Cleaning a Passive Index

How to use portfolio optimization to satisfy CSR constraints.

Moshe A. Milevsky, Andrew Aziz, Allen Goss, Jane (Thomson) Comeault, and David Wheeler

Moshe A. Milevsky
is an associate professor at the Schulich School of Business of York University and executive director of the IFID Centre in Toronto, Canada.
milevsky@yorku.ca.

Andrew Aziz
is a vice president of Algorithmics Incorporated in Toronto.
andrew@algorithmics.com

Allen Goss
is a doctoral candidate at the Schulich School of Business of York University.
agoss@sympatico.ca

Jane (Thomson) Comeault
is a research fellow at York University's Institute for Research and Innovation in Sustainability.
janethom@yorku.ca

David Wheeler
is the Erivan K. Haub chair in Business and Sustainability at the Schulich School of Business.
dwheeler@schulich.yorku.ca

Most pension funds and institutional investors in North America use some form of passive or indexed management, at least with some fraction of their assets under management. Funds thus own hundreds and perhaps even thousands of individual stocks of publicly traded companies scattered around the globe, all in the name of portfolio diversification. And, while holding the market via index funds is consistent with efficient markets theory, it is becoming increasingly problematic as pension fund and endowment managers face growing pressure to monitor or even divest themselves of companies that do not maintain a minimal level of corporate social responsibility (CSR).

The increased scrutiny of stakeholders regarding the non-financial aspects of corporate performance has forced portfolio managers to weigh the benefits of holding the market against the cost of holding even token positions in companies that are subsequently found to have questionable business practices. We examine this cost-benefit analysis.

Unlike an individual investor, institutional portfolio managers cannot offset the costs of implementing a CSR screen by some non-pecuniary utility. For individual investors the possible costs of investing in socially responsible firms may be offset by the psychological benefits of this choice.

Professional fund managers, however, must always ask whether the reputational and economic risk of total index replication is worth bearing for a few extra basis points of return. The common response from most (although not all) investment professionals facing a fiduciary duty that does not typically recognize non-financial benefits is that 1) any constraints imposed on the investment and portfolio selection process must inevitably constrain risk-adjusted performance, and 2) CSR screens—both positive and negative—are inherently subjective, intrinsically unquantifiable, and subject to manipulation by politically motivated interest groups. It is not surprising, therefore, to see continued resistance to CSR screening in the portfolio management industry.

Yet there is still evidence of pressure on pension fund managers to adopt CSR screens. Leading European institutional investors including Universities Superannuation Scheme (USS); PGGM, the Dutch pension fund; BNP Paribas Asset Management; RCM, part of Allianz Dresdner Asset Management; and the boutique Generation Investment Management are spearheading an initiative to integrate non-traditional issues of corporate performance more fully into mainstream analysis. Mercer Investment Consulting has begun rating investment managers on their ability to incorporate CSR factors into decisions, and last year also saw the announcement of major CSR initiatives by both General Electric and WalMart.

The growing consensus in the literature is that CSR screens and constraints do not negatively affect investment returns. Stone et al. [2002] construct risk-adjusted screened and unscreened portfolios and find no significant differences in performance over the 1984-1997 time period. Hamilton, Jo, and Statman [1993], Guerard [1997], Goldreyer, Ahmed, and Diltz [1999], and Bauer, Koedijk, and Otten [2005] provide similar evidence. Geczy, Stambaugh, and Levin [2003] do find screening has the potential to impose significant penalties, conditional on the beliefs of the investor about the ability of the fund manager to outperform the market through active management.

Perhaps equally important to passive index investors is tracking error. Sector biases pose a significant concern for index investors, because any divergence from the target index represents a tracking error. Statman [2000] finds in this regard that the Domini Social Index outperforms the S&P 500 over the 1990-1998 period.[1] DiBartolomeo and Kurtz [1999] demonstrate that such a result is largely due to economic and sector exposures that are the result of the screening process itself.

We are agnostic about the subsequent performance of companies conditional on their CSR scores. Rather, we address the question from the perspective of a practitioner attempting to balance seemingly competing objectives.

We show how a pension fund or endowment can maintain a statistically indistinguishable level of diversification while incorporating CSR-based screens and constraints on portfolio holdings. We address how best to redeploy funds that are freed by divesting positions in companies with poor CSR attributes—while staying as close to the index as possible.

