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ESG portfolio optimization: integrating combinatorial goal programming and corporate responsibility ratings

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Abstract

Investment approaches that embrace environmental, sustainability and governance factors (ESG factors) have shown evidence of providing investors with potential long-term investment performance advantages. With global approaches to investing becoming more predominant among various investment professionals, ESG factors provide portfolio managers with a wider view of a company's risk-return profile across systemic relationships. This paper introduces the combinatorial nonlinear multiple objective optimization model (MINLGP) of Dash and Kajiji (2014) to optimize a goal-oriented ESG portfolio based on the Thomson Reuters Corporate Responsibility Ratings. Temporal instability of correlation profiles is also treated by the proposed model. Following similar approaches in the literature, the MINLGP optimized portfolio is rebalanced periodically to incorporate new correlation information. During the interim periods between rebalancing periods, an active real-time futures-based hedging strategy is invoked to stabilize or enhance the desired risk-return outcomes. A temporal simulation of a MINLGP portfolio is undertaken by invoking the investment profile of an affiliate of the global non-profit service organization – World Association of Girl Guides and Girl Scouts (WAGGGS).

Introduction

The worth of a non-profit organization lies in the creation of social and environmental value. Understanding this statement, the Trillium Asset Management Corporation raised the question: *how can a non-profit organization achieve the greatest environmental, social and financial value from its philanthropic resources*? The local non-profit organization, Girl Scouts of South Eastern New England (GSSNE) [For philanthropic details, see: http://www.gssne.org], derives it specific mission from the philanthropic guidelines issued by Girl Scouts of the United States [For USA specific philanthropic details, see: http://www.girlscouts.org/] of America (GSUSA). In turn, GSUSA derives a core part of its mission from the global association: World Association of Girl Guides and Girl Scouts (WAGGGS) [The global philanthropic details of Girl Scouts are found here: http://www.wagggs.org/en/home]. The linkage of USA specific objectives to the long-term value creation assumed under sustainable investment (SI) approaches is evident under the “Teaching Social Responsibility” mission. This mission specifically recognizes “…*a global approach to solving social problems by applying business strategies that ensure long-term results*.” This research seeks to ascertain how the critical discipline expressed by the Girl Scout collective is reduced to a quantifiable diversification process that integrates risk-reward features without solely seeking short-term returns performance. A review of a recent GSSNE investment report presents the following objective: “*The current investment objective of this account is growth with income. This objective is consistent with a goal of emphasis on capital appreciation with moderate consideration toward income*.” Clearly, this summary statement by the investment manager fails to comply with extant methods of stating quantitative goals that are consistent with traditional investment methodologies. But, this actually makes the re-statement of these goals to a SI or socially responsible format easier as the process can begin unencumbered by the past.

Investment approaches that embrace environmental, sustainability and governance factors (ESG factors) have shown evidence of providing investors with potential long-term investment performance advantages. Recent global crises have caused the investment industry to reevaluate its preoccupation with short-term performance at the expense of long-term value. With comprehensive global securities information readily available to an already challenged world economy more investors are refining their portfolio diversification goals to specifically consider the long-term benefits derived by considering environmental and social factors in portfolio diversification. Under the ESG approach, investors express a desire to exhibit either sustainable investment or socially responsible investing. The two are close but are differentiated by the increased emphasis on environmental issues under sustainable investing. SI styles are often characterized by four main criteria which can be identified as: negative screening (e.g., "sin stocks"), best-in-class (ranked on sustainability criteria), sustainability leaders only (highly committed to SI) and, lastly, pioneers only (problem tackling industries). Despite these descriptions, measuring investment outcomes based on an integration of ESG factors into investment research and decision-making is very difficult [For additional discussion, see http://www.sustainableinvesting.net/].

