Quantifying the Performance and Trade- offs of Sustainable Investment: Triple Bottom Line Analysis using DEA Metrics

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Abstract:

In this era of global warming and climate change, sustainability is the key to combat the future challenges in almost every sector of the global economy. In this article we dig deep into analyzing the efforts of the benchmarked industries in the fields of ecological, humanity and ethical (GREEN) and their impacts on the economic aspects of the representing financial instruments. These days the investors are have developed interest to know about the contribution of the industries towards the sustainability of the environment, contribution towards society and how the company is monitoring their activities towards it. This research articles attempts to analyses the efficiency of the funds by applying data envelopment analysis and concluding policy recommendations on the basis of duality programing. The articles also analyze the tradeoffs of the funds on the basis of the triple bottom line (economical, environmental and social) factors.

In conclusion, this study intends to quantify the accomplishment of the sustainable funds by applying DEA techniques and analyzing the efficiency of the funds on the triple bottom line parameters. The findings hold significance for the funds house, investors, policy makers and corporate entities that are evolving in the sustainable finance in the increasingly interconnected and socially conscious world.

Keywords: Sustainable investment, Data envelopment analysis, Triple Bottom Line, GREEN

Backdrop: The growing concern over climate change and its societal effects has led to a notable shift in investment approaches, moving away from conventional strategies towards thematic or socially responsible investment (SRI) methods. Stakeholders now prioritize not only fund profitability but also seek insight into the sustainable practices of an industry or corporate. It has been found in the intense literature review that the financial instruments which includes green investment tactics such as impact investing and thematic investments focused to the GREEN objectives, are gaining more popularity amongst the investors. The investors have become more conscious while selecting the investment choices and the GREEN funds are making a mark in appealing the investors. To a large extent these

funds are successful in satisfying the conscious of the investors as they are actively or passively contributing towards the sustainability of the environment through his choices of investment.

Though the concept of sustainable investment in India is at its nascent stage, the corporates are evolving at a galloping rate to integrate the environmental, social and governance approaches in their management policies. The awareness is increasing but the need to accelerate the adopting rate in the policies is far reaching. Indian companies are gradually accepting the need of incorporating the GREEN principles into their operations *(Dutta. A, & Paul. B. 2023).*

Due to the increasing threats and alarming effects of climate change and global warming issues, it has been the need of the hour to put more stress on sustainability practices to save the planet and the species here in. the companies as a major part of the global economy has to take the onus to include the practices of reducing carbon emission, conservation of the resources, implementing renewable energy solutions, implementing zero waste management policies , encouraging reducing, recycling and refill concept, water conservation and bio diversity protection etc. to safeguard the planet for the future generations. Indian companies are gradually shifting from traditional operations to the sustainable practices of operations.

In the social front, there is a remarkable importance of Creating Shared Value (CSV) and the initiatives of the industries and firms towards the social upliftment. Corporates operating in India are investing a huge corpus towards the social and community development programs. The investors, these days are very much attracted towards the funds houses that are active in social development. The listed companies are involved in various developmental activities related to education, healthcare and poverty alleviations. The investors are also keen to investigate if the , funds houses or the corporates where they are investing, are maintain healthy relations with the employees in terms of good working conditions, employee development and protection policies etc.**(Akhtar & Farooqi, 2022).**

It has been found that the investors are conscious and keen to know the GREEN practices of the industry before investing. On account if this growing demand, there is a constant push to maintain transparency, accountability and the ethical conduct in the financial market. Indian companies are fastening their practices towards strengthening their corporate governance frameworks and ensuring the conformance with the regulations and ethical standards. There is an increasing demand for the disclosure if the GREEN related information in the investment documents.

It can be concluded that Indian approach towards the GREEN reflects that there is a paradigm shift in the practices of the companies and in the investment- decision making process of the investors. Both the parties have developed an understanding and acceptance of the fact that there is a interconnectedness between business success and sustainable practices. Companies have realized the fact that the inclusion of GREEN practices will give a dual benefit of mitigating risk and will also enhance the wealth creation and foster positive societal image *(Dutta. A, &Paul. B. 2023)*.

The investment philosophy of responsible investment, the funds focuses on integrating non-monetary factors into financial decision-making processes, in addition to traditional financial analysis.

The Environmental criteria of GREEN philosophy, evaluate a firm's imprints on the environment, including its carbon balance, energy efficiency, and exhaustion of non- renewable natural resources. Societal component analyses a firm's relationships with its employees, customers, suppliers, and communities, considering factors such as labor practices, human rights, diversity, and community engagement. Ethical criteria examine a firm's leadership structure, board composition, executive compensation, lucidity, and adherence to ethical standards (*Das, N., Chatterjee, S., Sunder, A., & Ruf, B. 2018).*

Green investing aims to line up investment strategies with green practices, seeking to generate positive monetary returns while also promoting healthy societal and ecological outcomes. Investors who follow the GREEN philosophy believe that companies with strong ecological conscious practices are better equipped to handle risks, foster capital growth, and contribute to a green future.

Green investing encompasses various approaches, including screening out corporates indulged in contentious industries (e.g., tobacco, weapons), actively selecting companies with high GREEN ratings, engaging with corporates to improve their GREEN performance, and investing in thematic strategies enthralled on specific green themes (e.g., clean energy, water conservation) (*Gupta, S. 2022).*

Overall, the GREEN philosophy of investment reflects a broader recognition of the importance of green practices in driving durable investment success and making a positive impact on society and the environment.

The motivation behind GREEN (ecological, social, and governance) investing arises from the amalgamation of factors concerned to shift in societal expectations, pressure to adherence with regulations and controlling laws, and recognition of the value addition of green factors in monetary decision-making.

To name a few the factors that encourages the GREEN investment philosophy are awareness and expectation of the society towards the services and contribution of the corporates in the development and growth of the society in terms of employees safety and protection, human rights, inclusion of diversity and conservation of the environment and ecology. The increased awareness has in turn increased the demand for investment options that are aligned with the personal values and encourage positive consequences. The investors are aware of the information that inclusion of the GREEN components have a durable impact on the financial productivity of the firm. It is also believed that by embracing GREEN into the investment process, the investors intend to identify and mitigate the risks associated with the natural disasters, social conflicts and financial punishments for non-adherence to the regulations and other governance failures of the company or the industry as a whole.

Another motivating factor is the governmental pressure to conform with the rules and regulations set by the authoritative bodies of the financial sectors. SEBI being strict on the companies has made it mandatory for the companies to disclose the information related to the GREEN practices. The investors are also interested to know whether the funds house is adhering to the regulations so that they can reduce the legal and reputational risks of investment.

GREEN investing is being considered as a way to capitalize long-term value creation by marking the companies that are well-positioned to flourish in a changing global dynamic. Companies with robust GREEN philosophies and practices are believed to be better equipped to appeal and retain talent, innovate, adapt to market shifts, and maintain strong relationships with stakeholders. Previous research works have established a strong and positive correlations between GREEN performance and financial outperformance over the long term. As investors aims to maximize risk-adjusted returns, the GREEN factors has emerged as potential indicators of future financial performance and resilience.

