DO SOCIALLY RESPONSIBLE AND RISK-TAILORED PORTFOLIOS WIN? A COMPARATIVE ANALYSIS

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ABSTRACT

This study introduces three extensions of the Markowitz portfolio selection model: (1) matching portfolio risk to individual investors' risk appetite; (2) excluding certain shares; and (3) environmental, social, and governance (ESG) integration. The models are compared to the traditional Markowitz model using empirical data from JSE Limited.

The findings reveal that differentiating portfolios on the basis of risk appetites or exclusions had a limited impact on future returns. However, portfolios differentiated by ESG integration showed significantly higher future returns than the other models or industry investments. The study highlights the superiority of ESG integration and suggests that current portfolio selection models do not fully capture the art of investing.

OPSOMMING

Hierdie studie stel drie uitbreidings van die Markowitz-portefeuljekeusemodel bekend: (1) pas portefeuljerisiko by individuele beleggers se risiko-aptyt; (2) sluit sekere aandele uit; en (3) omgewings-, maatskaplike en bestuursintegrasie (ESG). Die modelle word met die tradisionele Markowitz-model vergelyk deur empiriese data van JSE.

Die bevindinge toon dat die onderskeid van portefeuljes gebaseer op risiko-aptyt of uitsluitings het 'n beperkte impak op toekomstige opbrengste gehad het. Portefeuljes wat deur ESG-integrasie onderskei word, het egter aansienlik hoër toekomstige opbrengste getoon in vergelyking met ander modelle of industriebeleggings. Die studie beklemtoon die superioriteit van ESG-integrasie en stel voor dat huidige portefeuljekeusemodelle nie die kuns van belegging ten volle vasvang nie.

1. INTRODUCTION

The concept of portfolio selection with multiple objectives has existed for millennia, but was only formalised in 1952 when Markowitz [1] published his proposition of a risk-reward trade-off. This risk-reward trade-off has since become the cornerstone of modern portfolio selection theory and practice [2-5]. Today, multiple objectives such as rate of return (ROR), risk, market liquidity, and socially responsible (SR) factors are considered concurrently to select an investment portfolio [6]. Many of the objectives in portfolio selection are plagued with the uncertainty that is endemic to the investment market. Multi-objective stochastic programming models solved with a goal programming approach are commonly used to incorporate both the uncertainty and the multiple objectives of portfolio selection problems [7-9]. Despite being a well-established field, three areas of contribution to portfolio selection models have been identified.

Firstly, the portfolio selection models are generic, and fail to account for the goals and preferences of individual investors — especially in respect of risk. Current models account for risk by considering how reliant one asset's return is on another asset or the market as a whole, and then minimising this dependence over all of the assets being considered [1, 6, 10]. Yet there exists great variance among individuals' risk appetites. Allowing individual risk tolerance to influence the selection of a portfolio would result in a risk-reward trade-off that is better suited to individual risk appetites [11].

Secondly, many portfolio selection models do not incorporate socially responsible investing (SRI) principles. Recently, investors have become more aware of the impact that their investments have on the moral and ethical dilemmas within society [12, 13]. Many thus wish to invest in assets that align with their value systems. Despite the trend towards considering the return-responsibility trade-off having gained ground in the past decade, there is still no consensus about how SRI principles should be incorporated into portfolios. Furthermore, the results regarding the performance of such portfolios are mixed [12-14].

Finally, the few authors that do account for SRI generally employ the most predominant strategy, namely exclusion. Despite it prevalent use, many researchers argue that there are problems with exclusion, both in theory and in practice [15, 16]. Thus, these researchers suggest that environmental, social, and governance (ESG) integration is the preferred method of incorporating SRI into portfolio selection. Despite the many sound arguments made in favour of this point, there is very little empirical evidence proving the superiority of ESG integration over exclusion.

This paper contributes to each of these three areas. A novel method is presented that incorporates an individual's risk tolerance into the portfolio selection process. Three models are developed that include this individualised risk approach: one does not consider any SRI principles, one incorporates exclusion, and one employs ESG integration. These three models are then used to select portfolios across a range of ROR goals and risk preferences using historical training data from JSE Limited[1] (henceforth JSE), a South African securities exchange. These models are then validated by assessing the performance of the selected portfolios over a three-year testing period. Throughout the analysis, the three proposed models' results are compared with the results produced by a model that uses the generic Markowitz-based risk measure. The historical dataset is limited to the shares of companies listed on the JSE; bonds and other financial instruments are excluded.

1.1. Literature Review

The three objectives that carry the most consensus in portfolio selection are to maximise the ROR and liquidity while minimising risk [10, 17]. More recently, awareness of ESG factors had led to the inclusion of another objective, namely the maximisation of Socially responsible investing (SRI) [18]. These four relevant objectives are defined next.

1.1.1. Rate of return (ROR)

The ROR is the gain or loss generated by investing in a company's shares. It includes capital gain and dividends. For any company j, the random ROR, $\widetilde{r_j}$, is:

$$\widetilde{r_j} = \frac{\widetilde{p_{j,t}} - p_{j,t} + \widetilde{d_{j,t}}}{p_{j,t-1}} \tag{1.1}$$

The random closing price of company j's shares at time t is represented by $\widetilde{p_{j,t}}$, and $d_{j,t}$ is the random dividends received by company j during the period $[t-1, t]$ [10, 17]. For a portfolio that invests in multiple companies, it follows that:

$$\text{Portfolio rate of return} = \sum_j^N \widetilde{r_j}\, w_j \tag{1.2}$$

where N is the number of assets in the portfolio and w_j is the proportion of the portfolio invested in company j.

