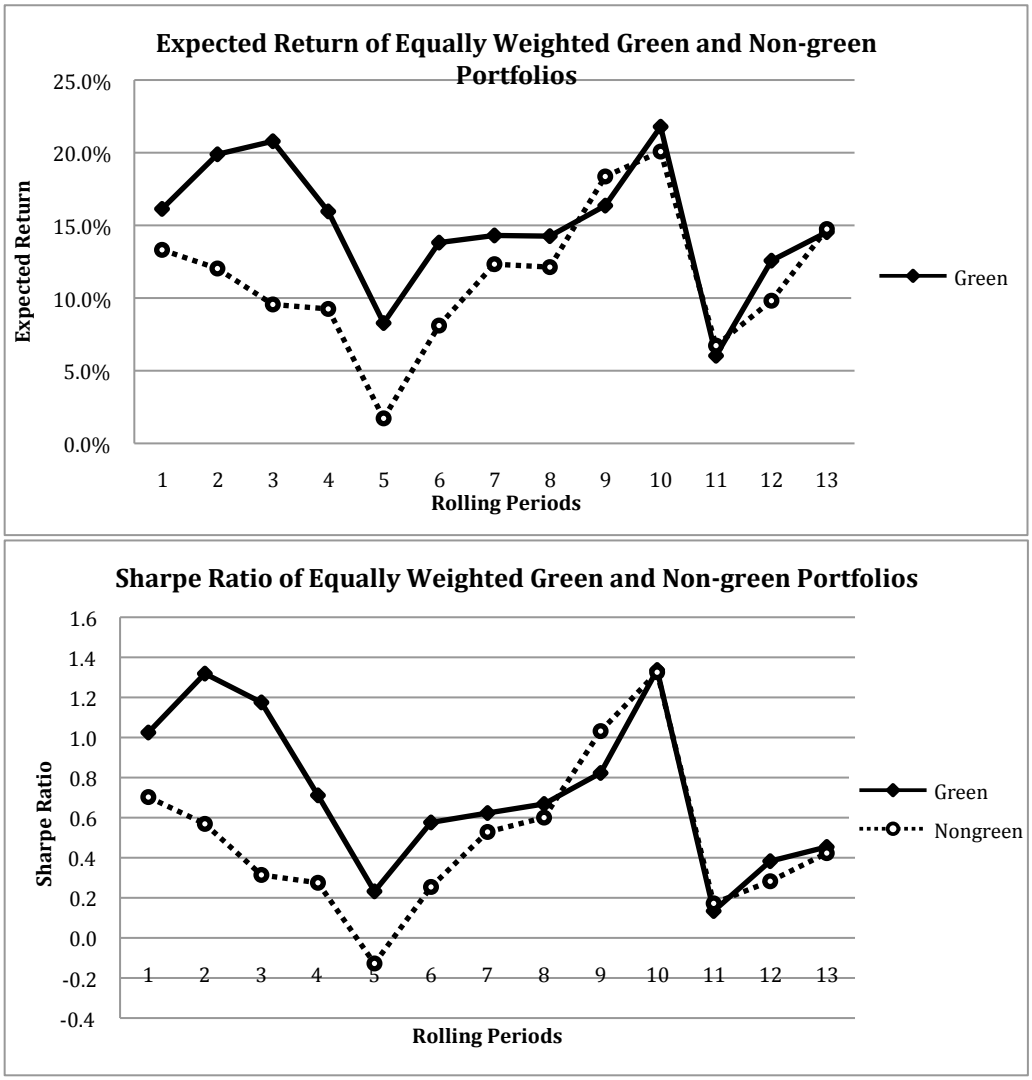
Various methods can be used to measure the financial performance of a portfolio. In this paper, we use expected return and Sharpe ratio as the performance measures. The expected return is the average of daily (portfolio) returns over a five-year performance period. Comparing performance by expected return might be misleading because a portfolio can reap higher returns than its peers by taking additional risk. We therefore introduce the Sharpe ratio into our analysis because it identifies whether a portfolio's higher returns are proceeds of wiser investment decisions or a result of assuming excess risk. In other words, the Sharpe ratio is a risk-adjusted performance measure. The greater a portfolio's Sharpe ratio, the better its risk-adjusted performance has been.