It has been eye witnessed that the companies with robust GREEN practices may find it easier to access capital and attract investment from a wider range of investors, including those with GREEN mandates or ethical considerations. GREEN-focused funds and indices are gaining popularity, providing capital to companies that meet certain sustainability criteria. (*Dutta. A, & Paul. B. 2023).*

As per *Das, N., Chatterjee, S., Sunder, A., & Ruf, B. 2018* GREEN mutual funds are investment tools that amalgamate the GREEN criteria into their financial strategies. These funds intend to generate and excel financial returns along with the promotion of the positive environmental and social outcomes and adhering to high governance standards. Green mutual funds employ various investment

approaches, including green incorporation, exclusionary screening, thematic investing, and impact investing. Fund managers may select investments based on green scores, ratings, or specific sustainability themes, such as clean energy, water conservation, or gender diversity (*Folger-Laronde et al. 2020*).

Green integration involves incorporating green factors into traditional financial analysis to identify companies with strong green practices and risk management. Fund managers assess companies based on their environmental impact, social policies, and governance structures alongside financial metrics where as some green mutual funds uses exclusionary screening to exclude companies that are involved in any type of controversial industries or conflicting activities, such as exploitation of non-renewable natural resources, tobacco, weapons, or human rights violations. This approach allows investors to align their investments with their ethical values and avoid negative societal impacts.

Thematic mutual funds emphasize on megatrends, such as renewable energy, sustainable agriculture, or cybersecurity. These funds invest in companies that are leading or benefiting from these themes, aiming to capitalize on growth opportunities while promoting positive societal or environmental outcomes (*Gupta, S. 2022*)

Impact mutual funds seek to generate significant positive social or environmental impact alongside financial returns. These funds invest in companies, projects, or initiatives that address alarming global threats, such as poverty alleviation, global warming, or waste management, access to clean water and healthcare.

GREEN mutual funds provide transparency regarding their GREEN criteria, investment process, and portfolio holdings. Many funds publish regular sustainable reports or disclose their green scores to help investors understand how GREEN considerations are integrated into investment decisions (*Das, N., Chatterjee, S., Sunder, A., & Ruf, B. 2018*).

To summarize the GREEN mutual funds, offer investors an opportunity to line up their funds choices with their sentiments and contribute to the healthy societal and environmental consequences while potentially generating competitive financial returns (*Domanovic, V. (2021)*. As per the previous research and reports, it can be claimed that GREEN mutual funds have experienced rapid growth in the global economy. According to the various industry reports, the assets under management (AUM) in GREEN funds have been steadily increasing, reflecting the mainstream adoption of sustainable investing principles.

GREEN mutual funds are still at the stage of infancy in India compared to mature markets like Europe or North America. However, there's growing awareness among Indian investors towards sustainable investing, driven by increasing awareness of environmental, social and ethical issues and regulatory initiatives of authoritative bodies promoting responsible investing practices.

There is a paradigm shift in the practices of the Indian companies. Several asset management companies, in India, have introduced sustainable mutual funds or green investment philosophy or GREEN-themed investment products to address to the rising quest for sustainable investment alternatives. However, the number of dedicated GREEN funds remains relatively smaller than the traditional mutual funds which is a matter of concern about the efficiency of GREEN funds. This research study will intend to dig deep into this research gap.

The Securities and Exchange Board of India (SEBI) also has introduced regulatory guidelines encouraging mutual funds houses to infuse GREEN factors into their investment processes and disclose ESG-related information to investors. These regulations intend to promote transparency and standardization in green investing practices.

Indian GREEN mutual funds faces challenges related to limited green data availability, sectoral constraints, and the need for greater awareness and education among investors. Performance comparisons with NON-GREEN funds may vary, and investors should carefully evaluate fund strategies, risk factors, and performance metrics.

In summary, while GREEN mutual funds are experiencing robust growth globally, the Indian GREEN mutual fund market is still evolving. Regulatory initiatives, increasing investor demand, and greater adoption of sustainable investing principles are driving the development of GREEN mutual funds in India, but there are challenges related to data availability, performance measurement, and market maturity that need to be addressed for further growth and adoption *(Domanovic, V. (2021).*

Considering the gap this research article will attempt to measure the performances of the top nine GREEN funds listed in Indian stock exchanges by applying Data envelopment analysis focusing on the triple bottom line approach to develop a better insight about the efficiency of the funds and thereby recommending the policy makers to improve the tradeoffs. This will further help the fund managers to implement stratergical changes to reach the efficiency frontiers *(Sarkar, S. 2022).*

Literature Review:

Gunnar Friede, Timo Busch, and Alexander Bassen (2015), examines the financial efficiency of green investments globally. The article analyzes over 2,000 empirical studies and finds a positive correlation between green factors and financial performance in the majority of cases.

Another research article investigates the associations amongst corporate conscience and monetary performances. The meta-analysis synthesizes the findings from 52 studies on the relationship between Corporate Social Responsibility (CSR) and financial performance. It concludes that there is a small but positive association between CSR and financial performance *(Marc Orlitzky,et.al, 2003).*

According to another study naming, ***"ESG and Financial Performance: Aggregated Evidence from More than 2000 Empirical Studies" by Philipp Krüger, Gunther Capelle-Blancard, Aurélien Petit, and Béatrice Parguel (2020),*** an extensive review and meta-analysis encompassing more than 2,000 empirical studies, exploring the association between green factors and financial efficiency have been performed which concludes that there is a predominantly positive association between green performance and financial performance.

Florian Berg and Julian F. Koelbel (2019), summarizes the academic literature on green investing, focusing on its impact on financial performance, risk management, and stakeholder preferences. It provides insights into the growing body of research in this field.

(Robert G. Eccles et. al, 2014) in their research work, explores the influence of corporate consciousness on various organizational activities and performance metrics. It highlights the positive effects of sustainability practices on financial performance, innovation, risk management, and employee engagement.

In a research literature, the Fama-French 5-factor model was applied to evaluate the risk-adjusted performance of Socially Responsible Mutual Funds (SRMF) and compared to the market from 2005 to 2016. They also investigated whether the green ratings of SRMF signal fund performance over time. The findings suggest that SRMFs generally underperformed in the market during this period. However, they also indicate that SRMFs with higher green ratings outperformed those with lower ratings, particularly during the Great Recession *(**Das et al. 2018**)*

Socially responsible investing (SRI) involves considering both financial gain and ethical conduct to drive social and environmental progress. Green criteria, are standards used to assess the actions of

companies being invested in, focusing on their governance practices and their influences on the environment and society *(Aw, E.N.et. al, 2017)*

These papers offer precious sneak peeks into the associations between green factors and financial performance, highlighting the growing interest and importance of green considerations in investment decision-making.