From a financial economics perspective, can one *reasonably replicate* or span the stochastic distribution of a given portfolio, using a restricted universe of tradable instruments? In a purely efficient market with no transaction costs, the theoretical answer is no, but it remains an open question as to whether one can get close enough to be properly diversified for all practical (empirical) purposes.

We use a portfolio replicating algorithm that effectively mimics the ex-post distribution of investment outcomes as defined by a set of scenarios within a smaller constrained set of securities. Thus, the algorithm is able to locate the appropriate portfolio weights among a restricted group of companies to best replicate the payoff from an unrestricted target portfolio. The algorithm minimizes the expected tracking error (two-sided or one-sided) between the optimal constrained portfolio and the original unconstrained portfolio, subject to the trading restrictions that define the constrained portfolio.

As an illustration, we subject the 60 companies in the S&P/TSX 60 index to a CSR screen based on an employment practices scoring system constructed by Thomson and Wheeler [2004]. The S&P/TSX 60 index is the large-capitalization component of a series of S&P Canadian indexes, including the S&P/TSX Composite, the leading benchmark for Canada. It is market cap-weighted, with weights adjusted for available share float, and is balanced across ten economic sectors. Offering exposure to 60 large liquid Canadian companies, the S&P/TSX 60 is the Canadian component of the S&P Global 1200 index.

We begin by calculating the first four moments of the return distribution of the S&P/TSX 60 index from September 4, 2001, through July 5, 2004. Using this as a baseline, we then restrict the universe of tradable equities by progressively eliminating companies from the S&P/TSX 60 using the Thomson-Wheeler scoring system. (Hereafter, we refer to the Thomson-Wheeler employment practices score simply as the *CSR score.*) We then use the optimization algorithm to overweight the remaining firms in the portfolio in an attempt to mimic the moments of the unconstrained portfolio.

While we illustrate the portfolio cleaning procedure on the S&P/TSX 60, the methodology is applicable to a wide variety of screens and indexes, and our results do not depend on the index or the screen chosen. The choice of the S&P/TSX index is purely one of convenience.

Our results are encouraging for those who want to implement CSR constraints and maintain a comparable level of diversification. Notwithstanding the narrowness of our target portfolio (60 stocks), or the depth of the screening (up to 20 stocks), we find that removing companies with the lowest CSR scores does not *materially* impact any of the first four moments of the investment return distribution, providing the funds released by divesting from the low-scoring companies are properly redistributed among the remaining stocks.

Our findings suggest that the costs of CSR screening on passive indexes may be lower than managers might expect, and are consistent with the results in Geczy, Stambaugh, and Levin [2003], who find that for a market index investor the cost of the CSR constraint is typically just a few basis points per month.

We also show how to rebalance a screened passive portfolio in an optimal manner when low-scoring companies are removed. The key to maintaining diversification after removing securities is not to continue indexing the remaining stocks, but to reweight those securities so that the "cleaned" portfolio mimics the original target index.

By demonstrating how CSR screening can be operationalized on passive indexes, where the manager is free to define the nature of the screening and the extent to which it is employed, we provide a bridge between the traditional and the socially responsible investment communities.[2]

HOW CSR SCORES ARE DETERMINED

Our optimization methodology is independent of the screening algorithm chosen by the fund manager. While our results do not depend on the employment practices screen we use, we first briefly describe the motivation behind it.

In a study funded by the Canadian Social Sciences and Humanities Research Council, Thomson and Wheeler [2004] hypothesize that of all potential measures of corporate social performance, those that measure labor and employment practices are likely to be especially salient to firm performance and risk minimization. This conclusion follows from an examination of a large number of sources relating firm performance and the generation of competitive advantage through the leveraging of intangible assets such as human, intellectual, and social capital (see, for example, Nahapiet and Ghoshal [1998] and Dess and Picken [1999]).

Thomson and Wheeler [2004] build on the resource-based view of strategic management and evidence of the growing importance of intangible assets to firm performance to establish a candidate set of investment criteria that can be applied to a basket of financial instruments (see Barney [1991]).