[1] JSE is not an acromyn, it is simply a name.

1.2. Liquidity

Liquidity refers to the ease and speed with which a company's shares can be traded at a low cost [19, 20]. It is considered to be one of the key determinants of portfolios returns and is measured in respect of an exchange flow ratio e_j [19].

$$e_j = \frac{n_j}{n_m} \quad (1.3)$$

The number of days on which shares of company j were traded during the analysis period is represented by n_j, while n_m is the number of days on which any shares were traded [10]. An investment is viable if $e_j > 0$, with higher ratios being preferred. As with the ROR, the liquidity of a portfolio is:

$$\text{Portfolio rate of return} = \sum_j^N e_j\, w_j \quad (1.4)$$

1.3. Risk

Risk is the possibility that an investor will experience a financial loss or gain due to unforeseen changes in market prices [21]. Markowitz [1] quantified investment risk according to mean, variance, and covariance of returns [22]. This risk is measured as follows:

$$\sum_{i=1}^N \sum_{j=1}^N w_i w_j \sigma_{ij} \quad (1.5)$$

where σ_{ij} is the covariance between the ROR of companies i and j .

In the Markowitz model,Equation (1.5) is minimised with no consideration of an individual's risk appetite. Thus, a new method is proposed that compares the risk associated with a certain investment with the risk tolerance of the investor.

The conditional value-at-risk (CvaR) method is a statistical technique used in practice to quantify the risk percentage associated with an investment [21]. CvaR values can be grouped into five different risk categories: conservative (0 – 36.73%), moderately conservative (36.74 – 44.90%), moderate (44.91 – 57.14%), moderately aggressive (57.15 – 65.31%), and aggressive (65.32 – 100%). The CvaR of a portfolio is the weighted sum of the constituent CvaR values. This measure should match the financial risk tolerance of an investor for that portfolio to be appropriate.

Financial risk tolerance is the maximum amount of uncertainty that a person is willing to accept when making a financial decision [23]. The 13-item financial risk tolerance scale developed by Grable and Lytton [24] is widely used and is regarded as reliable and valid [25-27]. This assessment calculates a risk tolerance score (RTS) between 20 and 69, with a higher score indicating a higher propensity towards taking risk. These RTS values fall into five risk categories: conservative (20–38), moderately conservative (39–42), moderate (43–48), moderately aggressive (49–52), and aggressive (53–69). Equation (1.6) ensures that a portfolio's risk (CvaR) does not exceed the investor's RTS score:

$$\sum_{j=1}^N w_j\ \text{CvaR}_j \leq \frac{\text{RTS}-20}{49} \quad (1.6)$$

1.4. Socially responsible investing (SRI)

Despite SRI principles dating back hundreds of years, the mainstream awareness of SRI and of investor demand for SRI alternatives is fairly recent [28]. Exclusion and ESG integration are the two most popular ways in which SRI has been incorporated into investment strategies (i.e., portfolio selection).

With exclusion, investors do not invest in, and thus exclude, companies that are believed to involve activities that may be considered harmful, controversial, or 'sinful' investors exclude the purchase of any company's shares whom they believe are involved in harmful activities [29]. Companies engaging in or promoting any 'sinful' activities are regarded as sin shares [15]. By outright excluding sin shares from the pool of possible investments, the objective of SRI is met. Different people have differing views on what constitutes a 'sinful' activity. Thus it is virtually impossible to find a set of 'sins' that is universally acceptable. Trinks and Scholtens [16] identify and study 14 such potentially controversial activities, termed 'sins'. These 14 activities are abortion, adult entertainment, alcohol, animal testing, contraceptives, controversial weapons, fur, gambling, genetic engineering, meat, nuclear power, pork, (embryonic) stem cells, and tobacco. Given that this list was published in 2017, during the timeframe of this study, these 14 'sins' are regarded as appropriate for consideration in this paper, and so are used as the set of 'sins'.

By contrast, ESG integration is achieved through the consideration of an ESG rating when selecting companies [30]. An ESG rating is a comprehensive measure of how well a company manages ESG issues. Agencies that determine ESG ratings look at and measure ESG factors such as biodiversity, climate change, customer responsibility, health and safety, labour standards, anti-corruption, corporate governance, risk management, and many more, in order to determine an overall 'goodness' score for a company [31]. The higher the ESG rating of a company, the more SR it is considered to be. By maximising the weight-average ESG rating of the selected portfolio, the objective of SRI is met.

Of these two methods, exclusion is by far the simplest to implement. Yet many authors argue against the exclusion approach and instead favour ESG integration [15, 16]. To explain their argument, consider the example of investing in hospitals. With exclusion, investors would never invest in hospitals because they perform abortions, provide contraceptives, and use stem cells in treatments, all of which are considered to be 'sinful' activities [16]. Yet hospitals provide millions of people with life-saving and much-needed medical care. Thus it could be argued that the good outweighs the bad; and therefore hospitals are SR companies. For this reason, the present authors suggest that ESG integration is the preferred method of incorporating SRI into the portfolio selection model.

