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Research Article

Sustainable Portfolio Optimization Model Using PROMETHEE Ranking: A Case Study of Palm Oil Buyer Companies

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Sustainability is one of the main concerns of decision makers, factories, and retailers. This importance increases when the organization needs to define, implement, and manage a sustainable portfolio to succeed in today's environment of change and uncertainty. Therefore, this study examines the portfolio of palm producers from 2010 to 2020. The proposed optimization model is based on the classic mean-variance approach and companies ranked using the PROMETHEE method. Our findings indicate that the effects of this asset allocation change in favour of high-score sustainability investments significantly influence risk-adjusted returns of portfolios. According to the finding, sustainable portfolios perform better than conventional ones. The findings could be useful to private and institutional investors and fund managers in constructing and managing their portfolios. The efficient frontier of the best 50% portfolio shows a higher risk for a higher return. This could explain that a higher sustainability score in different criteria leads to more optimal portfolios in terms of risk and return. Intended contributions include considering sustainability, minimizing risk, and portfolio management simultaneously.

1. Introduction

Sustainability means focusing on the long-term effects of the company's operations and the durability of resources for future use while being profitable today [1]. The extension of sustainability has now been added to many organizational topics [2]. These concepts are intended to emphasize the importance of social and environmental concerns along with economic factors in planning [3]. Also, the financial market globally has had a lot of growth in sustainable investment as sustainable investors seek their usefulness from financial returns and the social effects of their investment [4, 5].

Portfolio risk is an event with uncertain conditions that has both positive and negative effects on one or more objectives (Al Janabi, 2020). A risk may have one or more reasons, and if it does occur, it may have a positive or negative impact on portfolio success [6]. Risk management is a structured process for evaluating and analyzing portfolio risks with the goal of investing in potential opportunities and adjusting events, activities, or phrases that can affect the portfolio [7, 8].

Risk management is critical where the dependencies between portfolio components are high, where the cost of failure of portfolio components is high, or when the risks of one portfolio component increase the risks of other components. Risk management identifies and describes potential improvements in the performance of portfolio components that may increase quality, customer satisfaction, and service levels for the organization and portfolio components. Risk management may create new portfolio components. The purpose of portfolio risk management is to accept the correct amount of risk estimates by optimally delivering outputs at different times to the organization [9, 10].

The concept of sustainability was first introduced in the 1970s and early 1980s but was generally defined in the 1892 report of the World Commission on Environment and Development. Various definitions of sustainability have been proposed. One of the most complete definitions of the

World Commission on Development and Environment is sustainability, which is based on the definition that "sustainability is the use of resources to meet the needs must be such that the needs of future generations are not endangered" [11].

The term sustainability is becoming increasingly accepted in the business community, and the number of companies publishing sustainability reports is increasing. Zhang et al. [12] state that according to a report in 2016, about 79% of the 250 global companies have published separate annual reports on sustainability that address environmental, social, and economic issues.

Palm oil, the world's most widely consumed edible oil, hit a record high in October and grew in 2021 for the third year in a row. This added to concerns about global food price inflation as the supply chain suffered from adverse weather conditions, the COVID-19, and labor shortages. Prices are expected to remain high in the first quarter of 2022 [13].

Recently, sustainability has become an important concern of many manufacturing, retail, and hospitality industries, particularly among companies of palm-based products, as the result of the increasing international pressure and demand on sustainable production [14]. It is also considered an effective solution to advance the constant development and extension of the manufacturing industry [15]. Palm oil is among the top 17 oils and fats used as an ingredient in different products available in the supermarket, while consumers' perception of palm oil as a product ingredient is limited [16]. Despite the wide range of applications of palm oil, there have always been controversies about the environmental and social consequences of its production, processing, and trade. High oil yield by the palm trees has encouraged wider cultivation, leading to the clearing of forests in many parts of Indonesia and Malaysia for the availability of space for oil-palm monoculture [17]. Figure 1 shows the distribution of palm-based product companies based on the country of origin. The largest number of companies are in Europe, and then the U.S. and Asia are ranked next.

Recently, several largest multinational firms developed some awareness with respect to social and environmental losses [18]. Nevertheless, the implementation of sustainable palm oil principles remains voluntary. Though, some previous studies observed no significant difference between sustainable and nonsustainable investment returns [19, 20]. Most of the literature on sustainable investment compared the returns of either singular assets or of actively or passively managed portfolios, usually after accounting for the effects due to investment style [21]. The main issue of sustainable portfolio optimization is how to choose a set of reasonable asset weights while considering sustainability. It is unclear whether adopting sustainability standards affect the risk-adjusted return in an optimal portfolio.

The findings of the study contribute to the literature by shedding light on the influence of sustainability investment on risk-adjusted returns of portfolios. Moreover, the findings enable investors to realize the influence of the sustainability factor on portfolio performance and consequently make better investment decisions. Companies of palm-based products also benefit from the findings of the study by understanding the role that sustainable practices can play in their stock price. This paper has been organized as 5 sections. Introduction and literature review section have been presented in first and second sections. Methodology and results sections have been presented in sections 3 and 4. Finally, the conclusion section has been presented in section 5.