As Figure 2 illustrates, from 1994 to 2010, there exist 13 rolling five-year performance windows. The performance of a green portfolio and that of a non-green portfolio are compared in each of the 13 windows. Due to environmental screens, stocks in the two portfolios vary with the performance window. Portfolio returns can be calculated in different ways, depending on how the portfolio is built up. For an equally weighted portfolio, the portfolio returns are essentially the arithmetic mean of the returns of all stocks pertaining to the portfolio. For an optimal portfolio, the portfolio returns are the optimally weighted average of the returns of all stocks in the portfolio. The optimal weights can be achieved via mean-variance optimization.

Equally Weighted Portfolios

A portfolio is equally weighted if all the stocks in the portfolio have equal weights. By comparing the performance of the equally weighted green portfolio and the equally weighted non-green portfolio, we find that the green portfolio outperforms the non-green portfolio in all the other 11 rolling five-year performance periods except for the ninth and the eleventh periods, which are "2002–2006" and "2004–2008," respectively. From 2002 to 2006, the annualized average return of the green portfolio is 16.36% while that of the non-green portfolio is 18.36%. From 2004 to 2008, the annualized mean return of the green portfolio is 6.03%, which is only slightly lower than that of the non-green portfolio. A comparison of the Sharpe ratios between the two portfolios also brings us to the same conclusion: the green portfolio outperforms the non-green portfolio in all but periods 9 and 11. In particular, from 2002 to 2006, the Sharpe ratio of the green portfolio is .82, while that of the non-green portfolio is as high as 1.03; from 2004 to 2008, the Sharpe ratio of the green portfolio is .13, which is slightly lower than that (.17) of the non-green portfolio. An equally weighted portfolio is constructed by assigning even weight to all stocks in the portfolio (Figure 3). The rolling performance periods each have a span of five years and they roll over annually. Therefore, there exist 13 rolling performance periods from 1994 to 2010. Period "1" represents "1994–1998," for instance, period "2" represents "1995–1999," . . . and period "13" represents "2006–2010." Both expected return and Sharpe ratio have been annualized; that is, *annual return = 252 × daily return, and annual Sharpe ratio = 252 × daily Sharpe ratio*.

Figure 3: Comparing Performance of Equally-Weighted Green and Non-green Portfolios



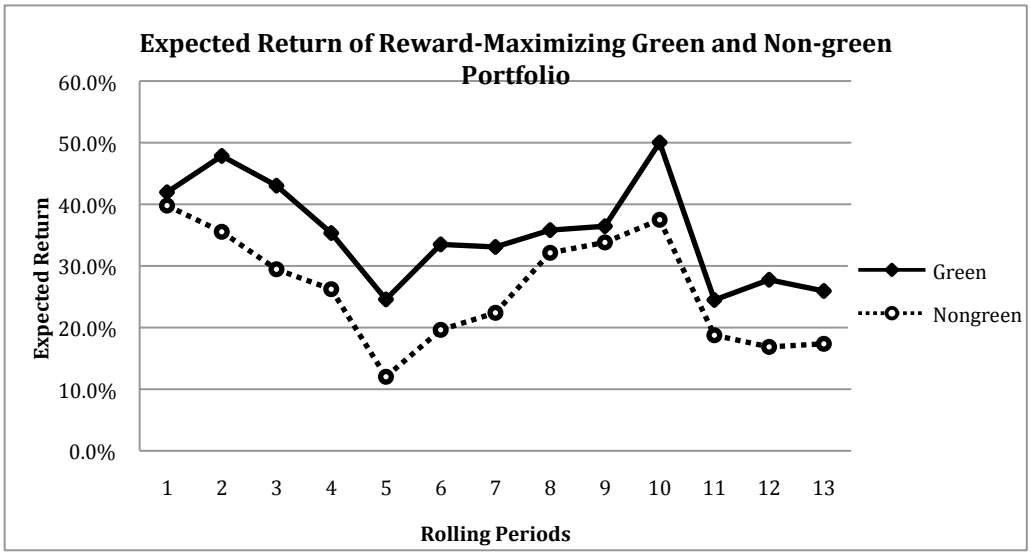
Source: The authors.