The methods for establishing candidate investment criteria are drawn from three principal sources: 1) academic and practitioner/applied literature describing studies of corporate social performance linked to financial performance; 2) relevant employment practice criteria currently in use by analysts; and 3) direct interviews with people knowledgeable about labor and employment practices in Canada and the United Kingdom.[3]

From an initial list of 45 candidate criteria, a final list of 14 employment practice metrics is identified. Following Wheeler, Colbert, and Freeman [2003], the conditions for inclusion in the final set are: 1) objective measurability; 2) comparability; 3) accessibility; 4) materiality; 5) significance; and 6) likely win-win impact on value creation for investors and other stakeholders (e.g., employees).[4]

The 14 indicators are listed in Exhibit 1 with the aggregate score on each indicator that forms the CSR score used in the optimization algorithm. Scores for the constituents of the S&P/TSX 60 index are shown in Exhibit 2. Scores range from a low of 9 to a high of 82; the median is 60.5. There is no evidence of sectoral bias; high- and low-scoring companies are evenly dispersed among the ten sectors of the S&P/TSX.[5]

OPTIMIZATION ALGORITHM

The optimization process begins with the assumption that the portfolio manager wishes to use the screen to identify and remove firms with low CSR scores because they may be potential attractors of real or perceived risk. The actual optimization algorithm is constructed by first defining the tracking error, y_s, as the difference between the value of a portfolio and the value of the target index under a given historical scenario s ($s = 1, \ldots, S$), for a given time horizon, or:

$$y_s = \sum_j x_j Q_{js} - I_s \tag{1}$$

Exhibit 1
Measurement Criteria for Employment Practices CSR Score

Dimension	Maximum Score
Board Composition, Skills and Diversity	9 points allocated between 4 sub-criteria
Health and Safety Record	4 points allocated between 2 sub-criteria
Health and Safety Culture	10 points allocated between 5 sub-criteria
Public Reputation as Good Employer	9 points allocated between 9 sub-criteria
Community Investment	6 points allocated between 2 sub-criteria
Employee Attitude Survey	6 points allocated between 3 sub-criteria
Employee Retention	3 points allocated to one criterion
Work/ Life Balance	5 points allocated between 5 sub-criteria
Performance Based Compensation	10 points allocated to one criterion
Pension Plan	6 points allocated to one criterion
Training	6 points allocated to one criterion
Employment Practice and Other Policies	12 points allocated between 6 sub-criteria
Convictions and Fines	8 points allocated between 4 sub-criteria
Freedom of Association	6 points allocated to one criterion

Each firm is measured across 14 dimensions. All information used in the measurement of each criterion comes from publicly available sources (web sites, reports, and accounts). The maximum allocation of scores (a total of 100) is denoted together with the number of subcriteria measured.

where Q_{js} is the value of security j under scenario s, x_j is the holdings of security j ($j = 1, \ldots, J$) in the portfolio, and I_s is the value of the target index under scenario s. I_0 and Q_{j0} denote the current values of the target index and each security, respectively.

The target index includes the 60 constituent firms in the S&P/TSX 60. The relative weights of each position match the weights of the S&P/TSX 60 on July 5, 2004, as reported by TSX Datalinx. We then rank the constituents of the S&P/TSX 60 by CSR score, and create new portfolios by successively removing the two stocks with the lowest CSR score. The first cleaned portfolio will therefore have 58 stocks, and the next 56.

We continue the process recursively until we create ten portfolios, each one with two fewer stocks than its predecessor. The sequential removal of stocks generates portfolios ranging from 40 to 58 stocks, which we label in Exhibit 2 as TSX40 to TSX58.[6]

We create this range of portfolios for two reasons. First, we want to test the ability of the algorithm to create portfolios that mimic the return distribution of the target index, in order to examine the trade-off between the use of screens and return distributions. The second reason is simply that we do not wish to make normative judgments about how extensive screening should be. Whether removing 2 stocks from the index or removing 12 stocks is either sufficient or necessary is a judgment that the stakeholders of the fund must make. Our aim is simply to illustrate how to undertake the process.

In order to perform the optimization, we define the regret function R as the expectation of the absolute value of tracking error across all scenarios, or:

$$R = \sum_S p_s \mid y_s \mid \tag{2}$$

where p_s is the probability of occurrence of scenario s. The scenarios used in the algorithm are the historical two-week returns for the S&P/TSX 60 calculated over the three years preceding the optimization date. These form the universe of possible returns for the new portfolios.

Implicit in this framework is the assumption that the returns over the three-year horizon are representative of returns in the period to optimize. We should emphasize again that our model and analysis is predicated on the assumption that future returns obey the same statistical generating process as historical returns.