As per the concept of Principle of Responsible investing, it is not feasible for the public sector alone to address the mammoth issues of global warming, climate change and the sustainability of the environment along with the economic growth and stability of the economy as a whole. The private sector plays an important role in responsible investing, required to build a sustainable environment and economy *(SDG Investment Case 2017).*

It has been evidenced that the number of participants or industries that are showing interest in sustainable investment have drastically increased from 100 to over 1800 by 2018. This supports the fact that there is a paradigm shift from the traditional investment to the responsible investment. There is a wave of awareness and sense of responsibility regarding the contribution of every industry and sector of the economy, towards the Environmental, Social, and Governance **(Alam, Md Wadood, et al.)**

Additionally, adopting sustainable investment practices is beneficial for institutional investors and investment management firms. This not only ensures stable economic growth, which increases investment returns, but also allows for further evaluation of potential risks and opportunities. This integration provides a strategic advantage to any investor with long-term goals *(Dunn, J. et. al, 2020).*

The notion on green investment has undergone a paradigm shifts recently. The Global Sustainable Investment Alliance (GSIA) data reveals that the value of assets associated with responsible investment have rose up to $30.7 trillion in 2018, compared to $22.9 trillion in 2016. *Lloyd Kurtz (2020)* have established that around half of the assets under management (AUM) in Europe, Canada, and Australia are now governed by responsible investment policies

However, the status of green investing in India has accelerated in recent years. Several initiatives have emerged to promote green investing in India. For example, stock markets have introduced green indices to facilitate investment in companies that meet certain sustainability criteria. In addition, regulatory bodies such as the Securities and Exchange Board of India (SEBI) have issued guidelines to encourage listed companies to disclose green-related information.

However, challenges remain, such as the need for standardized green reporting frameworks, reliable green data, and greater transparency from companies. Despite these obstacles, the green investment landscape in India is evolving, reflecting a broader global trend towards sustainable finance *(Crisil report, 2022)*

Research Question

As per the previous studies it is evident that though globally responsible investing has grown to achieve many milestones but the growth of green funds in India are still at a nascent stage. This research article attempts to explore and analyses the efficiency of few of the most successful green funds as per the statistics of Crisil report, 2022.

Research Objectives:

The objectives of this article intends -

- To explore the efficiency of the most prominent green funds in the Indian context by applying the CCR model of DEA techniques.
- To attempt policy prescriptions of the inefficient funds by applying duality of the efficiency models of the funds.
- To perform a tradeoff analysis of the green funds among themselves by exploring the indices of the factors of triple bottom line that is economic, ecological and social indices.

Research Methodology: -

In India, GREEN funds are gaining traction, albeit at a slower pace compared to the global market. As of March 2022, data from Morningstar India indicates that GREEN funds in the country have reached Rs. 12,447 crores, marking a significant increase from Rs. 2,268 crores in March 2019—a fivefold growth over four years.

Moreover, both the Bombay Stock Exchange (BSE) and National Stock Exchange (NSE) have introduced GREEN indices to gauge the eficiency of companies based on their GREEN scores. The S&P BSE 100 ESG Index by BSE and the Nifty 100 ESG Index by NSE are notable examples. Additionally, NSE offers the Nifty 100 Enhanced ESG Index, which includes companies scoring over 50% on the green scale. Recently, NSE launched the 'Nifty 100 green Sector Leaders' index in June 2020, which focuses on the top-performing large-cap companies within each sector of the NIFTY 100.

Various consultancies such as Morningstar, MSCI, and Sustainalytics, SES India, and CRISIL report 2022, (S&P Global Company) also offer their own green indices. Despite the growing interest, green investing is still in its nascent stage in India compared to global standards.

For this article the green scores data has been used of the top nine green Mutual funds of India *(Crisil report 2022).*

Table 1: GREEN Scores

Fund Name	Environmental sustainability Programs(E scores)	Social and Community Development(S-Scores	Governannce(G- Scores	Overall ESG Scores
Aditya Birla Sunlife ESG Integration Strategy Fund(G)				
SBI Magnum Equity ESG Fund(G)	57	57	73	63
Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G)	57	56	70	62
Axis ESG Integration Strategy Fund (G)	62	61	75	67
Invesco India ESG Equity Fund (G)	57	57	74	64
ICICI Prudential ESG Exclusionary Strategy Fund (G)	58	58	74	64
Quantum ESG Best in Class Strategy Fund (G)	58	57	72	63
Kotak ESG Exclusionary Strategy Fund (G)	60	59	75	66
Quant ESG Equity Fund	57	59	72	63
Average	55	60	71	63

Source: CRISIL Report 2022

Fig.1. GREEN Scores of Top 9 Funds
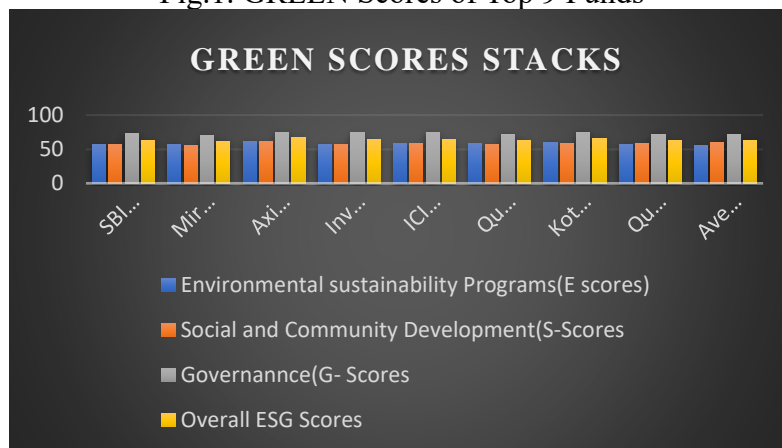
Source: Author Generated

In order to address the research gaps discovered in the literature review this article develops a DEA based framework to explore the performance of the GREEN funds prevailing at the Indian financial market with new measures representing the green matrices. The efficiency scores of the individual funds are used to develop the policy prescriptions for the managerial benefit with an objective to improve the efficiency. Following the policy recommendation by applying duality framework, indices models are developed to analyze the internal trade offs of the individual funds and amongst themselves on the basis of the triple bottom matrices of each DMUs. DEA has been widely applied in various fields and is one of the most practiced multi- criteria decision-making methods *(Liu, Lu, Lu, & Lin, 2013; Markovits-Somogyi, 2011).*

As per the literature, it has been discovered that data envelopment frameworks are applied to manufacturing and service sectors to evaluate the decision-making units' (DMU) performances. This study attempts DEA to analyze the efficiency of the financial instruments with reference to the triple bottom line matrices in the background. This makes the study unique in its way which will be a reference point for future research works.

DEA-Data Envelopment Analysis

Data envelopment analysis is one of the useful techniques to evaluate the relative performances of the decision-making units. DEA is one of the non- parametric methodologies for analyzing the productivity of the decision-making units, quantitively. This method envelops multiple criteria representing different factors without assigning pre- specified weights or notions to them. This helps to evaluate the efficiency without any pre notion or biases. This technique helps to aggregate the weightages of the individual attributes into a single performance score. This performance scores can be then utilized to evaluate the efficiency scores of the decision-making units (DMU). In this study the individual green funds are considered as each DMU and the ESG scores as shown in Table 1, represents the aggregates of the weightages of attributes related to the environmental, social and governance of the funds house. To name a few the environmental attributes includes, the strategies adopted by the funds house or the contribution of the mutual fund towards the environmental sustainability, identifying and reduction of the carbon footprints, afforestation, towards climate change management etc.. Similarly, the social attributes include the share of revenue of the funds that are invested for the development of the social factors such as management of gender biasness, diversity and inclusion, employee's welfare and growth. Coming to the governance part of the green concept, it represents the strategies and strictness of the fund house to select the investment instruments of the mutual funds. In other words, it shows

the monitoring of the fund house in terms of investment selection that whether the industry or sector is actively participating in the environment sustainability.