2. Literature Review

Palm oil is an oil from the kernel of the palm fruit. The largest supplier of this oil is Malaysia, which is used as a cholesterol-free oil in most African countries. The Worldwide Fund for Nature (WWF)'s palm oil scorecard provides insight into palm oil buyer firms' strategies and endeavours with respect to resolving environmental issues caused by palm oil production. The following is a summary of the literature review:

Momenitabar et al. [22] presented a model for sustainable closed loop supply chain. The main contribution is considering lateral resupply and backup suppliers. Also, they forecast demand using the fuzzy inference system. Ortiz–Sanchez and Alzate [23] presented a sustainable biomass supply chain model. They described some indexes based on environmental, social, and economic aspects. The main contribution of the paper was describing criteria for biomass upgrading selection. Tseng et al. [24] presented a new mathematical model for the textile industry. The contributions of their research were considering industrial disruption and ambidexterity. The fuzzy Delphi method is used to validate the proposed model.

Ghasemi et al. [25] presented a model for medical tourism destination decision. Considering sustainability is one of the contributions of their paper. They solved the model using the Fuzzy SWARA-PROMETHEE algorithm. The weights of the criteria were determined using the fuzzy SWARA algorithm, and the medical tourism destinations were ranked using the PROMETHEE method.

Khan et al. [26] presented a model for sustainable portfolio optimization. Considering the risk-taking behavior of investors is the main contribution of their paper. The results show that as portfolio allocation weights increases, the risk of portfolio increases. Also, results show that a portfolio with inclusion of skewness is sustainable.

Fang et al. [27] presented a sustainable portfolio model considering climate change. Considering risk management and pricing are the contributions of their paper. They used an integrated assessment model to optimize the portfolio. The results show that as price increases, the risk value increases.

Yu et al. [28] presented a value-at-risk model for crude oil portfolio. They extremely use value theory to model the considered problem. The main contribution is considering the expected shortfall of oil companies. Results show that as the demand increases, the risks increase.

Austin et al. [29] presented a sustainable oil palm model considering conservation value approaches. The considered case study was oil palm cultivation in Gabon. The main objective of their research was minimizing the negative

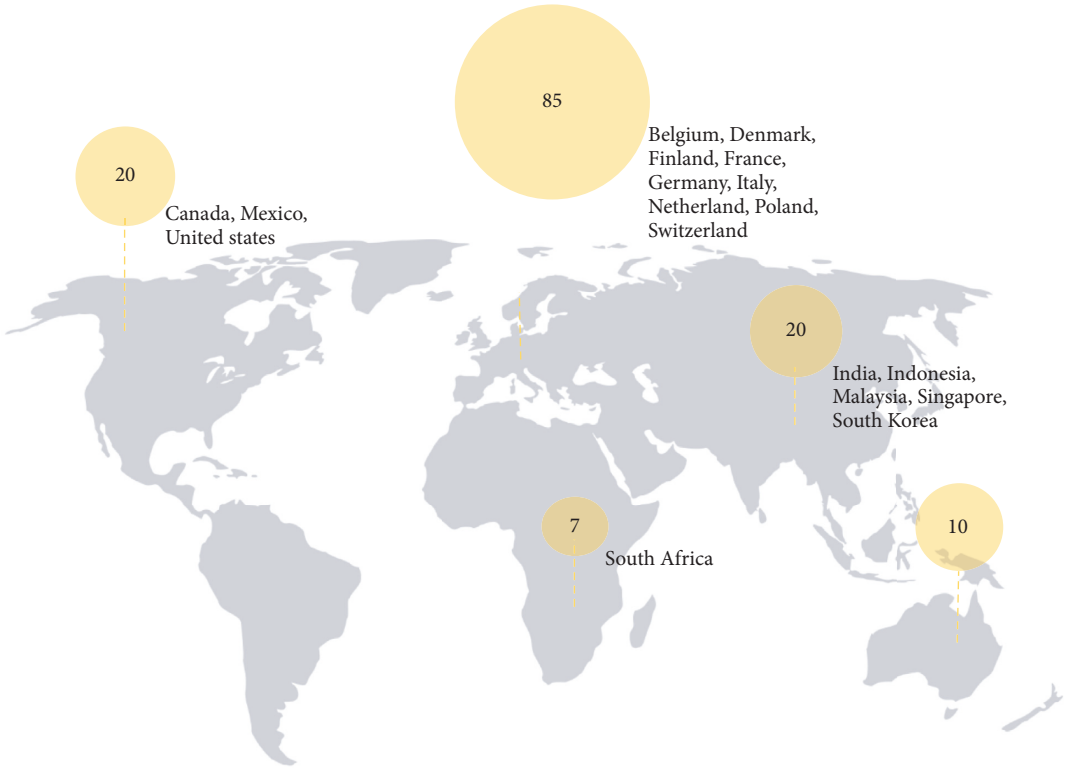

Figure 1: Distribution of palm-based product companies-based country origin (WWF palm oil buyer score card, 2021).

environmental impact. The results show the suitable performance of the presented model.

Due to literature review, the contributions of our paper include considering sustainability, minimizing risk, and portfolio management simultaneously.

Figure 2 presents the share of respondents who meet the key sustainability criteria for different sectors, including manufacturing, retail, and hospitality. Manufacturers of palm-based products conquer the average with respect to including policies and schemes to guarantee supplier accountability and compliance. For instance, 61% of manufacturers expect suppliers to implement deforestation-free and/or conversion-free procedures, while 48% need suppliers to verify their palm oil supply chain plant.