It is worth noting that the historical returns are used for more than generating portfolio variance-covariance matrices. Our approach is not constrained by the assumption of joint-normality of the variance-covariance matrix, and, while our portfolios do not hold derivative instruments, it can also handle the non-linearities of the more general case if the underlying index were to include derivatives.[7]

The optimization problem is cast as a linear program whose primary decision variables are the holdings x_j in each security, and whose the objective function is a minimization of the regret function subject to a number of constraints including maximum portfolio investment, individual and group trading limits, and tracking error bounds. We define the target index to be the original *unscreened* index, where X_j is the original holdings of secu-

Exhibit 2
CSR Scores and Relative Weights for Cleaned Index

Name	Ticker	CSR Score	TSX 60	TSX 58	TSX 56	TSX 54	TSX 52	TSX 50	TSX 48	TSX 46	TSX 44	TSX 42	TSX 40
Biovail	BVF	9	0.64%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Teck Cominco	TEK.B	42	0.72%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Royal Group Tech.	RYG	45	0.15%	0.15%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Telus	T	45	1.10%	1.13%	0%	0%	0%	0%	0%	0%	0%	0%	0%
CAE	CAE	46	0.24%	0.24%	0.24%	0%	0%	0%	0%	0%	0%	0%	0%
Celestica	CLS	46	0.74%	0.74%	0.79%	0%	0%	0%	0%	0%	0%	0%	0%
Royal Bank	RY	46	6.28%	6.28%	6.28%	6.28%	0%	0%	0%	0%	0%	0%	0%
Thomson Corp	TOC	46	1.49%	1.49%	1.59%	1.49%	0%	0%	0%	0%	0%	0%	0%
CP Ships	TEU	47	0.34%	0.34%	0.51%	0.87%	1.24%	0%	0%	0%	0%	0%	0%
Domtar	DTC	48	0.65%	0.65%	0.65%	0.87%	0.65%	0%	0%	0%	0%	0%	0%
Imperial Oil	IMO	48	1.11%	1.11%	1.11%	1.11%	1.11%	1.11%	0%	0%	0%	0%	0%
Rogers Comm.	RCI.B	48	0.72%	0.76%	1.09%	1.20%	1.27%	0.72%	0%	0%	0%	0%	0%
TransCanada Corp	TRP	48	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	0%	0%	0%	0%
EnCana	ECA	49	4.27%	4.27%	4.27%	4.27%	4.27%	4.27%	4.27%	0%	0%	0%	0%
George Weston	WN	49	0.73%	0.76%	0.73%	0.73%	0.95%	0.73%	0.73%	0.73%	0%	0%	0%
Manulife Fin'l	MFC	49	7.10%	7.19%	7.10%	7.10%	7.12%	7.10%	7.57%	7.10%	0%	0%	0%
Fairmont Hotels	FHR	50	0.47%	0.47%	0.47%	0.47%	0.47%	0.47%	0.54%	1.06%	0.62%	0%	0%
NOVA Chemicals	NCX	50	0.54%	0.54%	0.54%	0.54%	0.54%	0.54%	0.54%	0.54%	0.54%	0%	0%
Petro-Canada	PCA	50	2.48%	2.57%	2.48%	2.48%	2.48%	2.84%	3.08%	3.55%	4.73%	4.56%	0%
T-D Bank	TD	50	4.64%	4.64%	4.64%	4.64%	4.97%	5.94%	6.06%	6.85%	5.53%	5.34%	0%
Potash Corp	POT	51	1.13%	1.13%	1.13%	1.13%	1.13%	1.13%	1.13%	1.13%	2.28%	2.53%	1.13%
Suncor	SU	51	2.49%	2.49%	2.49%	2.49%	2.49%	2.49%	2.49%	2.49%	2.49%	2.49%	2.49%
Nortel Networks	NT	52	4.06%	4.07%	4.06%	4.16%	4.10%	4.06%	4.06%	4.17%	4.06%	4.06%	4.23%
Barrick Gold	ABX	55	2.28%	2.28%	2.28%	2.28%	2.28%	2.28%	2.28%	2.28%	2.28%	2.28%	2.30%
MDS	MDS	55	0.47%	0.47%	0.47%	0.47%	1.15%	0.67%	0.47%	0.87%	1.54%	1.16%	1.73%