Triple bottom Analysis: In this study, the DEA analysis has been conducted by considering the attributes that represents the green factors of the various DMUs. Primarily, the overall efficiency scores have been analyzed and then the efficiency indices of the individual DMUs have been calculated by using each green attributes. The efficiency indices further help to observe the tradeoffs of the DMUs among themselves. These indices help in proposing the recommendation strategies to the lagging DMUS in the efficiency frontier. The triple bottom line analysis represents the Economical model, ecological model, social model and overall model of each DMUs.

Analysis and Interpretation

DEA is a method commonly used for the performance analysis, and the triple bottom line (TBL) is an responsibility framework that considers three dimensions of efficiencynamely, environmental, social and economic. When applying DEA to TBL performance analysis of GREEN funds following steps are adopted:

⇨ Defining inputs and outputs- The inputs and outputs relevant to each dimension of the Triple Bottom Line are identified. For this study, the outputs are included as AUM (asset under management and CAGR (compound annual growth rate) of each GREEN funds and the environmental, social and governance matrices aggregated as GREEN scores published by CRISIL report 2022 has been used as the input matrices.

⇨ Data Collection- the AUM and CAGR data has been collected from NSE and BSE index and websites of Individual fund house.

⇨ The data has been normalized to ensure comparability across different units of measurement and magnitudes.

⇨ Model specification has been performed which involves defining DEA models, for each DMUs, specifying the inputs and outputs.

⇨ DEA analysis has been attempted by making linear programming Model using SOLVER application of MS-Excel. DEA will assess the efficiency of GREEN funds in transforming inputs into outputs for each dimension of TBL.

⇨ The efficient units are identified which means the GREEN funds that has achieved the highest level of outputs given their inputs. These funds can be used as benchmarks for the relatively inefficient units.

⇨ Policy recommendation have been performed by attempting Duality method of the inefficient units.

⇨ The results of the DEA in the context of TBL has been interpreted by evaluating Ecol (index), Econ(index), Social(index), overall(index) to understand the trade offs between economic, social and environmental performance and how well each GREEN fund is balancing these dimensions *(Mittal, S., & Bhasin, N. 2021)*

Table 2: Input- Output Matrix

Fund Name	Output indicators		Input Indicators		
	AUM	CAGR	Environmental sustainability Programs(E scores)	Social and Community Development(S-Scores	Governannce(G- Scores
	CR	%			
Aditya Birla Sunlife ESG Integration Strategy Fund(G)	710.704	13.1	57	57	73
SBI Magnum Equity ESG Fund(G)	5471.501	12.3	57	56	70
Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G)	110.463	16.1	62	61	75
Axis ESG Integration Strategy Fund (G)	1353.31	16.9	57	57	74
Invesco India ESG Equity Fund (G)	555.303	14.3	58	58	74
ICICI Prudential ESG Exclusionary Strategy Fund (G)	1421.31	20.1	58	57	72
Quantum ESG Best in Class Strategy Fund (G)	83.531	17.6	60	59	75
Kotak ESG Exclusionary Strategy Fund (G)	1000.24	13.3	57	59	72
Quant ESG Equity Fund	214.66	52.34	55	60	71

Sources: Author Generated

DEA Models: It has been observed in the literature review that a considerable attention has been given to the academic contribution of **Charnes et. al (1987)** and it is being incorporated in many studies by the scholars and the management experts for efficiency analysis. It has been evident in the literature review that data envelopment analysis is an accepted and established method to analyses the productivity and performances of DMUs with many inputs and outputs by applying linear programming.

According to the efficiency concept in economics, the efficiency of DMU, DMU_k where (k= 1,2,3,…..k) can be expressed as the ratio of the total value of outputs to the total value of inputs. In case of multiple outputs and inputs, the value of the output can be computed as weighted sum of the individual outputs to the weighted sum of the individual inputs. As per Charnes et. al, the optimization models each DMU search for the ideal weight value each input and output to boost its own performance determined as the ratio of the weighted sum of the output to the weighted sum of the input maintaining the efficiencies of all other DMUs limited to (not more than) than certain value that is 1. In this study the outputs are denoted as O and inputs are denoted as I. The weights of output and inputs be denoted as y and x.

According to the concept of efficiency, it can be represented as

Efficiency= Total weighted value of output / Total weighted value of the inputs-----------(Equ1)

For DMU $_k$

Objective function can be written as maximizing the weighted outputs

Maximize Z= y_{1k} +O_{1k} +$y_{2k}O_{2k}$+ $y_{3k}O_{3k}$ +…………...+$y_{mk}O_{nk}$

Subject to Constraint

First constraint is normalizing the denominator of the Equ 1

$x_{1k} I_{1k}$+$x_{2k}I_{2k}$+$x_{3k}I_{3k}$+…………...+$X_{nk}I_{nk}$ =1

the other constraints can be interpreted as that using the weights of DMU_k none of the DMUs should get an efficiency of more than 1. Then the numerator and denominator of efficiency equation are arranged in such a way that the resultant constraints are linear functions of the input and output weights. So, for the DMU1, O_{11}, O_{21} will represents the output values. However, the weights will be used for

DMUk will be y1k, y2k and not y11, y21 and so on. DMU1 is ot using the weights that it has assigned itself, DMU1 is essentially using the weights assigned by DMUk and ensuring the fact that they do not get an efficiency of more than 1.

The remaining constraints could be formulated as follows:

$y_{1k}O_{11}+y_{2k}O_{21}+,,,,,+y_{mk}O_{m1} \leq x_{1k}I_{11}+x_{2k}I_{21}+……+x_{nk}I_{n1}$

$y_{1k}O_{12}+y_{2k}O_{22}+……..y_{mk}O_{m2} \leq x_{1k}I_{12}+x_{2k}I_{22}+………+x_{nk}I_{n2}$

.

.

$y_{1k}O_{1k}+ y_{2k}O_{2k}+…….y_{mk}O_{mk} \leq x_{1k}I_{1k}+x_{2k}I_{2k}+…….+x_{nk}I_{nk}$

$y_m, x_n \geq 0$, for all m and n

For DMU₁

$E=\sum(y_{11} O_{11}+ y_{21} O_{21})/\sum (x_{11} I_{11} + x_{21}I_{21} + x_{31} I_{31})$

As per the input output matrix,

$O_{11}= 710.704$

$O_{21} = 13.1$

$I_{11} = 57$

$I_{21} = 57$

$I_{31} = 73$

are the inputs and outputs values and the $y_{11}, y_{21}, x_{11}, x_{21}, x_{31}$ are the weights assigned to the DMU1 and the decision variables.