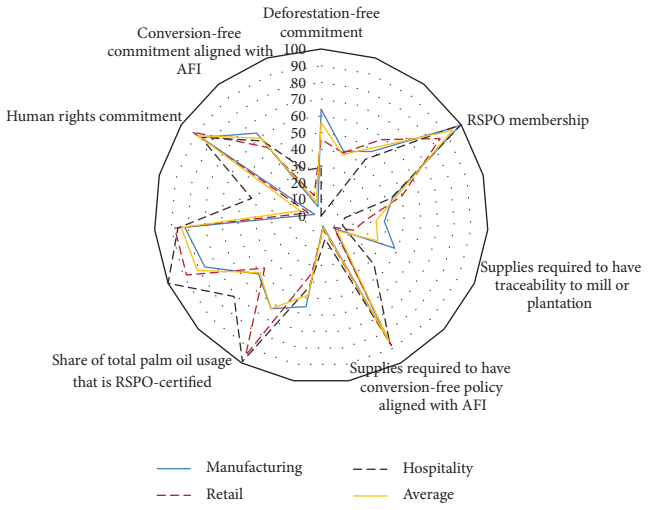

Figure 2: Share of palm oil buyer companies who meet key sustainability criteria by sector (data from WWF palm oil buyer scorecard, 2021).

3. Methodology

To investigate the significance of the sustainability score in stock market value and optimal investment portfolio, we adopted the modern portfolio theory (MPT) within a three-step framework (Figure 3). The first step includes extracting the historical data of monthly adjusted close prices for each stock. In the second step, we calculate the variance-covariance matrix based on the value of the monthly return of each stock and the average return of each stock. The expected return and risk of the optimal portfolio are then estimated using a simulation method based on the Markowitz model.

3.1. Data. There are several palm oil buyer companies available worldwide. However, the focus of this study is to evaluate the impact of the sustainability score on the performance of companies of palm-based products as the buyers of palm oil (palm oil buyer scorecard, 2020). Figure 4 illustrates the performance of the companies in individual sectors that includes 61% manufacturers such as Ferrero, Henkel, PepsiCo, Johnson $ Jonson, and others. In the next rank, there are 35% of suppliers including 35% retailers such as IKEA, Carrefour, Marks and Spencer, and some hospitality companies (%4) such as McDonald's corporation, SODEXO, and Greggs.Companies are ranked by using the PROMETHEE method according to the score they have

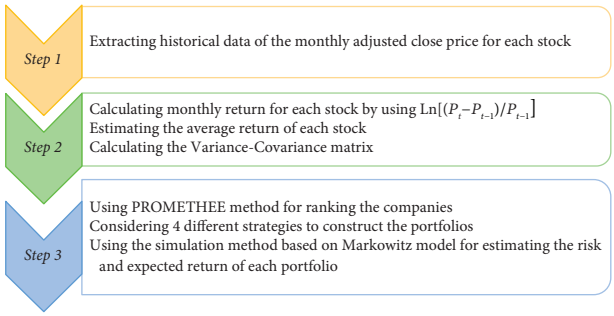

Figure 3: The framework of methodology.

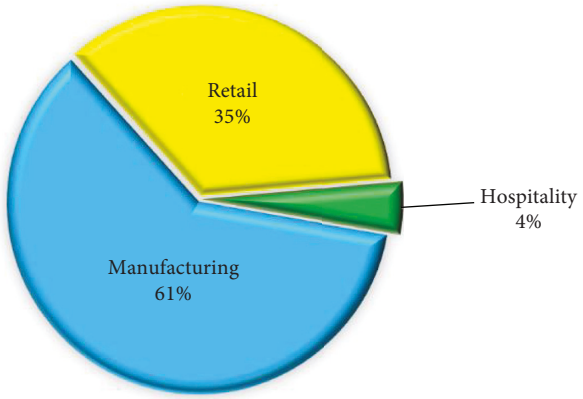

Figure 4: Performance of the companies in individual sectors.

achieved in each criterion. The palm oil buyers' scorecard evaluates a varied selection of companies worldwide. Accordingly, the data regarding the monthly closure prices for 70 stocks of companies of palm-based products from 1st January 2010 to 10th September 2021 were investigated. A description of the selected companies of palm-based products is presented in Table 1. The following analysis and outcomes of this paper are based on the historical data of the stock price that was downloaded from http://finance.yahoo.com.

Figure 5 presents the palm oil volumes captured by countries. The highest amount of palm oil volume captured belongs to Europe, followed by North America, Asia, Africa, and Australia.

3.2. Promethee. To calculate the ranking of the companies according to their scores in each criterion, including commitments, sustainable palm oil purchasing, supplier accountability, sustainability platforms, and on-the-ground action, the PROMETHEE method is applied.

The deviations between two alternatives with respect to j the criterion is as (1) [30]:

$$d_j(a,b) = f_j(a) - f_j(b) \quad j = 1, 2, \ldots, k. \tag{1}$$

Applying the preference function using (2) and (3)

$$P_j(a,b) = F_j\left[d_j(a,b)\right], \quad j = 1, 2, \ldots, k, \tag{2}$$

$$0 \le P_j \le 1 \cdots j = 1, 2, \ldots, k. \tag{3}$$

Table 1: Screened and nonscreened Portfolios.