Bank of Montreal	BMO	57	4.33%	4.33%	4.33%	4.33%	5.34%	4.33%	4.33%	4.33%	4.33%	4.81%	5.94%
Enbridge	ENB	57	1.39%	1.39%	1.39%	1.39%	1.39%	1.39%	1.39%	2.86%	2.04%	2.28%	1.39%
Alcan	AL	59	3.27%	3.48%	3.41%	3.27%	3.30%	3.70%	3.56%	3.89%	3.66%	4.11%	4.41%
Placer Dome	PDG	59	1.51%	1.51%	1.51%	1.51%	1.94%	1.54%	1.63%	1.51%	1.51%	1.51%	1.51%
Bank of Nova Scotia	BNS	60	5.84%	5.84%	5.84%	5.84%	5.84%	5.84%	5.84%	5.84%	7.10%	7.54%	10.06%
Abitibi	A	61	0.65%	0.65%	0.65%	0.65%	0.65%	0.65%	0.65%	0.65%	0.65%	0.65%	0.65%
Agrium	AGU	61	0.41%	0.41%	0.41%	0.41%	0.41%	0.51%	0.84%	0.41%	0.41%	0.41%	0.41%
Cameco	CCO	61	0.71%	0.98%	0.71%	0.71%	0.71%	0.71%	0.71%	0.71%	0.71%	0.71%	0.71%
CIBC	CM	62	3.77%	3.77%	3.77%	3.77%	3.77%	3.77%	3.77%	3.77%	3.77%	3.77%	5.53%
Kinross Gold	K	62	0.42%	0.42%	0.42%	0.42%	0.42%	0.49%	0.42%	0.74%	1.03%	1.04%	0.87%
Loblaw Co.	L	62	1.00%	1.00%	1.00%	1.00%	1.00%	1.04%	1.00%	1.00%	1.32%	1.00%	1.10%
Cognos	CSN	66	0.69%	0.91%	0.69%	0.74%	1.13%	1.29%	1.32%	0.94%	1.30%	1.52%	1.94%
ATI Technologies	ATY	67	0.97%	1.00%	1.13%	1.44%	1.33%	1.74%	1.69%	1.34%	1.18%	1.24%	1.55%
TransAlta	TA	69	0.52%	0.52%	0.57%	0.53%	1.05%	1.82%	2.27%	1.72%	0.52%	0.98%	1.48%
Canadian Natural Resources	CNQ	69	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%	3.43%	1.75%	1.75%	1.75%
Molson	MOL.A	69	0.62%	0.62%	0.62%	0.62%	0.62%	0.66%	0.62%	0.62%	1.38%	1.14%	1.43%
Nexen	NXY	69	1.09%	1.09%	1.09%	1.09%	1.09%	1.09%	1.09%	1.09%	1.09%	1.09%	1.09%
Precision Drilling	PD	69	0.58%	0.62%	0.65%	0.58%	1.33%	1.74%	1.88%	2.86%	1.65%	1.82%	2.51%
Brascan	BNN.A	70	1.32%	1.32%	1.32%	1.32%	1.32%	1.32%	1.32%	1.32%	1.32%	1.32%	1.32%
Cott	BCB	70	0.50%	0.51%	0.56%	0.50%	0.81%	0.50%	0.55%	0.87%	1.15%	1.22%	1.97%
Inco	N	70	1.39%	1.39%	1.39%	1.39%	1.39%	1.39%	1.39%	1.39%	1.39%	1.39%	1.39%
Shaw Comm.	SJR.B	70	0.81%	0.81%	0.81%	0.81%	1.27%	0.81%	1.52%	0.81%	0.81%	0.81%	0.81%
Bombardier	BBD.B	71	0.93%	0.93%	0.93%	0.93%	0.93%	0.93%	0.93%	0.93%	1.15%	1.17%	1.29%
CNR	CNR	71	2.68%	2.68%	2.68%	2.68%	2.68%	2.85%	2.68%	2.73%	3.34%	3.29%	3.18%
CPR	CP	71	0.84%	0.84%	0.84%	0.84%	0.84%	0.84%	0.84%	0.84%	0.84%	0.84%	0.84%
Magna	MG.A	71	1.74%	1.74%	1.74%	1.74%	1.74%	1.74%	1.74%	1.74%	3.51%	3.61%	1.74%
National Bank	NA	71	1.18%	1.18%	1.18%	1.18%	2.27%	2.65%	2.23%	2.69%	3.68%	3.39%	2.56%
Sun Life Fin'l	SLF	71	3.78%	3.78%	3.78%	3.98%	4.77%	4.66%	4.85%	5.30%	10.65%	9.94%	9.13%
BCE	BCE	72	4.00%	4.00%	4.56%	4.24%	4.69%	4.85%	4.40%	6.73%	5.65%	5.87%	7.96%
Dofasco	DFS	72	0.48%	0.65%	0.95%	0.87%	0.72%	1.21%	1.25%	1.53%	0.71%	0.80%	2.44%
Talisman	TLM	72	1.80%	1.80%	1.80%	1.80%	1.80%	1.80%	1.80%	1.80%	2.80%	3.11%	3.96%
Canadian Tire	CTR.A	73	0.61%	0.61%	0.67%	0.87%	1.30%	1.94%	1.94%	0.97%	1.50%	1.67%	2.67%
Husky Energy	HSE	73	0.52%	0.55%	0.52%	0.52%	0.60%	0.74%	1.31%	0.82%	0.82%	0.52%	0.52%
Quebecor World	IQW	73	0.40%	0.49%	0.75%	1.01%	0.88%	0.68%	0.60%	0.40%	0.54%	0.62%	0.83%
Noranda	NRD	82	0.64%	0.64%	0.64%	0.64%	0.64%	0.64%	0.64%	0.64%	0.64%	0.64%	1.13%