By now it is evident that the investment problem faced by the Girl Scout collective is one that is characterized by multiple and, possibly, hierarchical objectives. Additionally, the investment scenario for this non-profit is bound by hard constraints (e.g., barring investment into "sin stocks"). Thus, the purpose of this paper is twofold. First, the research demonstrates how the combinatorial nonlinear multiple objective optimization model (MINLGP) of Dash and Kajiji (2014) can optimize the complex and long-term goal-oriented ESG portfolio building process envisioned by Urwin (2010). Second, following the Gârleanu and Pedersen (2013) controlled trading cost approach as well as Dash and Kajiji (2014) minimum variance hedge ratio method, a dynamic futures-based hedge is presented as a risk-mitigating approach for both short- and long-term control of temporal instability across asset correlation profiles.

Literature Review (Abbreviated)

Contemporary research has found significant correlation between risk-adjusted returns given an ESG investment focus. For example, reported results indicate that companies with high ESG scores tend to have less company-specific risk (see: (Bouslah, Kryzanowski *et al*. 2011; Oikonomou, Brooks *et al*. 2012)), and that ESG criteria contribute to overall portfolio diversification (Hoepner 2010; Hoepner, Rezec *et al*. 2013). A more comprehensive review of the literature is provided by Deutsche Bank Climate Change Advisers (2012). While these results clearly give rise to the importance of ESG factors in investing they stop short of proposing how to build an optimizing long-term wealth building strategy.

Urwin (2010) establishes an inter-generation economically efficient and fair model (U-SI) for sustainable investing. For many non-profits, state investment authorities, and other sovereign wealth management firms, the main barrier to sustainable investing is explained by a behavioral bias and, to some degree, by the lack of a political will. The question arises about how these fund managers can transition to SI. By definition, SI argues for a greater breadth when defining the institutional investment policy. An SI approach will also require fund managers to expand the scope of their investment objectives as it relates to a focus on short-term risk mitigation. That is, long-term value creation expands the risk-return paradigm to include factors that are sometimes difficult to reconcile from a strictly financial basis. The U-SI model adjudicates traditional investment approaches along five dimensions. Four of those dimensions relate specifically to the SI portfolio building process: a) an explicit optimization of the risk-return tradeoff to encompass the expected life of the investment fund; b) rebalancing portfolio diversification based on endogenous fund factors; c) incorporating advanced performance metrics that target long-term absolute return targets; and, d) expanding and widening the view of "investment manager." The U-SI approach to SI portfolio management rests on two key assumptions: a) that the SI approach will incur lower costs than traditional approaches and b) the SI objective function is more aligned with inter-generational equity.

Combinatorial Nonlinear Goal Programming

Under the SI approach to diversification it is not always possible to satisfy all investment objectives simultaneously. For this reason alone the modelling process preferred for SI factor diversification implements recent advances in convex nonlinear multiple objective modeling (for a review, see Pennanen (2012), Dash and Kajiji (2005), and Dash and Kajiji (2013) for a specification of the bi-criteria Sharpe portfolio problem). Modeling the Sharpe portfolio diversification problem by MINLGP relies upon a three-step application. The first step involves defining the non-profit's set of investable securities after the application of all negative screens. The second step is to add a descriptive goal-directed constraint set to account for the multiple and hierarchical objectives of the long-short style. The third step is to choose an action for F (the futures hedge) and formalize the entire operation. This last step is captured by the hierarchical goal objective function and its bounding constraints:

$$MINLGP = Min\ Z = \left[P_1(h^-, h^+),\ P_2(h^-, h^+),\ \ldots,\ P_L(h^-, h^+) \right]$$

$$S.T. \quad Ax + Bf + h^- - h^+ = b$$

$$x, f, h^-, h^+ \geq 0$$

$$f \in \mathcal{Z}^F,\ x \in \Re^{n-F}$$

Here m is the number of constraints such that $A \in \Re^{m \times n}$; $B \in \mathcal{Z}^{m \times F}, b \in \Re^m$, and Z quantifies the attainment of L hierarchical levels such that $P_1(h^-, h^+) > P_2(h^-, h^+) > \ldots > P_L(h^-, h^+)$. When necessary, scaling effects applied to $P_l(h^-, h^+)$ are defined by the nature and numerical definition of the separable goal programming model. We note that in the absence of hedging constraints, $F = 0$, we obtain the solution to the convex goal program. Under this specification b is the m-component vector of goal targets while h^- and h^+ are m-component column vectors that capture goal under- and over-achievement, respectively. Lastly, we define the optimal solution to the convex MINLGP, x^*, as the one that satisfies all hierarchical levels as much as possible. It is the ability of the MINLGP and its convexity property that permits adding the necessary *if-then* constraint that controls the overall portfolio optimization problem with dynamically determined optimal trading of the contingent claim contract. Throughout, we refer to this formulation as the Sharpe MINLGP optimization.