The efficiency equation can be represented as DEA optimization model by maximizing the numerator and normalizing the denominator as follows:

Max Z = 710.704y_{11}+13.1y_{21}

Subject to constraints,

$x_{11}57+x_{21}57+x_{31}73 =1$

$y_{11}710.704 +y_{21}13.1 \leq x_{11}57+x_{21}57+x_{31}73$

$y_{11}5471.5 + y_{21}12.3 \leq x_{11}57+x_{21}56 +x_{31}70$

$y_{11}110.463 + y_{21} 16.1 \leq x_{11}62 +x_{21} 61+x_{31}75$

$y_{11} 1353.31 + y_{21} 16.9 \leq x_{11}57 +x_{21}57 +x_{31} 74$

$y_{11} 555.303 +y_{21} 14.3 \leq x_{11} 58 +x_{21} 58 +x_{31} 74$

$y_{11} 1421.31 + y_{21} 20.1 \leq x_{11}58 +x_{21} 57 + x_{31} 72$

$y_{11} 83.531 +y_{21} 17.6 \leq x_{11}60 +x_{21} 59 +x_{31} 75$

$y_{11} 1000.24 + y_{21} 13.3 \leq x_{11} 57+ x_{21} 59 + x_{31} 72$

$y_{11} 214.66 +y_{21} 52.34 \leq x_{11} 55+ x_{21} 60 +x_{31} 71$

$y_{11}, y_{21}, x_{11}, x_{21}, x_{31} \geq 0$

similarly, the DEA optimization models are framed and solved via MS excel Solver to derive the efficiency matrix for the 9 DMUs provided in the Table. 3

Table.3: Efficiency Matrix

Efficency And Ranks of DMU								
Fund Name	AUM	CAGR	Environmental sustainability Programs(E scores)	Social and Community Development(S-Scores)	Governannce(G- Scores)	Efficiency	Reference Points	Rank
Aditya Birla Sunlife ESG Integration Strategy Fund(G)	710.704	13.1	57	57	73	0.35884 inefficient	Dmu 2& DMu9	5
SBI Magnum Equity ESG Fund(G)	5471.501	12.3	57	56	70	1 Efficient		1
Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G)	110.463	16.1	62	61	75	0.308191 inefficient	Dmu 2& DMu9	8
Axis ESG Integration Strategy Fund (G)	1353.31	16.9	57	57	74	0.513991 inefficient	Dmu 2& DMu9	3
Invesco India ESG Equity Fund (G)	555.303	14.3	58	58	74	0.348819 inefficient	Dmu 2& DMu9	6
ICICI Prudential ESG Exclusionary Strategy Fund (G)	1421.31	20.1	58	57	72	0.585789 inefficient	Dmu 2& DMu9	2
Quantum ESG Best in Class Strategy Fund (G)	83.531	17.6	60	59	75	0.343449 inefficient	Dmu 2& DMu9	7
Kotak ESG Exclusionary Strategy Fund (G)	1000.24	13.3	57	59	72	0.382302 inefficient	Dmu 2& DMu9	4
Quant ESG Equity Fund	214.66	52.34	55	60	71	1 Efficient		1

Source: Author Generated

As per the efficiency matrix the DMU_2 and DMU_9 are found to be efficient and others GREEN funds can adopt the strategies to improve their efficiencies to attract the investors in various aspects. The Fig.2, represents the efficiency frontier of the nine DMUs and on the basis of the efficiency matrix the further analysis of duality has been performed for the inefficient funds individually taking the DMU_2 and DMU_9 as the reference points.

Fig.2 Efficiency Frontier
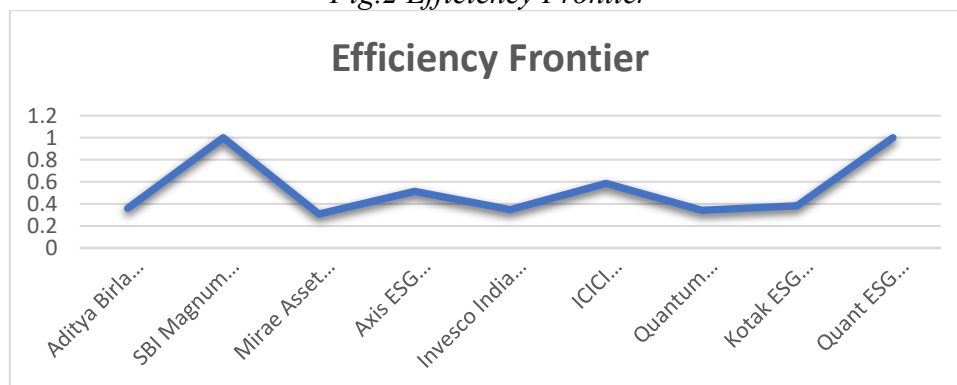
Source: Author Generated

For DMU1, the sensitivity reports shows the recommendations for upgrading the existing inefficiency to the efficiency frontier.

The sensitivity reports for the DMU 1 is provided in Table 4. And the policy recommendations is provided in Table 5.

Table 4: Sensitivity Report Of DMU1

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
L4	SBI Magnum Equity ESG Fund(G) x11	0	-1.346683635	0	1.346683635	1E+30
M4	SBI Magnum Equity ESG Fund(G) x21	0.017857143	0	0	1E+30	0.709781492
N4	SBI Magnum Equity ESG Fund(G) x31	0	-0.887226865	0	0.887226865	1E+30
O4	SBI Magnum Equity ESG Fund(G) y11	0.00013802	0	710.704	5116.666984	656.9774811
P4	SBI Magnum Equity ESG Fund(G) y21	0.019904495	0	13.1	160.1891426	11.50232887

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
M7	Invesco India ESG Equity Fund (G) x21	1	0.35884001	1	1E+30	1
M8	ICICI Prudential ESG Exclusionary Strategy Fund (G) x21	0.35884001	0	0	1E+30	0.659017133
M9	Quantum ESG Best in Class Strategy Fund (G) x21	1	0.121189957	0	1.707075959	0.748212239
M10	Kotak ESG Exclusionary Strategy Fund (G) x21	0.335708436	0	0	1E+30	0.753577278
M11	Quant ESG Equity Fund x21	0.523169353	0	0	1E+30	0.49468779
M12	x21	0.361277011	0	0	1E+30	0.674437275
M13	x21	0.596249074	0	0	1E+30	0.421608069
M14	x21	0.361848033	0	0	1E+30	0.691723395
M15	x21	0.40278257	0	0	1E+30	0.650788859
M16	x21	1.071428571	0.221806716	0	1.293325855	1.032196193

Source: Solver Generated

Table 5: Duality Report of DMU1

Policy Prescription					
	REFERENCE UNITS		HCU1	ACTUAL VALUES	RECOMMENDATION
	D2(57,56,70,5471.501,12.3)	D9(55,60,71,214.66,52.34)			
DUAL VARIABLES	0.353327	0.646673			
I1	20.139639	35.567015	55.706654	57	
I2	19.786312	38.80038	58.586692	57	1.586692
I3	24.73289	45.913783	70.646673	73	
O1	1933.229034	138.8148262	2072.04386	710.704	1361.33986
O2	4.3459221	33.84686482	38.19278692	13.1	25.09278692

Sources: Author Generated

Policy Prescriptions for DMU 1: It is found that DMu1 is consciously putting efforts in the governance part of the GREEN parameter and choosing it portfolio over consciously which is causing them to compromise in the asset undermanagement and CAGR. As per the optimization outcome it is suggested to increase the AUM by 1361.339CR and CAGR by 25.09% approx. to fall on the efficiency frontier. The result also portrays that DMU1 also needs to improve their social scores by 1.58 to meet the benchmark set by the efficient fund.

Similarly, the sensitivity and duality reports have been derived to get the policy recommendations for the remaining inefficient DMUs.