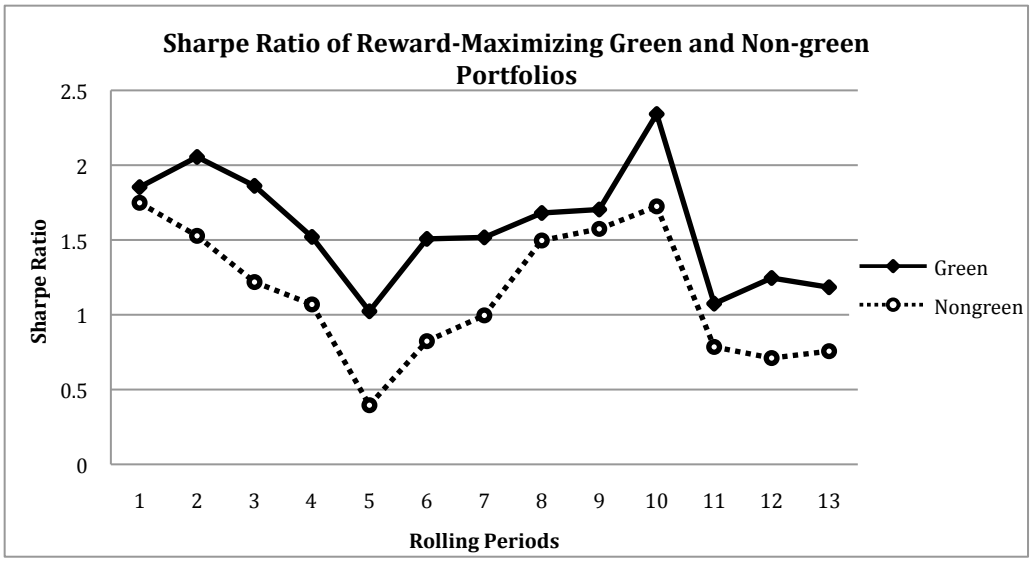
Reward-Maximizing Portfolios

A reward-maximizing portfolio is assembled by maximizing the expected portfolio return at a given volatility (or risk tolerance). In this research, we set the upper limit of the annualized volatility to be 20% for both the green portfolio and the non-green portfolio (The preset annualized volatility (20%) is a random positive number. We can draw the same conclusion by setting different numbers for the volatility due to the property of

comparative analysis). By comparing the performance of the reward-maximizing green portfolio with that of the reward-maximizing non-green portfolio, we find that the green portfolio distinctly performs better than the non-green portfolio in any of the 13 performance periods. The outperformance of the green portfolio over its counterparty, with respect to both expected return and Sharpe ratio, is remarkably significant over all the rolling performance periods (Figure 4). The rolling performance periods each have a span of five years and they roll over annually. Therefore, there exist 13 rolling performance periods from 1994 to 2010. Period "1" represents "1994–1998," for instance, period "2" represents "1995–1999," . . . and period "13" represents "2006–2010." Both expected return and Sharpe ratio have been annualized. i.e., *annual return = 252 × daily return*, and *annual Sharpe ratio = 252 × daily Sharpe ratio.*

Figure 4: Comparing Performance of Reward-Maximizing Green and Non-green Portfolios