Screening approach	Number of companies
All stocks, no screening	70
Best 80%	56
Best 50%	35
Best 20%	14

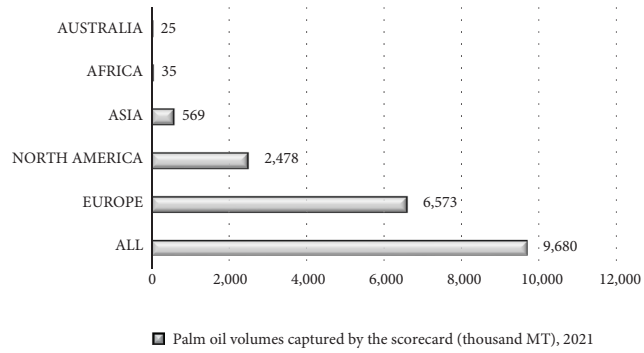

Figure 5: Palm oil volumes captured by countries, 2021.

The overall multicriteria preference list $\pi(a,b)$ is denoted as (4) [31]:

$$\pi(a,b) = k\sum_{j=1}^{k} W_j P_j(a,b), \quad j = 1, 2, \ldots, k. \tag{4}$$

where W_j represents the weight of the criterion j. The incoming flow phi−, which indicates the outranked character of the alternative "a", can be represented as follows [32]:

$$phi^{+}(a) = \sum_{x \epsilon A} \pi(x,a), phi^{-}(a) = \sum_{x \epsilon A} \pi(a,x). \tag{5}$$

(6) expresses the overall preferred degree of the alternative "a".

$$\varnothing(a) = \varnothing^{+}(a) - \varnothing^{-}(a). \tag{6}$$

3.3. Portfolio Construction and Screening. The main concern of sustainable portfolio optimization is to select the best set of rational asset weights whilst taking the sustainability score into account. The modest and effective approach to incorporate sustainability constraints in a portfolio decision is screening. Generally, the portfolio risk is calculated as the market risk while the number of involving assets in the portfolio approaches infinity. However, there is no consensus on the best number of assets to be included in the portfolio that eliminates the nonsystematic risk. Statman et al. [33] believe that a suitable portfolio could be constructed with 30 and 40 stocks for a borrowing and lending investor, respectively. However, a complete diversification impact could be obtained with only 18 stocks or more in the portfolio if the investments are allotted within different asset classes [34].

To examine the role of including the sustainability score in optimal portfolio decision-making, we performed the screening procedure to construct four different portfolios. A partial screening approach is applied, where a predetermined proportion of the companies is excluded from the investment universe. We performed three levels of partial screening at 20%, 50%, and 80% levels, where companies with a lower sustainability score at the bottom of the list will be excluded. The fourth portfolio contains all the available stocks in the investment universe with no screening. Table 1 presents the screening approach and number of companies included in each portfolio.

To attain the objective of the study, all the companies are selected from manufacturers of palm-based products. Thus, sector properties or the company size are not considered while constructing these four portfolios. The selection procedure is based on the sustainability score, where the best 20% portfolio consists of the stocks with the highest sustainability score. The best 20% portfolio consists of fourteen stocks which is less than the required number of stocks for a complete diversification impact [34, 35]. Nevertheless, we consider these portfolios interesting from an appraisal viewpoint to examine the possibility of diminishing diversification impact with a small number of stocks.

3.4. Markowitz Model. Prior to modern portfolio theory, the investors' concern was the individual securities' risk and return, where the investment decisions were made by investing in securities with the highest return and lowest risk. This approach has changed following the introduction to modern portfolio theory. Harry Markowitz, in his seminal Portfolio Selection in 1952 known as modern portfolio theory, pursues to generate a greater possible return for a certain level of risk or returns in the lowest possible risk for a particular level of return. In fact, investment decisions are made based on the assessment of the total portfolio risk and not to build a portfolio of preselected individual securities. Hence, the modern portfolio theory underlines the association between the attributes of the assets rather than the individual assets' qualities [36].

The main assumption in modern portfolio theory is that the securities' return is a set of random variables which could be estimated for a specific period. The mathematical characteristic of return allows us to estimate the investment risk based on the standard deviation of return. The expected return of the portfolio is represented by a linear combination of the returns for all assets involved in the portfolio. The portfolio risk is then estimated based on a nonlinear standard deviation and correlations of the individual assets' return, known as portfolio standard deviation. Markowitz's theory is based on the diversification effect which assumes that the higher the number of assets in the portfolio, the greater the corresponding number of covariances and therefore the lower the portfolio risk. This assumption is based on the heightening of the significance of the correlations between the assets which influences the portfolio risk more than the effect of individual assets' risk. The mathematical representation of Markowitz model also known as the mean-variance model is shown as follows(see [37]).

$$\begin{aligned} \max E\left(r_p\right) &= \max \sum_{i=1}^{n} w_i \mu_i, \\ \min \sigma_p &= \min \sqrt{\sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j \sigma_{ij}}, \\ 0 \le w_i \le 1, &\quad i = 1, \ldots, n, \end{aligned} \tag{7}$$

where ω_i is the weight of capital to be invested in the asset. i r_i is the return on the asset. i μ_i is the expected return on the asset. i μ_{ij} is the covariance between the return on assets i and j. $E(r_p)$ is the expected return of the portfolio. σ_p is the standard deviation or risk of the portfolio.

Rate of return or the percentage of gain or loss on the investment is calculated by the formula, see [38]:

$$r_{it} = \frac{P_{it} - P_{it-1}}{P_{it-1}}, \tag{8}$$

where P_{it} refers to the price of stock i at time t, and P_{it-1} refers to the price of stock i at time $t-1$.