Application

In this section the science of systems-based cybernetic control and regulation focus on how systemic risk factors communicate within, and across, ESG dimensions. The dimension of control is treated objectively by including estimated ESG returns-to-scale for individual investment securities as a goal in the hierarchical portfolio optimization model.

Latent ESG Factor Extraction

Following extant literature (see: (Han 2006)) we calibrate the arbitrage return-generating framework by invoking a linear principal components analysis (PCA) on the market returns for each security in each of the three primary Thomson Reuters Corporate Ratings ESG portfolios (http://www.trcri.com). We collect monthly log-difference returns over the period January, 2007 through February, 2014, inclusive, for traded securities (either ETFs or equities) that sample unique ESG factors. Next, we employ the PCA method with a varimax rotation to reduce the collinear structure of historical market returns to simple structure. From the simple structure matrix, we estimate 'maximum validity variables' by factor score transformation.

Neuro-Cybernetic Production Economics

Starting with Cobb and Douglas (1928) an enormous literature has focused on the building and estimating of production-theoretic models based on the double log functional form. The complexity involved in specifying systemic risk relationships defies the belief in a strictly linear relationship among all independent variables. Hence, in this research the model weights, β_j are estimated by applying the K4 radial basis function artificial neural network (K4 RANN):

$$\ln(r_{i,t}) = \alpha_i + \sum_{j=1}^{n} \beta_j \ln(PCAmx_j^K) + \varepsilon_i$$

where $\varepsilon_i \sim N(0,1)$, $r_{i,t}$ represents the monthly return on the i_{th} security for t months and $PCAmx_{j,t}^K$ are the zero-valued transformed ESG latent domain observations over t periods. In the next section we provide a brief overview of the RANN topology and show its appropriateness for estimating factor (quasi-) elasticity metrics.

The GSSNE Multiobjective ESG Portfolio

In this section of the paper we examine the computational tractability of the Sharpe MINLGP algorithm by executing a temporal trading strategy using a single-period Sharpe efficient portfolio with N_f contingent claims attached. The GSSNE board promotes an approved equity security list of approximately 75 securities. We adapt a GSSNE security list created in September, 2012 to form a decision-date foundation long-short hedge fund. We obtain historical daily price data for n, $n \in \{1, \ldots, 75\}$, instruments and the market proxy over the period from January, 2007 through February, 2014.

Due to the restriction on page count we present the detailed Sharpe MINLGP equations online at: http://www.nkd-group.com/research/ICAOR/Attachments.pdf. (Note: the equation numbers that follow refer to the online document) Equation (2) and (3) state the unsystematic and systematic risk goals, respectively. Equation (2) expresses the variance of the idiosyncratic risk (ε_j) for *n* investment securities, or σ_j^2 plus the variance of returns for the market proxy, σ_M^2 to account for *n+1* model securities. Structural systematic risk (β_j) is expressed by equation (3). As required by the Sharpe formulation, this constraint requires the portfolio beta to equal the weighted sum of the individual security beta coefficients. Equation (4) forces the portfolio to be fully invested (no short-sales). Equation (5) is the goal constraint used to set the required return for the efficient portfolio, R_{R_p} . Equation (6) is an accounting restatement of portfolio return. The hierarchical objective function is stated as equation (1). Because it is augmented to include ESG factors, its definition is presented after adding integer goal constraints.