Despite the clear case made for the superiority of ESG integration over exclusion, there is very little empirical evidence to support this argument. Thus both approaches are applied and compared in the paper.

While incorporating SRI into a portfolio selection model may be simple, trading off this and the remaining three objectives of maximising the (uncertain) ROR and liquidity while minimising risk is not as simple.

2. METHODS

Aouni *et al.* [32] reviewed 116 publications on multiple criteria optimisation methods used in portfolio selection. They found that goal programming is the most prevalent technique, appearing in 42% of the publications that were considered. Using a goal programming model with investor preference as the objective goals is considered appropriate for this study [33].

Further to the multiple objectives of the portfolio selection model, the stochastic nature of the ROR must also be accommodated. Shapiro *et al.* [34] show that two methods are primarily used for portfolio selection. These are the expected value (EV) method and chance-constrained programming (CCP). For the EV method, the value for a random variable is the average of values found in a distribution of that variable's historical values [34]. In the CCP approach, the emphasis is placed on the reliability of the system. This is expressed as a minimum requirement for the probability of satisfying the constraints. Values are iteratively sampled from known distributions to account for the uncertainty [35].

CCP requires either a theoretical distribution that is a good fit of the historical data or a large sample of historical data to sample from. Such data is not always practically obtainable. Thus, in this study, both the EV and the CCP methods are used to observe whether the study's findings are sensitive to different stochastic methods.

Four multi-objective models are formulated. All four models use a goal programming approach, and are solved using both the EV method and the CCP.

- The **Markowitz model** seeks to meet the ROR, liquidity, and covariance risk goals.
- The **risk-adjusted model** is similar to the Markowitz model, but the risk objective is enforced through equation (2.6).
- The **exclusion model** is similar to the risk-adjusted model, but excludes sin shares from the pool of potential investments.

- The **integration model** is similar to the risk-adjusted model, but includes ESG integration.

Investment portfolios are rebalanced from time to time owing to changes in an investor's risk profile, regulatory requirements, market conditions, or company performance [36, 37]. The holding period is the period between rebalancing, during which the portfolio remains static. A holding period of up to three years is considered the maximum in the South African market [38]. Because the validation data is sourced from the JSE (see Section 4), a three-year timeframe is used in the model formulations. Equations (2.1) to (2.6) are thus calculated over the period $[t-3, t]$. In addition to the terms already defined in equations (2.1) to (2.6), the following terms are also defined:

$\boldsymbol{J} \triangleq$ sample set of companies such that $\boldsymbol{J} = \{1, \dots, N\}$

$\boldsymbol{K} \triangleq$ set of attributes that define a company's shares as sin share $\boldsymbol{K} = \{1, \dots, 14\}$

$\boldsymbol{T} \triangleq$ set of years for which an investment portfolio is selected such that $\boldsymbol{T} = \{1, \dots, 3\}$

Decision variables

$x \triangleq \begin{cases} 1 \text{ if company } j \in \boldsymbol{J} \text{ is selected as part of the investment portfolio} \\ 0 \text{ otherwise} \end{cases}$

$w_j \triangleq$ the proportion of the portfolio invested in company $j \in \boldsymbol{J}$

$R \triangleq$ the ideal value for the ROR goal

$E \triangleq$ the ideal exchange flow ratio for the liquidity goal

$C \triangleq$ the ideal value for the portfolio covariance goal (Markowitz model)

$G \triangleq$ the ideal ESG rating at the end of period $[0, 3]$

$c_j \triangleq$ the CVaR of company $j \in \boldsymbol{J}$

$T \triangleq$ the financial RTS of the investor

$s_{j,k} \triangleq \begin{cases} 1 \text{ if company } j \in \boldsymbol{J} \text{ does not have attribute } k \in \boldsymbol{K} \\ 0 \text{ otherwise} \end{cases}$

$g_{j,t} \triangleq$ the ESG rating of company $j \in \boldsymbol{J}$ at time $t \in \boldsymbol{T}$

The deficiency variables, σ_1, σ_2 and σ_3, measure the degree to which the portfolio falls short of the ROR, liquidity, and risk goals respectively.

2.1. Markowitz model

$$\min z = \delta_1 + \delta_2 + \delta_3 \tag{2.1}$$

Subject to

$$\textstyle\sum_{j \in \boldsymbol{J}} w_j \widetilde{r_j} + \delta_1 \geq R \tag{2.2}$$

$$\textstyle\sum_{j \in \boldsymbol{J}} w_j e_j + \delta_2 \geq E \tag{2.3}$$

$$\textstyle\sum_{i=1}^{N} \sum_{j=1}^{N} w_i w_j \sigma_{ij} - \delta_3 \leq C \tag{2.4}$$

$$\widetilde{r_j} = \frac{\widetilde{p_{j,t}} - p_{j,t-3} + \widetilde{d_{j,t}}}{p_{j,t-3}} \quad \forall\, j \in \boldsymbol{J} \tag{2.5}$$