rity j, so the current value of the target index can be expressed as:

$$I_0 = \sum_J X_j Q_{j0} \tag{3}$$

and the values of the target index under all scenarios $s = 1, \ldots, S$ can be expressed as:

$$I_s = \sum_J X_j Q_{js} \tag{4}$$

As each new portfolio is formed, the algorithm forces the weight of the two discarded stocks to zero and redistributes that mass among the remaining stocks in the index. The investment weights chosen by the algorithm represent the asset allocations that produce the least tracking error between the portfolio and the S&P/TSX 60 target index. We rank the securities $j = 1, \ldots, J$ on the basis of increasing CSR score and, for each formulation, determine the number of offending securities J^* (starting with $J^* = 2$ and increasing in increments of 2 until $J^* = 20$).

The linear program is expressed as follows:

$$\text{Minimize: } R = \sum_S p_s \cdot |y_s| \tag{5}$$

$$\text{Subject to: } \sum_J x_j \cdot Q_{j0} \leq \sum_J X_j \cdot Q_{j0}$$

$$y_s = \sum_J x_j Q_{js} - I_s$$

$$x_j = 0 \text{ for } j = 1, \ldots, J^*$$

$$x_j \geq X_j \text{ for } j = J^*+1, \ldots, J$$

where p_s is equal across all scenarios.

The first constraint limits portfolio investment in any of the constrained alternatives to be no higher than the amount invested in the original index. The second constraint defines the tracking error variable. The third constraint forces the weighting for any stock removed from the index to be equal to zero. The rebalancing process is further constrained by not allowing short-selling or the selling of any position, except those that are identified as poor performers by the CSR screen. The final constraint forces weightings for any stock remaining in the new portfolio to be at least as great as in the original portfolio.

The net effect is to replicate initiation of a portfolio manager's CSR screen on a passive index portfolio. The stocks failing the screen are sold, and the funds are reallocated to the remaining constituents in the portfolio. The only positions sold at any time are the stocks that are completely eliminated; all other transactions are buys only. Finally, we assume no transaction costs in the reported results.

Running the algorithm yields portfolio weights for the S&P/TSX 60 and the ten constrained portfolios as shown in Exhibit 2.

RESULTS AND ANALYSIS

In order to understand the trade-offs inherent in implementing the CSR screens, a tracking error measure is computed as the mean squared error (two-sided) between the expected return distribution of the S&P/TSX 60 and the distribution of the constrained portfolio. Because the tracking error is relatively low, it is reported as deviations from the true index value of 469.28 on July 5, 2004, the optimization experiment date. Hence, the expected tracking error of the TSX 60 is 0, while the TSX 58 has an average squared error of less than 0.08 points.

As expected, the tracking error rises as stocks are removed, but errors remain exceedingly low. Mean absolute deviation never exceeds 0.87 points, and the maximum absolute deviation is 6.79 points when 16 stocks are removed from the index. Results are given in Exhibit 3.

We are encouraged by the ability of the algorithm to track the index (on average) to within a single point of its true value of 469.28. Perhaps of equal importance, however, is an analysis of how the reported tracking errors impact the return distributions of the constrained portfolios. Obviously, the index tracking error is relevant only to the extent that it changes the risk/return distribution of the constrained portfolios.

We begin by calculating the two-week returns (r_s) across all scenarios for the target as well as each constrained portfolio. We evaluate the change in the risk/return distribution by measuring the first four moments of the target and of the constrained portfolios.