Then, the expected return of the asset i, $i = 1, \ldots, n$, is calculated by

$$\mu_i = E\left(r^i\right) = \frac{\sum_{t=1}^{m} r_t^i}{m}, \tag{9}$$

where r_{it} is the return on the asset i between periods $t-1$ and t, and for a specific period of time (m), we have $t = 1, \ldots, m$.

The following formula presents the variance for asset i:

$$\sigma_i^2 = Var\left(r^i\right) = \frac{\sum_{t=1}^{m} \left(r_t^i - \mu_i\right)^2}{m-1}. \tag{10}$$

To measure the level of risk of assets, investors often use standard deviation [32] which is recognized as the most popular indicator for risk of assets. Standard deviation determines the dispersion around the expected returns, which is calculated as follows:

$$\sigma_i = \sqrt{\sigma_i^2} = \sqrt{\frac{\sum_{t=1}^{m} \left(r_t^i - \mu_i\right)^2}{m-1}}. \tag{11}$$

While constructing a portfolio consisting of different assets, dimensions of risk are structured in the return covariance matrix represented by $\Omega_{n\times n}$. This matrix includes variances in its principal diagonal and covariances between all pairs of assets.

$$\Omega_{n\times n} = \begin{pmatrix} \boldsymbol{\sigma}_1^2 & \cdots & \boldsymbol{\sigma}_{1n} \\ \vdots & \ddots & \vdots \\ \boldsymbol{\sigma}_{n1} & \cdots & \boldsymbol{\sigma}_n^2 \end{pmatrix}. \tag{12}$$

We calculate the covariance as (8):

$$\sigma_{ij} = COV\left(r^i, r^j\right) = \frac{\sum_{t=1}^{m}\left(r_t^i - \mu_i\right)\left(r_t^i - \mu_j\right)}{m}. \quad (13)$$

3.5. Performance Measurements. We applied risk measures to evaluate the portfolios' performance, which is essential to compare the constructed portfolios and analyse the findings properly. The Sharpe ratio is one of the most consistent assessments of performance given that it determines the surplus return, $r_p - r_f$, per unit of risk, σ_P. The greater the Sharpe ratio, the better the risk-adjusted return is attained [39].

$$\text{Sharpe} = \frac{r_p - r_f}{\sigma_p}. \quad (14)$$

To explain more about the Sharpe ratio, let us suppose that we have a portfolio, and we are trying to add a particular stock to our investment portfolio of risky assets. If we can borrow and lend at the risk-free rate, we would add the stock if it can improve the portfolio's Sharpe ratio. Using this law, we arrive at the risk-return equilibrium relationship by the capital asset pricing model. The expected excess return is called the risk premium [40].

We estimated the risk-free rate based on the average monthly 1-month treasury for countries which are included in the research, that equals to 0.49%.

3.6. Simulation Optimization Model. The development in computer science over the last decade has provided the opportunity of application of optimizing simulation models. This advancement presents one of the extremely exciting possibilities in simulation. Compared with traditional portfolio optimization models, simulation optimization can cope with more scenarios and schemes. The simulation optimization model might outperform the traditional optimization technique due to its capability of forecasting the aimed outcomes as various sources of risks, and multiple constraints are employed [41]. The statistically significant outcomes are in fact the results of two discrete functions based on a metaheuristic search algorithm. The optimization model applies the outcomes from the simulation model within an aligned operation. The simulation model provides the best outcomes for the optimizer based on a proper determination of the probability distributions. Next, another group of inputs are created by the optimizer. These values will be later assessed by the simulation model. The simulation model will repeat this procedure for almost 10,000, which produces a distinctive value in every round with the aim of achieving the global optimum.

In this study, we applied Crystal Ball opt Quest as it provides all the necessary attributes to perform proper simulation optimization. Based on a spreadsheet risk analysis model, we investigated the impact of several unique inputs on the outputs using the spreadsheet estimation and simulation method. The inputs were calculated according to their statistical distribution. To perform the simulation model, we employed the Monte Carlo model to produce arbitrary and independent values required for the simulation model [42, 43].

Table 2: Risk, return, and the maximum Sharpe ratio of portfolios.

Period	All	Best 80%	Best 50%	Best 20%
2015	−0.00328	0.010	0.0119	−0.0003
2016	0.01591	0.009	0.0105	0.009
2017	0.01095	0.012	0.0160	0.020
2018	−0.01037	−0.012	−0.0060	0.003
2019	0.01025	0.020	0.0244	0.025
2020	0.01730	0.017	0.0049	0.011
Mean return	0.012	0.013	0.014	0.014
Min stdv	0.044	0.024	0.024	0.014
Sharpe ratio	0.16	0.33	0.38	0.65

Based on the data collected from WWF, four experimental portfolios have been created. Each portfolio contains a specific number of stocks according to the sustainability score of the company (Table2). Each company is determined based on its historical stock value over the past 10 years in the experimental portfolio set. Then, the best distribution for each strategy is calculated using the historical data and statistical computing mechanism of Oracle Crystal Ball Simulation.

4. Results and Discussion

The effectiveness of the proposed approach was tested from two aspects. On the one hand, we examined the excess returns of the proposed portfolios constructed based on the screening over the investment horizons from 2015 to 2020. On the other hand, we constructed and compared the efficient frontiers for these portfolios.

Companies ranked using the PROMETHEE method, and the results are shown in table (C. Table 3). Figure 6 illustrates the GAIA chart of ranked companies based on 5 criteria including C1: commitments, C2: sustainable palm oil purchasing, C3: supplier accountability, C4: sustainability platforms, and C5: on-the-ground action.