Table 6: Sensitivity Report of DMU₃

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
K5	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x13	0	-1.828384914	0	1.828384914	1E+30
L5	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x23	0.016393443	0	0	1E+30	0.681144476
M5	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x33	0	-0.837472716	0	0.837472716	1E+30
N5	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) y13	0.000126707	0	110.463	2524.161099	44.43269813
O5	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) y23	0.018272979	0	16.1	10.83391139	15.42496848

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
L10	Kotak ESG Exclusionary Strategy Fund (G) x23	0.329426894	0	0	1E+30	0.604999335
L11	Quant ESG Equity Fund x23	0.918032787	0.008196319	0	1.5671517	0.686883367
L12	x23	0.308191351	0	0	1E+30	0.691808649
L13	x23	0.480286619	0	0	1E+30	0.45413961
L14	x23	0.331664141	0	0	1E+30	0.619155531
L15	x23	0.547376199	0	0	1E+30	0.38705003
L16	x23	0.332188358	0	0	1E+30	0.635024756
L17	x23	0.369767605	0	0	1E+30	0.59744551
L18	x23	0.983606557	0.305677976	0	1.187315539	0.947589947
L9	Quantum ESG Best in Class Strategy Fund (G) x23	1	0.308191351	1	1E+30	1

Sources: Solver Generated

Table 7: Duality Report of DMU₃

Policy Prescription					
	REFERENCE UNITS		HCU3	ACTUAL VALUES	RECOMMENDATION
	D2(57,56,70,5471.501,12.3)	D9(55,60,71,214.66,52.34)			
DUAL VARIABLES	0.026113	0.973887			
I1	20.139639	35.567015	55.706654	62	
I2	1.462328	58.43322	59.895548	61	
I3	1.82791	69.145977	70.973887	75	
O1	142.8773056	209.0545834	351.931889	110.463	241.468889
O2	0.3211899	50.97324558	51.2944355	16.1	35.19443548

Sources: Author Generated

Policy Prescriptions for DMU 3: It is found that DMU3 has maintained a balanced approached toward all the three parameters of GREEN but still suffering from choosing portfolio in efficient manner causing them to compromise on AUM and CAGR. As per the optimization outcome it is suggested to increase the AUM by 241.46 CR and CAGR by 16.1% approx. to fall on the efficiency frontier.

Table 8: Sensitivity Report of DMU4

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
K5	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x14	0	-1.099284302	0	1.099284302	1E+30
L5	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x24	0.01754386	0	0	1E+30	1.099284302
M5	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x34	0	-2.482385738	0	2.482385738	1E+30
N5	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) y14	0.000135598	0	1353.31	2739.887369	1283.998689
O5	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) y24	0.019555293	0	16.9	313.0741237	11.31245146

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
N10	DMU1 y14	0.352544571	0	0	1E+30	0.647455429
N11	DMU2 y14	0.98245614	0.236854002	0	1.677127258	0.735085708
N12	DMU3 y14	0.329818814	0	0	1E+30	0.740356624
N13	DMU4 y14	0.513990944	0	0	1E+30	0.486009056
N14	DMU5 y14	0.354938818	0	0	1E+30	0.662605042
N15	DMU6 y14	0.585788564	0	0	1E+30	0.414211436
N16	DMU7 y14	0.355499822	0	0	1E+30	0.679587897
N17	y14	0.395716209	0	0	1E+30	0.65691537
N18	y14	1.052631579	0.267227661	0	1.270635928	1.014087487
N9	Quantum ESG Best in Class Strategy Fund (G) y14	1	0.513990944	1	1E+30	1

Sources: Solver Generated

Table 9: Duality Report of DMU4

Policy Prescription					
	REFERENCE UNITS		HCU4	ACTUAL VALUES	RECOMMENDATION
	D2(57,56,70,5471.501,12.3)	D9(55,60,71,214.66,52.34)			
DUAL VARIABLES	0.469872	0.530128			
I1	20.139639	35.567015	55.70665	57	
I2	26.312832	31.80768	58.12051	57	1.120512
I3	32.89104	37.639088	70.53013	74	
O1	2570.905118	113.7972765	2684.702	1353.31	1331.392394
O2	5.7794256	27.74689952	33.52633	16.9	16.62632512

Sources: Author Generated

Policy Prescriptions for DMU4: As per the optimization outcome it is suggested to increase the AUM by 1331.39CR and CAGR by 16.62% approx. to fall on the efficiency frontier. The result also portrays that DMU4 also needs to improve their social scores by 1.12 to meet the benchmark set by the efficient fund or reference units.

Table 10: Sensitivity Report of DMU5

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
J5	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x15	0	-1.166802523	0	1.166802523	1E+30
K5	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x25	0.017241379	0	0	1E+30	1.166802523
L5	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x35	0	-1.529963526	0	1.529963526	1E+30
M5	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) y15	0.00013326	0	555.303	2908.171697	496.6549679
N5	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) y25	0.019218133	0	14.3	121.0981134	12.00726406

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
K10	DMU1 Max	0.346466217	0	0	1E+30	0.636292404
K11	DMU2 Max	0.965517241	0.091615917	0	1.648211271	0.722411817
K12	DMU3 Max	0.324132283	0	0	1E+30	0.727591855
K13	DMU4 Max	0.505129031	0	0	1E+30	0.47762959
K14	DMU5 Max	0.348819183	0	0	1E+30	0.651180817
K15	DMU6 Max	0.575688761	0	0	1E+30	0.407069859
K16	DMU7 Max	0.349370515	0	0	1E+30	0.667870864
K17	DMU8 Max	0.388893515	0	0	1E+30	0.628347864
K18	DMU9 Max	1.034482759	0.251683688	0	1.248728412	0.99660322
K9	Quantum ESG Best in Class Strategy Fund (G) Max	1	0.348819183	1	1E+30	1

Source:

Table 11: Duality Report of DMU5

Policy Prescription					
	REFERENCE UNITS		HCU4	ACTUAL VALUES	RECOMMENDATION
	D2(57,56,70,5471.501,12.3)	D9(55,60,71,214.66,52.34)			
DUAL VARIABLES	0.266869	0.733131			
I1	20.139639	35.567015	55.706654	58	
I2	14.944664	43.98786	58.932524	58	0.932524
I3	18.68083	52.052301	70.733131	74	
O1	1460.174	157.3739005	1617.547901	555.503	1062.044901
O2	3.2824887	38.37207654	41.65456524	14.3	27.35456524

Source: Author Generated

Policy Prescriptions for DMU5: As per the optimization outcome it is suggested to increase the AUM by 1062.044 CR and CAGR by 27.354 % approx. to fall on the efficiency frontier. The result also

portrays that DMU5 also needs to improve their social scores by 0.93 to meet the benchmark set by the efficient fund or reference units.