The first moment, the sample mean, is defined as:

$$\frac{1}{S}\sum r_s \tag{6}$$

The sample standard deviation is defined as:

$$\sqrt{\frac{S\sum r_s^2 - \left(\sum r_s\right)^2}{S(S-1)}} \tag{7}$$

The skewness of the distribution is computed as:

$$\frac{S}{(S-1)(S-2)}\sum\left(\frac{r_s-\bar{r}}{d}\right)^3 \tag{8}$$

where d is the sample standard deviation computed in (7).

The kurtosis is defined as:

$$\left\{\frac{S(S+1)}{(S-1)(S-2)(S-3)}\sum\left(\frac{r_s-\bar{r}}{d}\right)^4\right\}-\frac{3(S-1)^2}{(S-2)(S-3)} \tag{9}$$

where d is similarly defined.

The resulting statistics characterize the return distribution for the unconstrained portfolio and the cleaned portfolios. Along with the tracking error, these four moments of the return distribution form the basis for evaluating the trade-offs inherent in incorporating the CSR screen. The narrower the gap between the two sets of moments, the lower the cost of imposing the CSR constraints.

Our results suggest that the cost of cleaning a passive index may be less than fund managers and trustees might expect. While the maximum loss of return comes when 12 stocks are removed (49 basis points), there are also several restricted portfolios with higher expected returns than the fully indexed portfolio.

Examining the moments of the return distribution in Exhibit 4 yields a similar story. The restricted portfolio has the same shape as the unconstrained index. There is no appreciable change in skewness or kurtosis.

As we examine the weighting of the stocks in the cleaned indexes, it is apparent that the algorithm is searching for the stocks most closely correlated to the stocks being removed, and then overweighting them. Note that the extra mass—i.e., the proceeds of selling the low-scoring CSR companies—is not spread evenly among the remaining stocks. This is an appealing result because it suggests that the transition costs of implementation need not be onerous.

Moving from the unscreened 60-stock portfolio to the 58-stock portfolio, the sale proceeds of the two deleted stocks are not redistributed among the universe of the 58 remaining stocks, but to only 15 of the remaining 58. The most rebalancing transactions occur in the 44-stock portfolio, where the rebalancing requires additions to 26 posi-

Exhibit 3

Expected Return and Standard Deviation of Cleaned Index

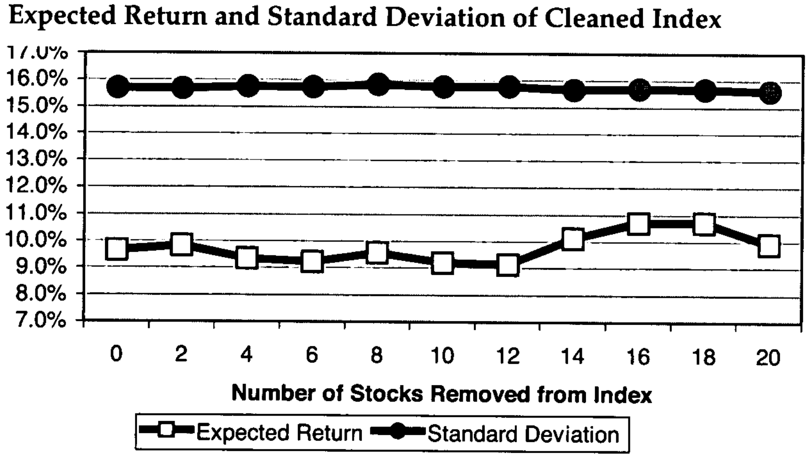

Exhibit 4

Portfolio Moments and Tracking Error of Cleaned Index

Stocks Removed	0	2	4	6	8	10	12	14	16	18	20
Return (%)	9.65	9.85	9.36	9.23	9.66	9.22	9.16	10.13	10.70	10.70	9.92
Standard Deviation (%)	15.69	15.68	15.77	15.74	15.83	15.76	15.79	15.66	15.70	15.70	15.63
Skewness	−0.936	−0.933	−0.918	−0.956	−0.945	−0.960	−0.943	−0.954	−0.946	−0.918	−0.922
Kurtosis	2.522	2.534	2.457	2.635	2.549	2.499	2.448	2.543	2.634	2.544	2.643
Mean Squared Error	0	0.078	0.233	0.355	0.584	0.677	0.706	0.881	1.686	1.565	2.392
Mean Absolute Deviation	0	0.19	0.31	0.42	0.50	0.54	0.53	0.61	0.71	0.69	0.88
Maximum Deviation	0	0.93	1.74	1.80	2.50	2.35	2.56	3.43	6.79	6.75	5.77
Rebalancing Transactions	0	17	17	18	31	32	32	35	42	43	45

tions. Obviously, the total number of buy/sell transactions is an increasing function of the number of stocks removed.