As shown in Figure 7, the actions are marked with points, and the criteria are marked with vectors. As it turns out, the criteria of sustainable palm oil purchasing and on-the-ground action are in conflict. Commitments and sustainability platforms are also in line with the decision brain. According to the GAIA chart, the second action is selected as the best action.

Table 2 reports the excess returns of the constructed portfolios. The first portfolio called "All" consists of 70 companies, and the others have been reduced according to the screening level with best 80%, best 50%, and best 20% sustainability scores. The mean and volatility of annual excess returns and Sharpe ratios are also examined and reported in Table 2. The findings based on the risk and return of the tangency portfolio reveal that the portfolio's movements are close but incomparable.

The highest values are shown in bold. The portfolio of the best 20% provides the maximum average return, implying a significant linkage between the financial performance and the sustainability score.

Table 3: Companies ranked using the PROMETHEE method.

	Company name	Action ranking	Phi	Phi+	Phi−
C1	Coop Switzerland (2,033 MT)	2	0.5159	0.5971	0.0812
C2	John Lewis Partnership (2,252 MT)	1	0.4957	0.6029	0.1072
C3	Ferrero (220,570 MT)	3	0.4261	0.5304	0.1043
C4	IKEA (29,000 MT)	4	0.4000	0.5014	0.1014
C5	Mars, Inc. (64,416 MT)	9	0.3971	0.5536	0.1565
C6	Cerealia (20,429 MT)	5	0.3913	0.5478	0.1565
C7	Kaufland stiftung & Co. KG (2,989 MT)	10	0.3855	0.5478	0.1623
C8	The Co-operative Group (7,431.6 MT)	17	0.3681	0.5391	0.1710
C9	Beiersdorf (28,601 MT)	14	0.3507	0.5275	0.1768
C10	The Hershey Company (32,566 MT)	36	0.3420	0.5304	0.1884
C11	Arla Foods (39, 329 MT)	12	0.2870	0.4957	0.2087
C12	The Estee Lauder Companies Inc. (3,614.7 MT)	59	0.2841	0.4435	0.1594
C13	REWE Group (8,048 MT)	8	0.2667	0.4812	0.2145
C14	Legacy DuPont Nutrition and Biosciences (100, 743 MT)	6	0.2406	0.4580	0.2174
C15	Continental Bakeries B.V. (12, 484 MT)	16	0.2029	0.4029	0.2000
C16	Danone (67,231 MT)	20	0.1797	0.3913	0.2116
C17	Unilever (810,437 MT)	7	0.1739	0.4290	0.2551
C18	Migros (19,659 MT)	13	0.1507	0.3884	0.2377
C19	Upfield Europe B.V. (243,225.5 MT)	29	0.1333	0.3681	0.2348
C20	L'Oreal (83,383 MT)	25	0.1275	0.3652	0.2377
C21	Kerry Foods (11,929 MT)	30	0.1188	0.3884	0.2696
C22	ALDI Sud (Hofer) (91,355 MT)	42	0.1130	0.4290	0.3159
C23	EDEKA Zentrale (11,004 MT)	22	0.0899	0.3507	0.2609
C24	Carrefour (6,127 MT)	32	0.0841	0.4174	0.3333
C25	Pepsico Inc. (451,136 MT)	11	0.0841	0.3971	0.3130
C26	Rossmann (5,369 MT)	15	0.0812	0.3826	0.3014
C27	Tesco Plc. (31,714 MT)	18	0.0754	0.3507	0.2754
C28	Kellogg Company (65,232.9 MT)	26	0.0667	0.3391	0.2725
C29	Henkel AG & Co. LGaA (109,913 MT)	43	0.0493	0.3623	0.3130
C30	*Lotus* Bakeries	28	0.0435	0.3275	0.2841
C31	Johnson and Johnson (52,525.1 MT)	19	0.0406	0.3710	0.3304
C32	SODEXO (2,932 MT)	53	0.0377	0.4435	0.4058
C33	Saputo Dairy UK (29,161 MT)	39	0.0203	0.3391	0.3188
C34	Nairn's Oatcakes Ltd (1,239.6 MT)	24	0.0174	0.3246	0.3072
C35	Barry Callebaut (76,965 MT)	45	0.0029	0.3391	0.3362
C36	Toms Group (85 MT)	21	0.0029	0.3652	0.3623
C37	Young's Seafood Ltd. (592.2 MT)	35	−0.0029	0.3043	0.3072
C38	Marks & Spencer (5,469 MT)	46	−0.0203	0.3159	0.3362
C39	Sainsbury's (11,876 MT)	67	−0.0261	0.2928	0.3188
C40	Royal FrieslandCampina (131,747 MT)	37	−0.0493	0.3072	0.3565
C41	Zeelandia H.J. Doeleman b.v. (3,506 MT)	31	−0.0522	0.3246	0.3768
C42	LIDL (87,662 MT)	65	−0.0696	0.3159	0.3855
C43	Premier Foods (13,375 MT)	27	−0.0783	0.2986	0.3768
C44	Groups Casino (2,679.7 MT)	23	−0.0870	0.2899	0.3768
C45	Colgate-Palmolive Company (204,616 MT)	38	−0.1014	0.2870	0.3884
C46	Oriflame Cosmetics (3,648 MT)	44	−0.1014	0.2783	0.3797
C47	Procter & Gamble (604,011 MT)	34	−0.1043	0.3275	0.4319
C48	ALDI Nord (30,238 MT)	61	−0.1188	0.3130	0.4319
C49	Brioche Pasquier (3,909 MT)	47	−0.1217	0.2522	0.3739
C50	Bahisen Family (13,707 MT)	50	−0.1391	0.3043	0.4435
C51	Fraser and Neave, Limited (44,000 MT)	49	−0.1623	0.2986	0.4609
C52	Nestle SA (452,719 MT)	48	−0.1797	0.3043	0.4841
C53	Dragsbaek A/S (26,771 MT)	41	−0.1913	0.2899	0.4812
C54	Dm-drogerie-market (11,684 MT)	57	−0.2058	0.2290	0.4348
C55	Denis Asia Pacific Pte Ltd (Ayam Brand) (698 MT)	51	−0.2087	0.2464	0.4551
C56	Lutosa SA (9,880)	52	−0.2116	0.2029	0.4145
C57	Asda Stores Ltd (17,693 MT)	55	−0.2580	0.2406	−0.4986
C58	BASF (441,108 MT)	54	−0.2667	0.2580	0.5246
C59	COOP Denmark (825 MT)	63	−0.2783	0.2203	0.4986
C60	Aigremont (29,032 MT)	56	−0.2928	0.2348	0.5275
C61	Wm Morrison Supermarkets plc (13,861 MT)	40	−0.2957	0.2319	0.5275
C62	Amorepacific (23,064 MT)	69	−0.3130	0.2000	0.5130