Table 12: Sensitivity Report of DMU6

Variable Cells						
		Final	**Reduced**	**Objective**	**Allowable**	**Allowable**
Cell	**Name**	**Value**	**Cost**	**Coefficient**	**Increase**	**Decrease**
K4	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x16	0	-1.968749341	0	1.968749341	1E+30
L4	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x26	0.01754386	0	0	1E+30	1.380105725
M4	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x36	0	-1.743291443	0	1.743291443	1E+30
N4	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) y16	0.000135598	0	1421.31	7411.988808	1338.874654
O4	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) y26	0.019555293	0	20.1	326.4543902	16.86583668
Constraints						
		Final	**Shadow**	**Constraint**	**Allowable**	**Allowable**
Cell	**Name**	**Value**	**Price**	**R.H. Side**	**Increase**	**Decrease**
M8	Quantum ESG Best in Class Strategy Fund (G) x36	1	0.585788564	1	1E+30	1
M9	DMU1 x36	0.352544571	0	0	1E+30	0.647455429
M10	DMU2 x36	0.98245614	0.246976748	0	1.677127258	0.735085708
M11	DMU3 x36	0.329818814	0	0	1E+30	0.740356624
M12	DMU4 x36	0.513990944	0	0	1E+30	0.486009056
M13	DMU5 x36	0.354938818	0	0	1E+30	0.662605042
M14	DMU6 x36	0.585788564	0	0	1E+30	0.414211436
M15	DMU7 x36	0.355499822	0	0	1E+30	0.679587897
M16	DMU8 x36	0.395716209	0	0	1E+30	0.639371511
M17	DMU9 x36	1.052631579	0.325987505	0	1.270635928	1.014087487

Sources:

Microsoft Excel 16.0 Sensitivity Report
Worksheet: [DEA Data sheet.xlsx]IcICI
Report Created: 19-03-2024 15:40:42

Table 13: Duality Report of DMU 6

Policy Prescription						
	REFERENCE UNITS		HCU4	ACTUAL VALUES	RECOMMENDATION	
	D2(57,56,70,5471.501,12.3)	D9(55,60,71,214.66,52.34)				
DUAL VARIABLES	0.431051	0.568949				
I1	20.139639	35.567015	55.70665	58		
I2	24.138856	34.13694	58.2758	57	1.275796	
I3	30.17357	40.395379	70.56895	72		
O1	2358.495978	122.1305923	2480.627	1421.31	1059.31657	
O2	5.3019273	29.77879066	35.08072	20.1	14.98071796	

Source: Author Generated

Policy Prescriptions for DMU6: As per the optimization outcome it is suggested to increase the AUM by 1059.31 CR and CAGR by 14.98 % approx. to fall on the efficiency frontier. The result also portrays that DMU6 also needs to improve their social scores by 1.27 to meet the benchmark set by the efficient fund or reference units.

Table 14 : Sensitivity Report of DMU 7

Variable Cells						
		Final	**Reduced**	**Objective**	**Allowable**	**Allowable**
Cell	**Name**	**Value**	**Cost**	**Coefficient**	**Increase**	**Decrease**
K4	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x17	0	-2.02021015	0	2.02021015	1E+30
L4	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x27	0.016949153	0	0	1E+30	1.394284016
M4	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x37	0	-1.772394936	0	1.772394936	1E+30
N4	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) y17	0.000131002	0	83.531	7476.349866	11.34880665
O4	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) y27	0.018892402	0	17.6	2.767150564	17.40553323

Constraints						
		Final	**Shadow**	**Constraint**	**Allowable**	**Allowable**
Cell	**Name**	**Value**	**Price**	**R.H. Side**	**Increase**	**Decrease**
M8	Quantum ESG Best in Class Strategy Fund (G) x37	1	0.343448981	1	1E+30	1
M9	DMU1 x37	0.340593908	0	0	1E+30	0.625507787
M10	DMU2 x37	0.949152542	0.002093468	0	1.620275487	0.710167549
M11	DMU3 x37	0.318638516	0	0	1E+30	0.630514027
M12	DMU4 x37	0.496567522	0	0	1E+30	0.469534173
M13	DMU5 x37	0.342906993	0	0	1E+30	0.640143854
M14	DMU6 x37	0.565931325	0	0	1E+30	0.40017037
M15	DMU7 x37	0.343448981	0	0	1E+30	0.656551019
M16	DMU8 x37	0.3823021	0	0	1E+30	0.6176979
M17	DMU9 x37	1.016949153	0.335770927	0	1.227563524	0.97971164

Source:

  Microsoft Excel 16.0 Sensitivity Report

  Worksheet: [DEA Data sheet.xlsx]Quantum

  Report Created: 19-03-2024 15:49:23

Table 15: Duality Report of DMU7

Policy Prescription				
	REFERENCE UNITS		**HCU4**	**ACTUAL VALUES**	**RECOMMENDATION**
	D2(57,56,70,5471.501,12	D9(55,60,71,214.66,52.34)			
DUAL VARIABLES	0.006196	0.993804			
I1	20.139639	35.567015	55.706654	60	
I2	0.346976	59.62824	59.975216	59	0.975216
I3	0.43372	70.560084	70.993804	75	
O1	33.9014202	213.3299666	247.2313868	83.531	163.7003868
O2	0.0762108	52.01570136	52.09191216	17.6	34.49191216

Source: Author Generated

Policy Prescriptions for DMU7: As per the optimization outcome it is suggested to increase the AUM by 163.700 CR and CAGR by 34.49 % approx. to fall on the efficiency frontier. The result also portrays that DMU7 also needs to improve their social scores by 0.97 to meet the benchmark set by the efficient fund or reference units.

Table 16: Sensitivity Report od DMU 8

Variable Cells						
		Final	**Reduced**	**Objective**	**Allowable**	**Allowable**
Cell	**Name**	**Value**	**Cost**	**Coefficient**	**Increase**	**Decrease**
J4	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x18	0	-0.126508141	0	0.126508141	1E+30
K4	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x28	0.016949153	0	0	1E+30	0.130947023
L4	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) x38	0	-0.183419737	0	0.183419737	1E+30
M4	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) y18	0.000131002	0	1000.24	190.7487933	945.6932289
N4	Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G) y28	0.018892402	0	13.3	230.5859666	2.130128314

Constraints						
		Final	**Shadow**	**Constraint**	**Allowable**	**Allowable**
Cell	**Name**	**Value**	**Price**	**R.H. Side**	**Increase**	**Decrease**
L8	Quantum ESG Best in Class Strategy Fund (G) Max	1	0.3823021	1	1E+30	1
L9	DMU1 Max	0.340593908	0	0	1E+30	0.625507787
L10	DMU2 Max	0.949152542	0.174448174	0	1.620275487	0.710167549
L11	DMU3 Max	0.318638516	0	0	1E+30	0.715259789
L12	DMU4 Max	0.496567522	0	0	1E+30	0.469534173
L13	DMU5 Max	0.342906993	0	0	1E+30	0.640143854
L14	DMU6 Max	0.565931325	0	0	1E+30	0.40017037
L15	DMU7 Max	0.343448981	0	0	1E+30	0.656551019
L16	DMU8 Max	0.3823021	0	0	1E+30	0.6176979
L17	DMU9 Max	1.016949153	0.213112103	0	1.227563524	0.97971164

Source:
  Microsoft Excel 16.0 Sensitivity Report
  Worksheet: [DEA Data sheet.xlsx]Kotak
  Report Created: 19-03-2024 15:54:50

Table 17: Duality Report of DMU 8

Policy Prescription					
	REFERENCE UNITS		HCU4	ACTUAL VALUES	RECOMMENDATION
	D2(57,56,70,5471.501,1	D9(55,60,71,214.66,52.34)			
DUAL VARIABLES	0.450119	0.549881			
I1	20.139639	35.567015	55.706654	57	
I2	25.206664	32.99286	58.199524	59	-0.800476
I3	31.50833	39.041551	70.549881	72	
O1	2462.826559	118.0374555	2580.864014	1000.24	1580.624014
O2	5.5364637	28.78077154	34.31723524	13.3	21.01723524

Source: Author Generated

Policy Prescriptions for DMU8: As per the optimization outcome it is suggested to increase the AUM by 1580.62 CR and CAGR by 21.01 % approx. to fall on the efficiency frontier. The result also portrays that DMU8 is over capitalizing in their social activities which is blocking the investments required to improve the other aspects to satisfy the efficiency. As per the outcome it is suggested that DMU 8 can reduce the social score by 0.8004.