$$e_j = \frac{n_j}{n_m} \quad \forall\, j \in \boldsymbol{J} \tag{2.6}$$

$$\sum_{j \in \boldsymbol{J}} x_j \ \geq 30 \tag{2.7}$$

$$\sum_{j \in \boldsymbol{J}} w_j = 1 \tag{2.8}$$

$$x_j \leq 1000 w_j \quad \forall\, j \in \boldsymbol{J} \tag{2.9}$$

$$w_j \leq 0.05 x_j \tag{2.10}$$

$$w_j \geq 0 \quad \forall\, j \in \boldsymbol{J} \tag{2.11}$$

$$x_j \in \{0,1\} \quad \forall\, j \in \boldsymbol{J} \tag{2.12}$$

$$\delta_1,\ \delta_2,\ \delta_3\ \geq 0 \tag{2.13}$$

Equation (2.1) minimises the degree to which the three goals are not met, with δ_1, δ_2, δ_3 calculated in Equations (2.2) to (2.4). The aggregation is possible, as the ROR, exchange flow ratio, and risk variables are all normalised ratios. The portfolio's ROR and liquidity is calculated by Equations (2.5) and (2.6) respectively. The covariance values are calculated outside the model and then incorporated into Equation (2.4). Equation (2.8) ensures that the portfolio is fully invested, while equations (2.9) and (2.10) ensure that only companies that are selected have a portion of the portfolio invested in them.

Equation (2.7) enforces diversity by ensuring that each portfolio consists of at least 30 companies. Diversifying a portfolio is standard practice to mitigate the risks associated with individual investments [4, 39]. According to Statman [40], an investment portfolio should contain at least 30 shares to be considered a diversified portfolio. Equation (2.9) further ensures diversity by requiring that each company that is selected must carry at least 0.001 (or 0.1%) of the total portfolio weight. Furthermore, Equation (2.10) ensures that no more than five percent of the total capital investment can be invested in a single company. This is in keeping with the market norms observed for unit trusts in the South African market, and the recommendation by Hallerbach *et al.* [41], who impose the restriction that a maximum investment proportion of five percent may be invested into a single company. Equation (2.8) ensures that the portfolio is fully invested, while Equations (2.9) and (2.10), in combination, ensure that only companies that are selected have a portion of the portfolio invested in them, and that no selected company carries a weight of less than 0.0001 (or 0.1%).

2.2. Risk-adjusted, exclusion, and integration models

The risk-adjusted model is based on the Markowitz model, with the exception that (2.4) is replaced by Equation (2.14)

$$\sum_{j \in \boldsymbol{J}} w_j c_j - \ \delta_3 \ \leq \ \frac{T-20}{49} \tag{2.14}$$

The exclusion model includes the additional set of exclusion factors $\boldsymbol{K}$ such that $\boldsymbol{K} = \boldsymbol{1}, \ldots, 14$, where each index correlates with one of the sin activities identified by Trinks and Scholtens [16]. The exclusion model thus extends the risk-adjusted model by including Equation (2.15), thereby excluding all sin shares from consideration in the portfolio.

$$x_j \leq \ \prod_{k \in \boldsymbol{K}} s_{j,k} \quad \forall\, j \in \boldsymbol{J} \tag{2.15}$$

The integration model extends the exclusion model by including the maximise SRI objective. Thus the objective function given in Equation (2.1) is replaced with Equation (2.16), given below.

$$\min z = \ \delta_1 + \ \ \delta_2 + \ \ \delta_3 \ + \ \ \delta_4 \tag{2.16}$$

Furthermore, to incorporate the SRI objective, the constraints given in Equations (2.17), (2.18), and (2.19) are added to the model formulation. Finally, constraint (2.13) is updated to (2.20).

$$\sum_{j\in \boldsymbol{J}} w_j \left(\frac{g_j - g_{\min}}{g_{\max} - g_{\min}}\right) + \delta_4 \geq \left(\frac{G - g_{\min}}{g_{\max} - g_{\min}}\right) \tag{2.17}$$

$$g_{\max} = \max_{j\in \boldsymbol{J}}\{g_j, 3\} \tag{2.18}$$

$$g_{\min} = \min_{j\in \boldsymbol{J}}\{g_j, 3\} \tag{2.19}$$

$$\delta_1, \delta_2, \delta_3, \delta_4 \geq 0 \tag{2.20}$$

2.3. Incorporating stochasticity

In this study, the stochastic equations (2.2) and (2.5) are converted to their deterministic equivalents using both the EV approach and CCP. In the EV model, Equations (2.2) and (2.5) are converted to the following:

$$\sum_{j\in \boldsymbol{J}} w_j E(r_j) + \delta_1 \geq R \tag{2.21}$$

$$E(r_j) = \frac{E(p_{j,t}) - p_{j,t-3} + E(d_{j,t})}{p_{j,t-3}} \quad \forall j \in \boldsymbol{J} \tag{2.22}$$

where $E(r_j), E(p_{j,t})$ and $E(d_{j,t})$ are the expected values of the respective random variable.