Table 3: Continued.

	Company name	Action ranking	Phi	Phi+	Phi−
C63	REMA 1000 Denmark (2,109 MT)	33	−0.3159	0.2290	0.5449
C64	Colruyt Group (112,600 MT)	60	−0.3217	0.2000	0.5217
C65	AAK AB (1,238,493 MT)	62	−0.3710	0.2203	0.5913
C66	Bayer AG (13,384 MT)	64	−0.3797	0.2232	0.6029
C67	Puratos Group NV (97,128 MT)	68	−0.3797	0.2348	0.6145
C68	S Group (1,443 MT)	66	−0.4145	0.1797	0.5942
C69	Chocoladefabriken Lindt & Sprungli AG (6,944 MT)	70	−0.4348	0.1884	0.6232
C70	2 Sisters Food Group (16,317 MT)	58	−0.4928	0.1275	0.6203

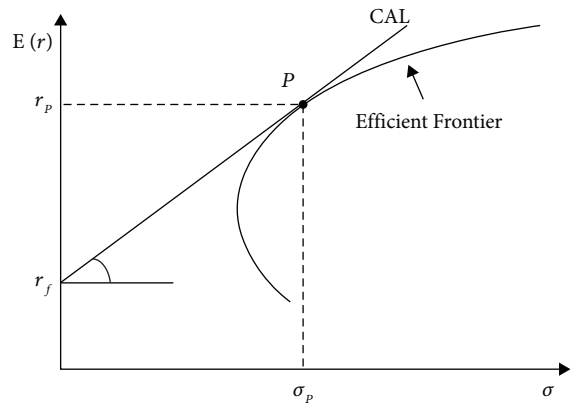

Figure 6: Sharpe ratio and CAL definition.

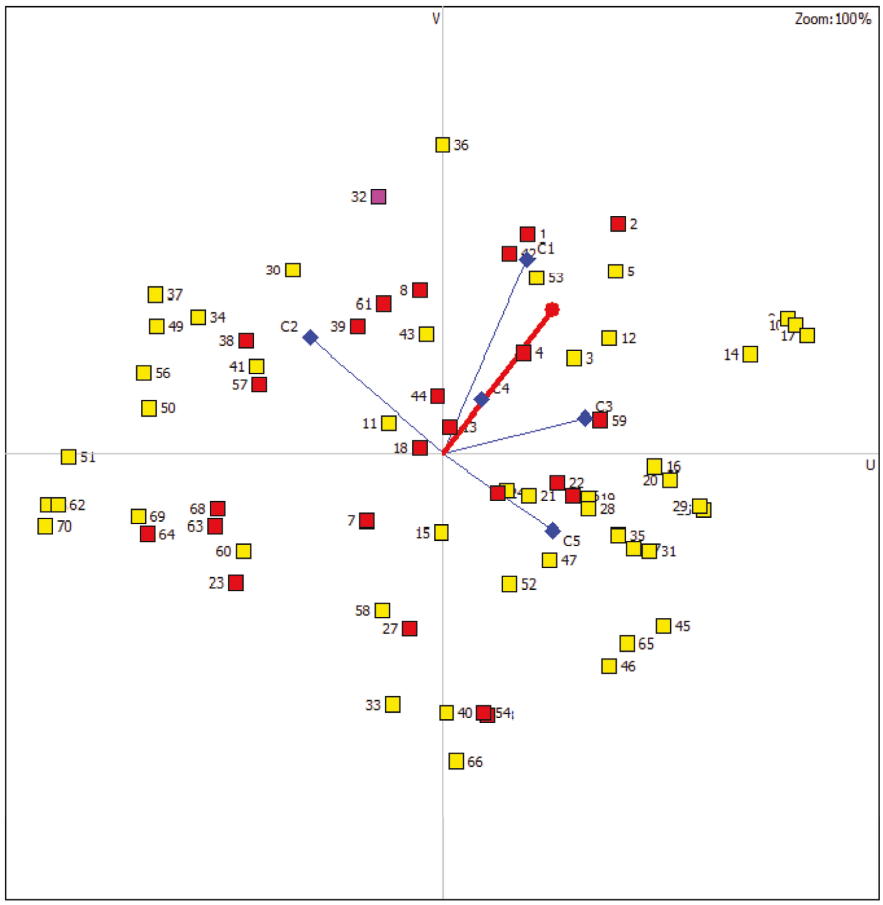

Figure 7: The GAIA analysis.