Table 18: Efficiency Index and Trade offs Matrix

Efficiency index and Trade -offs Matrix											
Fund Name	AUM	CAGR	Environmental sustainability Programs(E scores)	Social and Community Development(S-Scores	Governannce(G-Scores	Overall Efficiency	Economic efficiency	ecolo efficiency	social efficiency	Economi c index	social index	Ecological index
Aditya Birla Sunlife ESG Integration Strategy Fund(G)	710.704	13.1	57	57	73	0.35884	0.352545	0.335214	0.352545	0.982456	0.982456	0.93415999
SBI Magnum Equity ESG Fund(G)	5471.501	12.3	57	56	70	1	1	1	1	1	1	1
Mirae Asset Nifty 100 ESG Sector Leaders Fund of Fund (G)	110.463	16.1	62	61	75	0.308191	0.308191	0.278701	0.308191	1	1	0.90431244
Axis ESG Integration Strategy Fund (G)	1353.31	16.9	57	57	74	0.513991	0.513991	0.49055	0.513991	1	1	0.95439399
Invesco India ESG Equity Fund (G)	555.303	14.3	58	58	74	0.348819	0.348819	0.328702	0.348819	1	1	0.94232747
ICICI Prudential ESG Exclusionary Strategy Fund (G)	1421.31	20.1	58	57	72	0.585789	0.585789	0.551845	0.585789	1	1	0.94205426
Quantum ESG Best in Class Strategy Fund (G)	83.531	17.6	60	59	75	0.343449	0.339216	0.309779	0.343449	0.987674	1	0.90196457
Kotak ESG Exclusionary Strategy Fund (G)	1000.24	13.3	57	59	72	0.382302	0.382302	0.716092	0.382302	1	1	1.87310387
Quant ESG Equity Fund	214.66	52.34	55	60	71	1	1	1	1	1	1	1

Indices:

Proceeding towards the next stage of analysis, efficiency indices and the trade off matrix is developed by using the efficiency scores derived from the DEA models. These indices provide managerial insights about the strategies adopted by each decision-making units and their internal trade-offs. In this stage four efficiency models are developed and analyzed naming Overall efficiency model, Economic efficiency model, Ecological efficiency model, social efficiency model by applying DEA linear programming. Adopting from the literary contribution of Su and Rogers (2012), we have extended the relative performance analysis of each DMU by adding one more aspect that is economic index, ecological index and social index to identify and compare the trade- offs on the parameters of triple bottom line analysis.

The index analysis also allows an in-depth analysis among the dimensions of the triple bottom line. The indices provide a means of understanding the internal trade offs of each DMU, which further allows to identify which triple bottom line dimension are most valued and focused by each DMU. The extension of the research work by adding social indices makes this research work a unique contribution as application of DEA and triple bottom line analysis with respect to financial instruments will provide a direction to the further research work in this field as very less work has been noted in this field of research.

Interpretation of the Efficiency index and Trade off matrix:

As per the matrix it is evident that the *(Efficiency $_{overall}$) ≥ (Efficiency $_{economic}$)* as in (Efficiency $_{overall}$) model every DMU has more freedom to choose among the various factors to improve it the model performances in comparison to the (Efficiency $_{economic}$) model. It can be interpreted as more the difference between the two efficiency scores, the performance scores of the individua DMU will improve significantly when ecological and social dimensions are included. In the contrary, if the difference between the efficiency is found less , than it can be interpreted as the DMU is more focused on the economic development only and simultaneously, if the efficiencies are equal then it can be concluded as there is hardly any improvement in the performance of the DMU if the ecological and social dimensions are included in the model.

Adopting to the aforesaid argument, proposed indices are

Economic Index= (Efficiency $_{economic}$) / (Efficiency $_{overall}$)

Ecological Index = (Efficiency $_{ecological}$) / (Efficiency $_{overall}$)

Social Index = (Efficiency $_{social}$) / (Efficiency $_{overall}$)

The above indices measure the relative performance of the DMU all the triple bottom line dimensions are considered and when single TPL dimensions are included in the Efficiency Models. It is notable from the matrix the values lie between 0 and 1. A higher index value or to be precise more the index value is close to 1, it can be concluded that the DMU is more focused to the respective Tripple bottom line dimension and the lower indices value indicates that the other two dimensions have more beneficial influence on the performance of the DMU. For instance, a high Economic index means that the DMU is more focused on the economic aspect of the fund similarly if a DMU has relatively higher social index than it can be interpreted that the DMU is more focused on the social dimensions such as social welfare, education of the not so privileged social sectors, reduction of unemployment, inclusion of employee welfare and security to list a few. These differences in the efficiency indices indicates the technology gap of the respective DMU, which could be the effect of the use of obsolete technology. In the case of financial instruments, the gap could be blamed to the fact that the fund houses are not upgrading in the GREEN strategy or the difference between the resource intake from the society or the environment is more than the contribution done towards the development of the society and the ecological sustainability *(Hsiao, Ching, and Wan 2012)*. In this article the difference in indices are interpreted as the internal trade offs of the DMU and necessary policy recommendations have been provided to individual inefficient decision- making units, so that the efficiency scores of the same can be improved. It is also to be noted that the differences in the index values may not be the result of pre decided strategies of the DMU and the DMUs can consider the recommendations as feedbacks to be incorporated in their future decision-making process or selection of the weightage of the triple bottom line dimensions.

Conclusion and Future Scope

It is widely accepted fact that sustainability is new buzz in every sector of the global economy. the cause and effect of climate change on all sectors are quite evident and alarming and every sector of the economy are contributing to implement the sustainability in their corporate strategies so that the damage can be reduced and controlled. This article focusses on the study of the GREEN funds and their contribution towards the sustainability. DEA is one of the multicriteria decision making techniques which is popularly adopted in the supply chain and other specialized fields to measure the relative efficiency of the decision-making units. This study attempts the application of the DEA techniques in the analysis of the top nine GREEN funds (Crisil report 2022). As per the literature review, it has been found that the popularity of GREEN funds are still at the nascent stage in Indian aspect. This study attempts to explore the most efficient fund and attempted to provide recommendations for the inefficient funds for the improvement in the performance scores. This study also attempted to incorporate triple bottom line analysis of the GREEN funds considering the ecological, economical and social dimensions. The TBL analysis will provides remarkable insights for the managerial implications and identifying the internal trade offs of the individual DMUs. As in the DEA analysis, the efficiency models are sensitive to the DMU that it takes to compare itself, so the indices or the consequent recommendations cannot be generalized. The results and the interpretations are completely based on the data and the organizations for the analysis. These limitations of DEA based analysis has been found universal in most studies in the past. In this article the simplest model of DEA based analysis had been incorporated and the fundamental aim was to explore the most efficient GREEN funds floating in the financial market and providing benchmarking feedback for the inefficient funds. It will be interesting to find impact of the new technologies in the policies of the fund houses and implementing more innovative MCDM techniques.

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