For the CCP model, the solution adheres to the constraints 90 percent of the time ($\alpha = 0.1$) at a reliability level of 95 percent ($\Delta = 0.05$). Thus Equation (2.23) calculates the number of iterations (N) required to ensure, with a probability of at least $1 - \Delta$, that the optimal solution is feasible. The number of unknowns in the equations being considered is denoted by n.

$$N = \left\lceil 2n\alpha^{-1} \ln\left(\frac{12}{\alpha}\right) + 2\alpha^{-1} \ln\left(\frac{2}{\Delta}\right) + 2n \right\rceil \tag{2.23}$$

Let $\boldsymbol{B}$ **be the set of** N iterations, then Equations (2.2) and (2.5) are converted to the following deterministic constraints:

$$\sum_{j\in \boldsymbol{J}} w_j {r_j}^b + \delta_1 \geq R \quad \forall b \in \boldsymbol{B} \tag{2.24}$$

$$r_j = \frac{{p_{j,t}}^b - p_{j,t-3} + {d_{j,t}}^b}{p_{j,t-3}} \quad \forall j \in \boldsymbol{J} \quad \forall b \in \boldsymbol{B} \tag{2.25}$$

Each of the four models are solved using the EV Equations (2.21)–(2.22) and the CCP approach, Equations (2.23)-(2.25).

2.4. Obtaining the historical JSE dataset

At the time of this study, only 326 of the 344 companies listed on the JSE had historical share price and dividend data published on Yahoo Finance – the primary data source for this study. Of these 326 companies, only the 208 companies that had been listed for at least ten years (2010/01/01 – 2019/12/31) were selected.

Obtaining the distribution of three-year ROR observations for each company from the training set (2010/01/01 – 2016/12/31) was not trivial. Theoretically, the historical three-year ROR, as observed on each trading day between 2012/01/01 and 2016/12/31, could be calculated. A random sample of 500 of these three-year ROR observations were extracted for each company. It should be noted that these observations are not strictly statistically independent. However, given the historical data available, this sampling approach was the most practical.

While determining the expected ROR value for the EV model was relatively easy, the CCP model required defined distributions from which to sample. In the literature, many portfolio selection authors assume that share returns follow a normal distribution [6, 10], but this seldom reflects reality [5], as our dataset confirms. The Anderson-Darling test confirmed that none of the companies' three-year ROR observations were normally distributed. Instead, using the Kolmogorov-Smirnov test and visual comparisons of the empirical and theoretical distributions, each company's ROR data was fitted to a custom skew-normal, triangular, or uniform distribution.

2.5. Simulating a range of investors

This study compared an individualised approach to risk and SRI preferences with the more generic Markowitz model. To do so required the simulation of a range of 'individual' investors, each with a specific set of goals.

The ideal value for the liquidity goal, E, is not dependent on the individual, but is defined as the maximum portfolio exchange flow ratio (as per Equation (2.4)) that could be obtained from a portfolio of 30 companies selected from the dataset [10]. Given this study's sample, E was found to be 1. This ideal value is used in all four models.

In respect of the risk goal, the ideal value for C (Markowitz model) and the values of T (risk-adjusted and exclusion models) had to be determined. In the Markowitz model, C is the maximum portfolio covariance that the model is willing to accept without penalising the objective function. The value of C depends on the inherent covariance of the dataset at hand. The minimum C value that could be obtained if all other objectives were ignored was 9×10^{-5}. However, the distribution of $\sigma_{i,j}$ was very wide (minimum = $-2\,107$; maximum = $406\,842$; mean = 13; median = 9×10^{-3}). Therefore, the single ideal value $C = 1$ was used in the Markowitz model so that the risk goal did not unduly dominate the other objectives. On the other hand, an individual's RTS result could range between 20 and 69 [24], creating the range $T = \{20, 21, 22, \dots, 69\}$.

In respect of the SRI goal, the ESG integration methodology used by the JSE and created by FTSE Russel [31] was used. This methodology considers 14 different ESG factors, each measured by $10 - 35$ mathematical indicators, to determine the ESG rating of each company. If a company achieves an ESG rating of 2.5 or above, it is considered to be SR [42]. Thus $g = \{2.5\}$.

The last range of ideal values to specify is R. Presumably, no investor would ever want to lose money; thus $R \geq 0$. Bernstein [43] found that an ROR of 17.09% for three years is what can reasonably be expected when investing in a portfolio of shares. Thus, it was decided to execute the models for five possible three-year ROR values, namely $R = \{0\%, 5\%, 10\%, 15\%, 20\%\}$.

Two portfolios were selected using the training dataset for each simulated investor; one was selected using the EV method, and the other using CCP. Only five distinct investors existed in the Markowitz model, as $|E| \times |C| \times |R| = 5$. For the risk-adjusted, exclusion, and integration models, there were 250 simulated investors $((|E| \times |T| \times |R|)$ or $(|E| \times |T| \times |R| \times |G|))$. All models were solved using LINGO 18.0. It was assumed that the investors' goals remained unchanged from the point when the portfolios were selected until the end of the testing period (2017/01/01–2019/12/31). The next section analyses the performance of the portfolios that were selected for these simulated investors by the different models.

3. COMPARATIVE MODEL PERFORMANCE IN THE SOUTH AFRICAN EQUITIES MARKET

While analysing the composition of the selected portfolios and their performance in the training period may provide insight into the internal reasoning of the model, it does not address the aim of this study. Given that investors are interested in the ROR that they will achieve in an uncertain future, it is necessary to evaluate the performance of the selected portfolios during the testing period.

3.1. Portfolio performance during testing period

Should an investor's portfolio have met or exceeded their ROR goal and maintained its socially responsible status after some holding period, the investor would be satisfied, and the portfolio would be considered suitable for its intended purpose. The ROR and SRI goals are thus the only explicit investor goals. Risk and liquidity are ancillary goals that are intended to select a portfolio that is more robust. The future performance in this study is measured by the three-year ROR and ESG rating witnessed between 2017/01/01–2019/12/31.