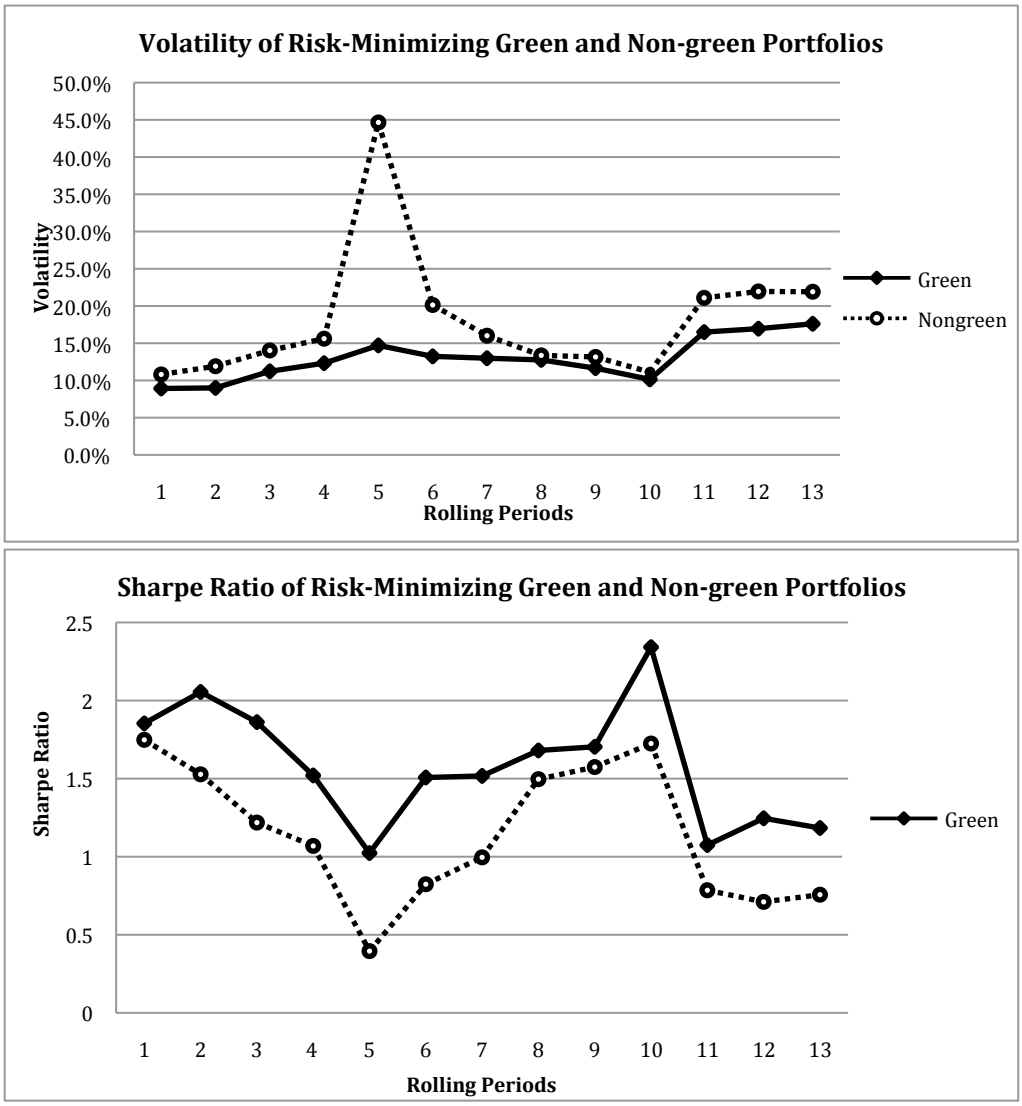
Source: the authors.