The objective of hedging is to offset an expected loss of wealth due to bearish-price volatility in the broad-based market by implementing a minimum variance hedge ration (MVHR) to offset expected changes to the market value of the underlying portfolio based upon its calculated market beta coefficient. When the measured relationship is such that $\hat{f}_{t+1} < f_t$, the MVHR is obtained and a hedge position is opened. Conversely, when a hedge position is opened and the price relationships are reversed $\hat{f}_{t+1} > f_t$ the hedged position is closed by offset. To begin, here we let $A = f_t - \hat{f}_{t+1}$; $B = N_f$; L_T is the acceptable loss threshold; *v* is the binary decision variable, $v \in \{0,1\}$; and, *M* is an arbitrarily high number. Equation 7 captures the expected dollar loss from the volatility of the futures contract; *A*. Equation 8 states the managerially determined loss threshold. Whenever the expected loss in value of the futures contract $\left(x_f\right)$ is greater than L_T, then set *v =1*. In turn, equation 9 executes a sale of N_f futures contracts.

$$x_f = A \qquad (1)$$

$$x_f - Mv + h_7^- - h_7^+ = L_T \qquad (2)$$

$$N_f + h_8^- - h_8^+ = Bv \qquad (3)$$

The importance of thwarting small to unwarranted hedges causes the deviation variable associated with the loss threshold, h_7^-, to be added to priority 2. The binary hedge decision itself is included in the updated objective function as a third-level goal priority. The minimization of h_8^+ is designed to restrict the discretionary placement of hedging instruments beyond those needed to optimally hedge the expected loss on the portfolio. The updated objective function, equation 10, replaces and enhances equation 1 as described.

$$Min\ Z = \left\{P_1\left[h_4^-\right], P_2\left[h_1^+,\ h_7^-\right], P_3\left[h_8^+\right]\right\} \qquad (4)$$

Lastly, following Daryl and Shawn (2012), we study the comparative benefits of ESG diversification against both small and large Sharpe portfolios. The simulation seeks to examine what, if any, crossover effects occurs between the ESG-optimized GSSNE portfolio and traditionally optimized small- (large-) portfolios over time.

Abbreviated Results

Portfolio Hedge Performance

At this early stage in the research it is not possible to evaluate comparative long-term portfolio performance. This reduces the question at hand to an analysis of what impact daily interim period hedging has on the performance of all reference portfolios. From the base date of portfolio creation, the daily interim investment period, δ_i, encompasses five trading days: 03-March-2014 through 07-March-2014, inclusive. As noted in the discussion on comparative efficient sets, the GSSNE and EqWg portfolios had an appreciably close relationship in the risk plane. We take advantage of this relationship by choosing to compare the EqWg portfolio against the target portfolio of this study, the ESG constrained portfolio. Tables 1 and 2 present the result of applying the minimum variance hedge ratio to both portfolios. Over the five day interim period the EqWg portfolio increased by $31,365 with an accompanying gain from hedging of $20,300 for a total increase in wealth of $51,665. The gain achieved by the ESG portfolio alternative was not nearly as impressive as that earned by the EqWg portfolio with hedge. For the ESG investment the change in wealth was a much smaller $3,185 with a corresponding gain from hedging of $13,050. The total net change to wealth was $16,235.

Table 1. Equally Weighted Portfolio (Eq)

Date (2014)	*Equally Weighted Portfolio Value*	*E-mini S&P 500 Index Price*	*E-mini S&P 500 Market Value x (50)*	N_f	*Dynamic Hedge Open*	*Dynamic Hedge Close*	*Hedge Profit (Loss)*
Feb 28	$2,594,002	$1,843	$92,162	28	$2,580,550		
Mar 3	$2,571,973	$1,828	$91,437	28		$2,560,250	$20,300
Mar 4	$2,610,097	$1,857	$92,862				
Mar 5	$2,608,256	$1,858	$92,912				
Mar 6	$2,616,590	$1,862	$93,100				
Mar 7	$2,625,367	$1,863	$93,187				
Position	$31,365						$20,300

Table 2. ESG Portfolio (ESG)

Date (2014)	*ESG Portfolio Value*	*E-mini S&P 500 Index Price*	*E-mini S&P 500 Market Value x (50)*	N_f	*Dynamic Hedge Open*	*Dynamic Hedge Close*	*Hedge Profit (Loss)*
Feb 28	$2,122,248	$1,843	$92,162	18	$1,658,925		
Mar 3	$2,104,906	$1,828	$91,437	18		$1,645,875	$13,050
Mar 4	$2,131,674	$1,857	$92,862				
Mar 5	$2,119,223	$1,858	$92,912				
Mar 6	$2,124,204	$1,862	$93,100				
Mar 7	$2.125,433	$1,863	$93,187				
Position	$3,185						$13,050