The three-year ROR performance of the Markowitz portfolios (Table 1) was dismal. None achieved a growth higher than 1% over three years, while two CCP portfolios had negative returns. Only the portfolios with the goal of not losing money ($R = 0\%$) satisfied the investor goals.

Table 1: The three-year ROR (%) achieved during the testing period by the portfolios selected by the Markowitz models

	EV	CCP
Portfolio 1 ($R = 0\%$)	0.86	0.89
Portfolio 1 ($R = 5\%$)	0.85	0.89
Portfolio 1 ($R = 10\%$)	0.85	-4.08
Portfolio 1 ($R = 15\%$)	0.94	-16.65
Portfolio 1 ($R = 20\%$)	0.83	0.89

Unfortunately, the risk-adjusted and exclusion models did not fare well either. Figures 1 and 2 plot the mean three-year ROR achieved by the portfolios in each risk category for the five ROR goals. In both figures, the results are identical regardless of the ROR goal. Upon investigation it was found that this was because the underlying portfolios were identical. In the case of the risk-adjusted model, only the moderately conservative portfolios, determined using the CCP approach, achieved the R = 0% goal. In the case of the exclusion model, all of the EV portfolios achieved the R = 0% goal, while the aggressive CCP portfolios also achieved the R = 0% goal, with the highest mean ROR of 4.6%. One of these aggressive portfolios even achieved the R = 5% goal with an ROR of 5.2 percent. However, the rest of the portfolios fell far short of the ROR goals, with most of them actually losing money (R < 0%). Furthermore, none of the portfolios selected by these two models could be considered to be SR (Figure 4).

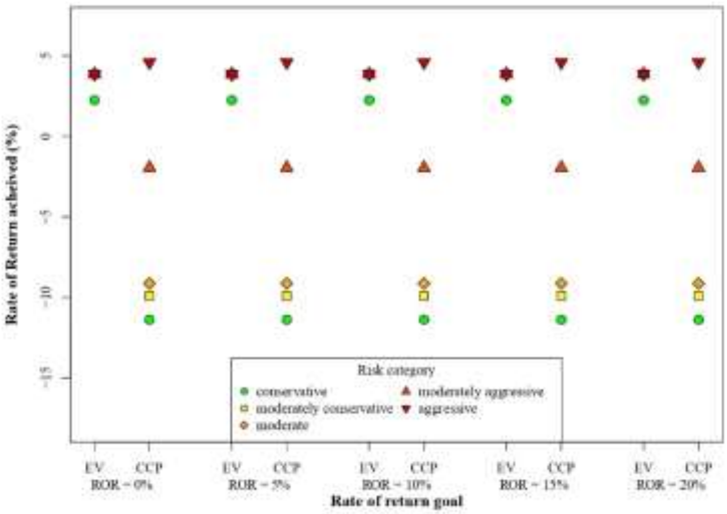

Figure 1: The testing period ROR values of portfolios selected by the EV and CCP risk-adjusted models for each risk category at each ROR goal

In contrast, all of the integration model portfolios greatly exceeded all five ROR goals (Figure 3). According to Bernstein [43], a reasonable three-year ROR is 17.09%. With the exception of five portfolios, all of the portfolios had ROR values that were more than double this reasonable ROR. Furthermore, as shown in Figure 4, all of these portfolios could be considered to be SR (ESG rating > 2.5).

When comparing the results of the integration and exclusion models, it is clear that the integration model's portfolios are far superior to those of the exclusion model. These results support the arguments made by De Colle and York [15] and by Trinks and Scholtens [16] that exclusion is not a comprehensive and all-encompassing method of accounting for the moral inclinations of investors. Furthermore, these results provide empirical evidence to support their claims that ESG integration is superior to exclusion. This comparison of the two methods, supported by data, is novel within the portfolio selection field.

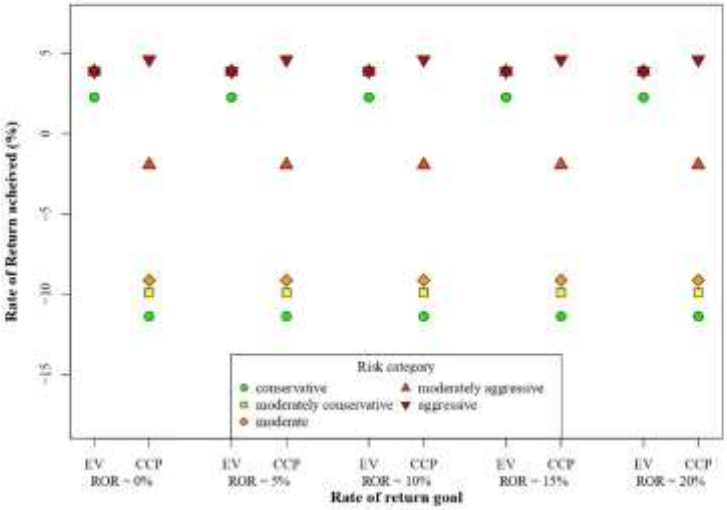

Figure 2: The testing period ROR values of portfolios selected by the EV and CCP risk-adjusted models for each risk category at each ROR goal