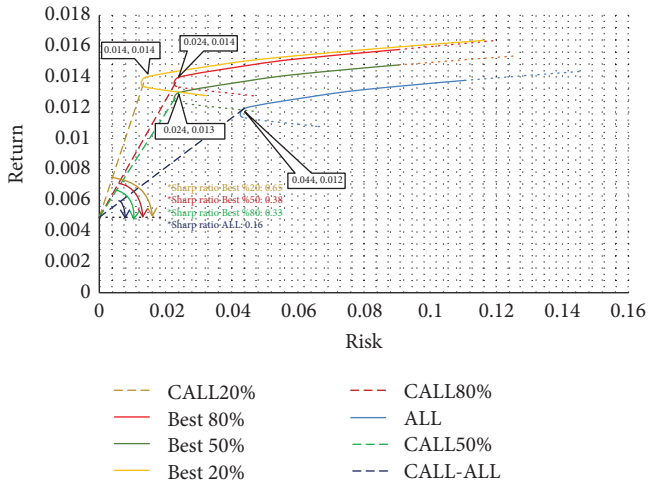

Figure 8: Efficient frontiers for screened and nonscreened portfolios.

For the means of the annual excess returns, Sharpe ratios of the best 20% portfolio are the best over the sample period. The observed Sharpe ratios for this period show that, in general, higher restrictions lead to a slightly lower risk-adjusted return.

To broaden the perspective and leave the portfolios with target volatility behind, we further construct the efficient frontiers of these portfolios. Figure 8 shows the efficient frontiers for different portfolios according to the screening levels. The differences between the efficient frontiers tend to be significant, particularly between screened and nonscreened portfolios. The screened portfolios of the best 20% and best 50% are identical and turn out to be the most efficient frontiers. However, the efficient frontier of the best 50% portfolio shows a higher risk for a higher return. This could explain that a higher sustainability score in different criteria leads to more optimal portfolios in terms of risk and return. On the other hand, the nonscreened portfolio including all the stocks presents a less efficient frontier compared with all other portfolios. This finding confirms the existence of material return or material increase in risk if sustainability scores are included in the asset allocation process.

Figure 8 also presents the Sharpe ratio for each efficient frontier. The slope of the intersection of the CAL (Capital Allocation Line) with the diagram, which represents the Sharp ratio, has the highest for the best 20% efficient frontier and the lowest value for the ALL-efficient frontier.

5. Conclusion

The main concerns of different parties in palm oil production and consumption including individuals and companies with respect to sustainability are CO2 emissions and environmental issues. Consequently, the responsible organizations such as RSPO will be under growing force to articulate more efficient policies for solving these issues. The tension caused by these concerns will not only affect palm oil suppliers but also affect the manufacturers of palm-based products. Hence, we can argue that although key initiatives in implementing sustainability solutions are taken by the most influential groups, the position of less powerful palm oil buyers could be significant.

Furthermore, investors increasingly incorporate sustainability aspects in their portfolios. Many investors are willing to own ethical companies in a sincere attempt to stimulate good corporate behaviour while expecting to not give up returns. In this study, we reviewed the existing, related studies and evaluated the developing shifts in manufacturers of palm-based products, underlining the significance of sustainability scores in the asset allocation decisions. We studied the effect of sustainability screening on optimal mean-variance portfolios for manufacturers of palm-based products according to their sustainability scores.

Our analysis was able to find a significant risk-adjusted return between portfolios. The findings show that the effects of changes in asset allocation in favour of high-rated sustainable investments significantly affect the adjusted risk returns of portfolios and show that sustainability integration can necessarily lead to higher returns and lower risk. Due to the increased risk, there is not much difference in the fluctuations. The big picture that emerges from our results is that screening investment portfolios for sustainability scores has a significant impact on portfolio returns, as well as an increase in Sharp ratios. Sustainable investment is becoming an emerging matter with the potential for long-term social and environmental impact. With the growing tendency in sustainable investment, financial capital might diverge into those companies that contribute to a cleaner environment and a better society. The manufacturing companies that are considering sustainable production would have a competitive advantage through utilizing opportunities and preventing risks on more and more sustainability-driven markets that lead them to a stronger financial and market performance. Our findings are obviously relevant to manufacturing companies, particularly manufacturers of palm-based products, considering the significance of sustainability scores in their market value. Fund managers and investment analysts might consider the implementation of sustainability screens in implying that it may enhance their performance. As there was no official database for some parts of cost elements, the estimations were asked to help. Considering the fact that COVID-19 has raised the awareness and concerns of sustainability, we expect that the sustainable investment perform even better in the post-COVID-19 world in comparison to the pre-COVID-19 era. Moreover, our findings could be useful to private and institutional investors in constructing and managing their portfolios. For future studies, these directions have been suggested: [44, 45].

(i) Considering the Fuzzy inference system for forecasting the demand of palm buyer

(ii) Considering uncertainty for input data such as price

(iii) Considering other different scenarios for the palm buyer such as recession and market boom

Data Availability

Data are available in the article appendix.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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