CONCLUSION

Our research illustrates how a pension fund or endowment can maintain a statistically indistinguishable level of diversification while incorporating CSR screens on portfolio holdings. Through the use of a simple and flexible optimization algorithm, we also address the question of how best to redeploy funds that are freed by divesting positions in companies that fail CSR screens.

The exercise yields two main insights. First, our findings are consistent with other research that finds CSR screening—with proper investment realignment—has a minimal impact on returns to investors holding the market portfolio. Yet instead of viewing the problem through the prism of active portfolio management and testing for evidence of abnormal return performance, we ask whether pension fund managers can simultaneously meet stakeholder demands for socially responsible investment while remaining indexed.

Our results show how fiduciaries and managers should be able to eliminate undesirable companies—using a replication algorithm to find statistical substitutes—and not risk violating their fiduciary responsibilities. Managers can then be viewed as taking a proactive role in value maximization and risk reduction without sacrificing risk-adjusted performance.

Our second contribution is to explicitly identify the optimal weights for the stocks that remain in a screened portfolio. While sectoral bias is not an issue in the Thomson-Wheeler screen that we use, it is often present in other screened indexes that may exclude entire industries. The algorithm can be used to weight the constituents of a portfolio optimally to mitigate the sectoral biases caused by exclusionary screening that often plague socially responsible portfolios.

So-called ethical portfolio construction is becoming increasingly important to fund managers as stakeholders press them to consider non-financial aspects of performance in portfolio construction. By illustrating how a pension fund or endowment manager—while remaining agnostic about the investment performance of companies with low CSR scores—can maintain a statistically indistinguishable level of diversification but incorporate CSR-based constraints on portfolio holdings, we have attempted to bridge the gap between the traditional financial community and advocates of socially responsible investing.

ENDNOTES

[1]Created by the social research firm of KLD Research & Analytics, the Domini 400 Social Index is a market capitalization-weighted common stock index. It monitors the performance of 400 U.S. corporations that pass multiple broad-based social screens. The index consists of approximately 250 companies included in the Standard & Poor's 500 index; approximately 100 additional large companies not included in the S&P 500 but providing industry representation; and approximately 50 additional companies with particularly strong social characteristics.

[2]The KLD Select Social Index overweights companies with strong social and environmental performance and underweights companies with weaker performance. Investors wishing to use the KLD screen and benchmark to the Russell 1000 index can purchase the associated exchange-traded fund that trades on the New York Stock Exchange.

[3]Margolis and Walsh [2001] review more than 80 CSR studies. Watson Wyatt is just one example of a practitioner organization that has also undertaken empirical research explicitly linking human resource management practices and firm performance (see "Human Capital Index" [2002]).

Sources for employment practice criteria include Michael Jantzi Research Associates, KLD Research & Analytics, Innovest IVA, FTSE4Good, Real Assets, Global Reporting Initiative, Sustainable Asset Management, Dow Jones Group Sustainability Indexes, Ethibel, GrowthWorks Working Opportunities Fund, and AMP Henderson.

A total of 37 interviews were conducted with experts in labor and employment practices: 23 labor representatives, 3 SRI specialists, 3 investment managers, 2 pension fund administrators, 3 consultants, and 3 non-government organizations.

[4]Indicators were discarded if they were determined to be too normatively skewed to any one stakeholder's perspective; that is, if they risked reducing opportunities for win-win value outcomes between the firm and its various stakeholders.

[5]Thomson & Wheeler's CSR score for Biovail is a significant outlier. It reflects, in part, their inability to collect complete data for each subcriterion, potentially leading to an artificially low score.

[6]In order to discriminate between firms with the same CSR score, we use a tie breaking system as follows. When two firms have the same score, the CSR score is calculated using an alternative unreported CSR specification that looks at the best predictors of firm performance among the subcriteria in the CSR. The poorer of the two firms as measured by this score is the next one chosen for removal. If, after recalculating the CSR, there is still a tie, firms are removed in alphabetical order.

[7]For more technical discussion, see Dembo [1991] and Dembo and Rosen [1999].

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