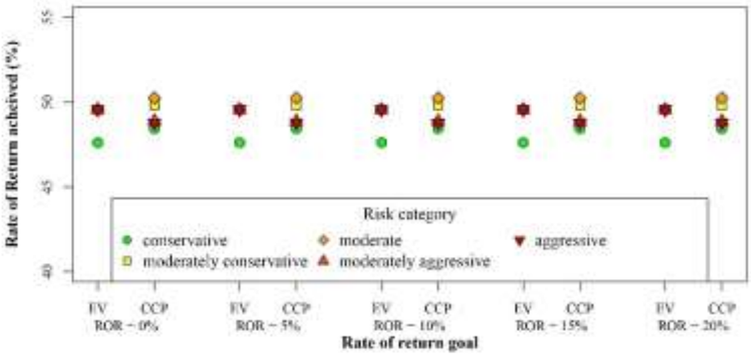

Figure 3: The testing period ROR values of portfolios selected by the EV and CCP integration models for each risk category at each ROR goal

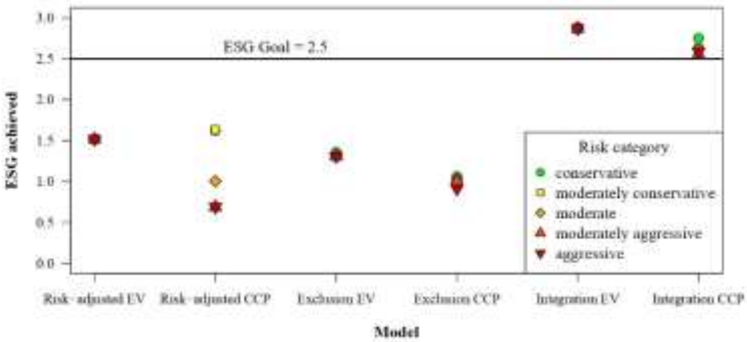

Figure 4: The testing period ESG ratings of portfolios selected by the EV and CCP risk-adjusted, exclusion, and integration models

These results show that the future returns were not very different between the generic and individualised models. Yet the inclusion of ESG integration resulted in portfolios that markedly outperformed the other models. Thus, it is clear that the inclusion of ESG integration, and not an individualised risk measure, is the differentiating factor when selecting successful investment portfolios.

Although the results produced by the integration model appeared very promising, it was still strange that this model so drastically outperformed the other models, especially considering that the same dataset was used. The next section explores the research and reasoning that supports this difference in the models' performance.

3.2. Integration model performance explained

Upon investigation, it was found that the superior performance of the integration model can be attributed to the allocation of the total investment to the selected companies. The integration models allocated much higher proportions (w_j) to the SR companies than the Markowitz, risk-adjusted and exclusion models. Furthermore, it was also was found that the companies that the integration model invested the highest proportions into, with minor exceptions, achieved at least a reasonable ROR of 17.09% in the testing period. Thus, generally, this model invested high proportions into companies that became more profitable and low proportions into companies that because less profitable.

Upon further investigation it was found that the high ROR values achieved by the integration model aligned with the findings of De and Clayman [44] and of Kempf and Osthoff [45]. De and Clayman [44] found that the shares that achieved the highest returns were those that had better ESG profiles than those that achieved lower returns. Furthermore, they stated that investors could increase their profitability by removing lower-tail ESG shares from their portfolios. In their study, Kempf and Osthoff [45] created portfolios, bought shares that had high SR ratings, and sold shares that had low SR ratings. They found that adopting this strategy led to their portfolios achieving abnormally high returns.

3.3. Portfolio performance compared with the South Africa market

The South African economy was in the doldrums during the testing period, which resulted in poor performance for most of the companies listed on the JSE. This poor performance could be qualified by considering the ROR performance of the JSE all share index – a market index that consists of 150 JSE-listed companies and is the largest South African index with regards to size and overall value [46].

While poor market conditions could explain the poor performance of the majority of the model portfolios, the performance of twenty-five South African unit trusts indicates that, in practice, fund managers were still able to back 'winning horses'. Thus, twenty-five unit trusts across the five risk categories were selected for comparison. Unit trusts are developed and managed, taking into account the same three objectives as the models in this study: ROR, risk, and liquidity. Some unit trusts also take SRI into account, yet this is not standard practice. Table 2 lists the unit trusts used in the comparison according to their risk categories and their three-year ROR after fees.

It should be noted that, for both the JSE all share index and the unit trusts, there are no published ESG ratings achieved by their funds. Thus all comparisons made with these instruments were only in respect of the ROR values achieved.

Table 2: The unit trusts, with their ROR values, used in the comparison

Risk category	Unit trust name	Three-year ROR achieved (%)
Conservative	Allan Gray Optimal Fund [47]	-5.59
	Coronation Money Market Fund [48]	25.27
	Momentum Money Market Fund [49]	24.23
	Prudential High Yield Bond Fund [50]	29.50
	Stanlib Enhanced Yield Fund [51]	25.55