Comparative Performance Measures

The respective Sharpe and the Sharpe-Omega ratios are presented in Figure 1. As would be expected both hedged portfolios had higher Sharpe ratios than their unhedged counterparts. We note that, over the short-run, the EqWg portfolio out-performed the ESG portfolio in both cases. The Sharpe-Omega ratio analysis also confirms the observed performance rankings.

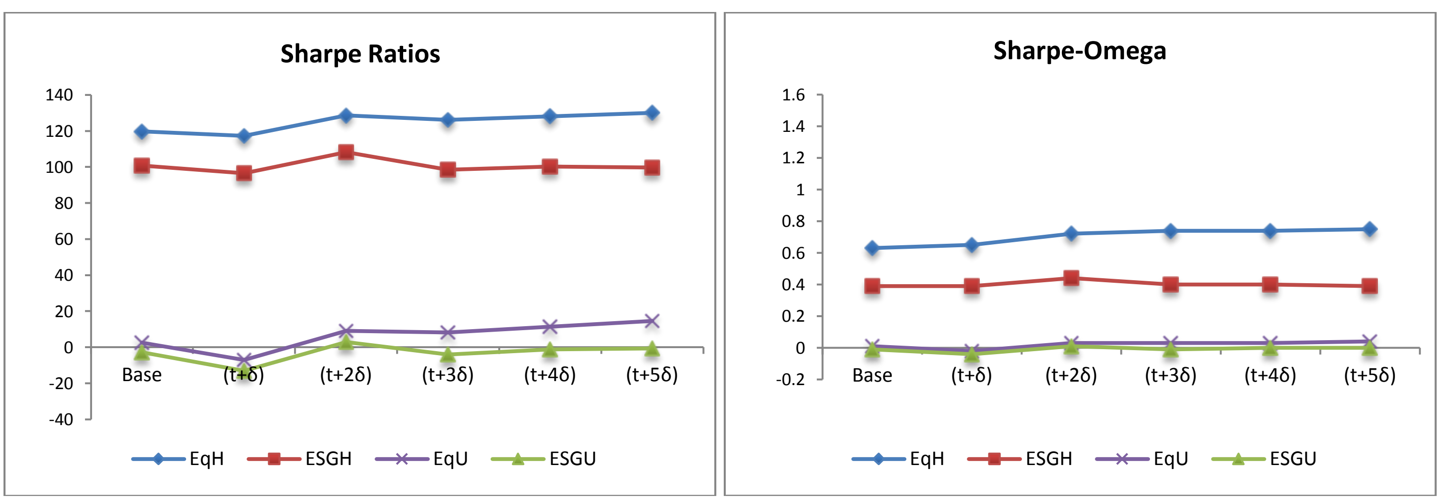

Fig. 1. Longitudinal Comparison of Sharp and Sharpe-Omega Ratios

Summary and Conclusions

The research presented in this paper was inspired by non-profit investors who seek long-term consistency in risk-adjusted performance for ESG dynamically traded efficient portfolios. The results of this study found the following. First, except for low rate of return portfolios, the results confirmed the ability of the MINLGP algorithm to produce an efficient set of portfolios generated from a bi-criteria Sharpe diagonal model that nearly replicates the efficient set produced by a uni-objective quadratic program based on the full covariance matrix approach. Second, the execution of consecutively hedged contingent-claim enhanced ESG-optimized MINLGP portfolios produced temporal risk-adjusted performance for a small portfolio that corroborated prior findings in the literature. The results indicated that risk-adjusted performance for a small equally weighted portfolio did not differ significantly when compared to a small efficiently diversified portfolio, hedged or unhedged. Third, the Thomson Reuters Corporate Responsibility Ratings ESG portfolios proved to be a significant indicator of environmental, social and corporate responsibility. In conclusion, the results derived from this research add new information about the usefulness of interim period hedging when investors follow SI directives.

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