Risk-Minimizing Portfolios

A risk-minimizing portfolio is constructed by minimizing the risk the portfolio is subject to at a given required rate of return. For simplicity, we set the annualized required rate of return to be 20% for both the green portfolio and the non-green portfolio. (The preset annualized rate of return (20%) is also a random positive number. Refer to the previous section on reward-maximizing portfolios.) The rolling performance periods each have a span of five years and they roll over annually. Therefore, there exist 13 rolling performance periods from 1994 to 2010. Period "1" represents "1994–1998," for instance, period "2" represents "1995–1999,"…, and period "13" represents "2006–2010." Both volatility and Sharpe ratio have been annualized, i.e., *annual volatility = 252 × daily volatility* and *annual Sharpe ratio = 252 × Sharpe ratio.* By contrasting the performance of the risk-minimizing green portfolio with that of the risk-minimizing non-green portfolio, we find that the green portfolio significantly outperforms the non-green portfolio in respect to Sharpe ratio in any of the 13 five-year rolling performance periods. The two portfolios turn out to enjoy the same expected return, which is constant at 20% throughout the 13 performance periods, due to the settings for the optimization. Rather than compare the expected return, therefore, we compare the volatility of the returns of the two portfolios. The volatility of the non-green portfolio is remarkably higher than that of the green portfolio, especially during the fifth rolling period (1998–2002), implying that in order to achieve the same rate of reward, the non-green portfolio has to assume higher

total risk, which includes market risk and specific risk, than the green portfolio (Figure 5). In other words, the green portfolio outdoes the non-green portfolio and therefore is a better investment choice.

Figure 5: Comparing Performance of Risk-Minimizing Green and Non-green Portfolios



Source: The authors.

Conclusion and Future Work

The study compares the financial performance of two actively managed portfolios: a green portfolio and a non-green portfolio. The portfolios are actively managed because the portfolio manager refreshes the stocks and their loadings in each portfolio annually. We

came up with definitions and criteria for selecting stocks and assembling portfolios, that is, we selected only stocks pertaining to a category, green or non-green, for three successive years (a screening window). We then built a green portfolio with the selected green stocks and a non-green portfolio with the selected non-green stocks. After portfolios were formed, we next examined the performance of the two portfolios in the following five years. In following this technique, investment managers can actively manage portfolios by rebalancing them once a year, a frequency in correspondence with that of KLD releasing new social ratings. The rebalancing starts from 1994 because KLD starts issuing social ratings from 1991 and we need to observe the environmental ratings for a stock for three successive years (1991, 1992, and 1993) before it is selected. The rebalancing occurs each year after 1994 and ends in 2006. We have to reserve 5 years (2006–2010) of historical data for examining the performance of the portfolios after the last rebalancing. The two portfolios, therefore, are rebalanced for 13 times based on the historical data.

After contrasting the performance of the two portfolios in each of the 13 rolling performance periods, we conclude that the green portfolio overwhelmingly outperforms the non-green portfolio in terms of expected return and the Sharpe ratio. The Sharpe ratio adjusts for risk and is a risk-adjusted performance measure, as does the mean-variance optimization methodology. The green portfolio's outstanding performance, therefore, is robust to biases in selecting performance measures. We also unveil that the green portfolio is subject to lower risk than the non-green portfolio when their yields are parallel. The better performance of the green portfolio might be interpreted by the fact that investors are becoming increasingly environment-conscious, thus reinforcing their investment in green companies. Another possible reason is that going green helps a company to build up a good image, which attracts new customers. It is also possible that a green company may face more profitable investment opportunities, such as opportunities in solar power.

In sum, in a medium or long run, green stocks outperform non-green stocks. The difference in the stocks' financial performance may be explained by the difference in the companies' involvement in environment-friendly activities. Particularly, the more a company participates in environment-friendly activities, the more lucrative and stable its stock will be in the future.

Our findings are currently based upon five-year returns data, thus reflecting only the long-term benefits in green investing. In the future, returns for shorter terms, such as a two-year horizon, will also be examined to reveal a richer picture of the relations between a company's involvements in "green" activities and its future financial performance. In addition to expected returns and the Sharpe ratio, more performance measures will be

incorporated into our future research. We will double check the soundness of the screening criteria defined in this paper by selecting current stocks and checking their performance up until five years into the future. In addition to historical data, we are also considering simulating stock returns and using them to test the reasonableness of this green investing strategy, which may also be applied to forecasting the reward and risk in green investing.

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