Moderately conservative	Allan Gray Stable Fund [52]	20.12
	Coronation Balanced Defensive Fund [53]	20.46
	Momentum Diversified Income Fund [54]	27.02
	Prudential Enhanced Income Fund [55]	23.54
	Stanlib Balanced Cautious Fund [56]	17.76
Moderate	Allan Gray Balanced Fund [57]	14.77
	Coronation Balanced Plus Fund [58]	19.10
	Momentum Odyssey Moderate Aggressive [59]	16.76
	Prudential Balanced Fund [60]	20.12
	Stanlib Balanced Fund [61]	17.49
Moderately aggressive	Allan Gray-Orbis Global Fund of Funds [62]	12.81
	Coronation Market Plus Fund [63]	16.43
	Momentum Aggressive Growth Fund [64]	13.46
	Prudential Enhanced SA Property Tracker Fund [65]	-14.26
	Stanlib Global Balanced Feeder Fund [66]	39.67
Aggressive	Allan Gray Equity Fund [67]	11.19
	Coronation Top 20 Fund [68]	20.12
	Momentum Equity Fund [69]	13.20
	Prudential Equity Fund [70]	15.76
	Stanlib Equity Fund [71]	16.96

The performance of the JSE all share index and the unit trusts give testimony to the difficulties in the South African equities market during the testing period. The JSE all share index achieved a meager ROR of 9.04%, compared with a reasonable three-year ROR of 17.09% [43]. Despite this unsatisfactory performance, from the results given in Section 4.1 it is evident that the market significantly outperformed the portfolios selected by the Markowitz, risk-adjusted, and exclusion models.

The performance of the unit trusts echoes the turbulence of the market. The conservative and moderately conservative unit trusts outperformed the higher-risk categories. These higher-risk funds — especially in the aggressive category — were more heavily invested in shares than their conservative counterparts. With the exception of 'global' funds, the majority of the shares were from companies listed on the JSE. Notwithstanding that, 24 of the 25 unit trusts outperformed all of the Markowitz, risk-adjusted, and exclusion portfolios by generous margins.

In contrast with the above results, all of the portfolios selected by the integration model achieved higher ROR values than the JSE all share index and any of the unit trusts that fall into the same risk category. Furthermore, for the moderately conservative, moderate, and aggressive risk categories, the selected portfolios outperformed the unit trusts by at least 20 percent, which is substantial. Thus, it is clear that this model significantly outperformed the market as well as existing investments, making these portfolios not only attractive but also preferable over the market and unit trusts.

As with the results presented in the preceding sections, these results clearly indicate that, of all of the models considered in this paper, integration model is by far the superior model. The results indicate that the inclusion of an SRI objective in the model formulation leads to the the selection of robust and agile portfolios that are able to navigate uncertain market conditions to produce highly desirable investments. Furthermore, these results provide additional evidence for the superiority of ESG integration over exclusion.

The vast contrast in performance between the unit trusts and the majority of this study's portfolios is ascribed to three fundamental differences between the theoretical models and the practice of investment. Firstly, unit trusts are much more diversified than the historical dataset in this study allowed, including lower-risk investments such as bonds and companies listed on foreign exchanges. During the testing period, these instruments mitigated the losses in the South African market. Secondly, unit trusts are frequently rebalanced, especially in volatile times, in pursuit of maximising ROR. Finally, fund managers also take qualitative market information, intuition, and experience into account, which can not be quantified in portfolio selection models.

4. CONCLUSION

The selection of an investment portfolio must take into account a number of competing objectives if it is to produce robust portfolios. Maximising returns and liquidity while minimising risk are the salient objectives in the portfolio-selection literature. More recently, investor sentiment has also required that portfolios adhere to SRI principles. This study has sought to address three areas of improvement in the portfolio selection research.

Firstly, an individualised approach was suggested that matches an individual's risk tolerance with a portfolio's overall risk instead of merely minimising the portfolio risk measure. Secondly, to extend the individualised approach, it was proposed that SRI principles should also be incorporated by excluding companies that are regarded as sin shares. Thirdly, an empirical study was conducted to compare the exclusion and ESG integration SRI methods. These three individualised models were tested against a Markowitz model with a generic risk goal and no SRI criteria. Using a seven-year empirical training dataset from the JSE, portfolios were selected for a range of simulated investors, using these four models. Two stochastic approaches, the EV method and CCP, were used to solve each model.

Given that investors are interested in their future returns, this study analysed the performance of the portfolios during an uncertain future period. The best-performing model during the testing period was the integration model that was solved using the CCP method. For the Markowitz, risk-adjusted, and exclusion models, all of the portfolios produced disappointing returns. The collective performance of these portfolios was dismal, with many losing money during the testing period. Not even the turbulent conditions of the South African equities market during the testing period could fully justify these results. The JSE all share index and South African unit trusts, which were exposed to the same turbulence, outperformed the portfolios by a generous margin.

It is true that three fundamental differences between the unit trusts and the model portfolios cannot be accommodated in current portfolio selection models. These differences hint at important future research in order to close the gap between theory and practice:

- Datasets used to test portfolio selection models should be as broadly representative as the datasets available in practice;
- Models should rebalance dynamically during the testing period. This suggestion is supported by the conclusions of He *et al.* [39]; and
- Qualitative factors and intuition must, somehow, be incorporated into prescriptive models.

The most significant contribution of this study is an empirical comparison of the exclusion and ESG integration SRI techniques. This study shows categorically that the argument made in favour of ESG integration and against exclusion has merit. Given that all other factors remain constant, ESG integration is by a reasonable margin superior to exclusion. As an extension of this study, the effects of exclusion and ESG integration on the traditional Markowitz model could be explored and investigated.

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