An Efficient Portfolio Management for Trading Under Uncertain Environment

Kocherlakota Satya Pritam#1, Trilok Mathur#2, Shivi Agarwal#3

#Department of Mathematics, Birla Institute of Technology and Science, Pilani
Pilani, India, 333031

1kspritam@gmail.com
2 tmathur@pilani.bits-pilani.ac.in
3shivi@pilani.bits-pilani.ac.in

***Abstract*—This study presents a framework for efficient portfolio management for trading under uncertain environment. The proposed framework can be used to determine the dominance of various sectors among the chosen set of alternatives. The dominance of these sectors are analyzed by considering various aspects such as Return on equity, Book value per share, Price earnings ratio, and Price to book ratio. For illustration, the dominance of various sectors is evaluated using the proposed framework. The historical stats of various sectors, corresponding to the aforementioned criteria's are collected from various sources and the dominance is studied using the proposed framework. The findings of this study facilitate novice users in understanding the relative dominance of each sector.**

Keywords*—Multi-criteria Decision making, Fuzzy TOPSIS, Satty scale, Performance index of sectors, BSE SENSEX*

1. Introduction

Stock equity is considered as one of the crucial part of any major economy. It plays a powerful role in growth of economy and hence in HDI (Human development index) which keeps government, nationalized banks and industries busy observing the trends of markets closely. Equity market is important from Industry and investor's sentiments. The stock market is a collection of companies where capital can be traded by an investor in the form of shares and becomes owner to certain portion of the company and also assure the warrant of settlement.

The primary functioning of the stock market is to collect funds and issue shares to investor and acts as common platform to buyers and sellers. The total market capitalization is above $69 trillion US dollars in 2015 end out of which the United states possess major share around 34%and with a large gap Japan with about 6% share comes second closely followed by United kingdom with 5%[1]. There are 16 stock exchange with market capitalization of more than 1 trillion US dollars and among them BSE and NSE are from India.

Many stock exchanges are located in India but two are principle due to their significant contribution to Indian economy which are BSE (Bombay stock exchange) and NSE (National stock exchange) located at Mumbai. The present study emphasizes on BSE due to its dominance in capitalization and registered stakes. By market capitalization, BSE is 11th largest exchange around the globe and with 6 microseconds median trade speed it claims to be the world's fastest stock exchange[1]. The establishment of BSE dates back to 1875 and is the oldest among all the stock exchanges in Asia[2]. There are five indices in BSE which are BSE SENSEX, S&P BSE Small Cap, S&P BSE Mid Cap, S&P BSE Large Cap and BSE 500. Among them the most prominent by capitalization is BSE SENSEX. Hence sectors in BSE SENSEX are given prominence.

30 prominent companies are listed in the BSE SENSEX (BSE30) which are listed on the Bombay Stock Exchange. Based on industry representation, the trading volume and liquidity of these companies were chosen. BSE SENSEX is capitalization index whose market is of free-float and 100 as its base value. The Index attained its historic high of 36360.22 in January, 2018 and marked its least value of 113.28 on December, 1979 till January, 2018 which can be observed from Figure 1.

Recently, Indian equity market is performing consistently even though marginal changes in global economies is observed. These act as auction between seller and buyer continuously a complying transaction at a location. Protecting the investor, determining realistic price, financing industry, creating of new ventures, attracting foreign investments and delivering financial needs to the government are some of the objectives of stock exchanges.

Figure1. Historical SENSEX from Jan. 1998 - Jan. 2018

The growth rate of BSE SENSEX is represented by Table 1.

Table 1. Growth rate of BSE SENSEX over 2012-2018

Year	Growth Rate
2012-13	7.58
2013-14	11.63
2014-15	39.02
2015-16	-19.01
2016-17	21.89
2017-18	17.46

The volatility of a market is high and investing in the right company and in appropriate share is a challenging task. An average investor ends up with losses by trading in market. Long term investment of stocks in well diversified Index funds like BSE SENSEX and NIFTY50 surpassed debt funds since decades [3]. Hence, investor's portfolio must be diversified and choosing the right company from the sector should be one's priority, which is essential for healthy diversified portfolio. There is an immense potential growth for stock market in India and investing in appropriate sector is a healthy way out. Owing to this need this study is to tradeoff between profits and reduce the risk. Six sectors are appraised in the present study by their market capitalization and impact to Indian economy which are Automobiles, IT, Oil, Finance, Pharma and Power. Figure 2 shows the sector wise breakup of SENSEX.

In the current study, four important financial derivatives, which significantly contributes for evaluating the performance of each major sectors are considered to evaluate the dominance of all sectors considered. These criteria include Return on equity (ROE), Book value per share (BVP), Price to earn ratio (PE ratio) and Price to book ratio (PB ratio).In this study Fuzzy AHP serves the purpose for prioritization along with equitable portfolio investment.

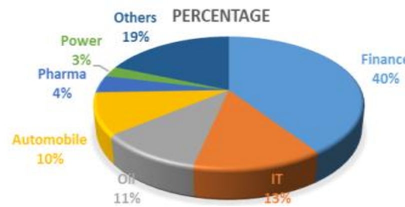

Figure 2. Sector wise breakup of SENSEX

2. BSE SENSEX Potential

It is evident from the statistics of past years that the number of investments and investors in Indian stock market has increased tremendously[1]. This phenomenal change can be interpreted with the high returns on investments. The average annual returns of BSE SENSEX since 2012 is observed to be nearly 13%, which can be observed from Table 1.Itis superior as compared to other debt funds like fixed deposits in nationalized banks etc.

Table 2. Sector wise values obtained over different criteria

	ROE (%)	*BVPS*	*PE Ratio*	*P/BV*
Banking(S_1)	10.19	10.26	44.77	2.93
Automobiles(S_2)	20.61	9.64	22.91	4.64
IT(S_3)	23.22	15.30	16.48	4.04
Oil(S_4)	10.89	12.65	13.81	1.47
Pharma(S_5)	14.56	10.25	30.94	3.34
Power(S_6)	13.54	11.90	13.67	1.86

Since the foundation of SENSEX, there is a mammoth variance in behavior of stock market with respect to normal distribution. This variation along with other statistical measures are used to scrutinize the behavior of stock market.

The mean, standard deviation, variance, skewness, kurtosis along with 1st quartile, median and 3rd quartile of all the sectors listed in Table 2 is evaluated and the statistics are shown in Table 3. These measures unveil the probable risk in the equity market. Further, by using A-squared and p-value are evaluated. The significance of all these indicators is well known form literature[4].

3. Performance Index Evaluation of Sectors in BSE SENSEX

The performance of various sectors is evaluated by considering different aspects which are presented in the subsequent sections. Each of the considered criteria serves as an indirect measure of profit. The significance of each sector is discussed below.

3.1.Return on equity (ROE-E_1)

This is the ratio that measures return rate interest of investors. It is one of the crucial financial ratios. This criterion can measure the impact of net assets

Table 3. Statistical measures of six sectors

	Mean	*S.D.*	*Var*	*Min*	*Max*	*Range*	*Skew*	*Kurt*	*A-sq*
Finance	885.0	280.9	78942.0	453.8	1581.1	1127.3	0.42	-0.89	32.72
Auto	2038.2	715.5	511914.9	1052.9	3759.0	2706.0	0.45	-0.86	34.01
IT	1551.5	318.3	101334.1	1156.1	2545.5	1389.4	1.10	0.13	86.85
Oil	611.7	81.9	6711.1	462.1	908.7	446.6	1.13	1.43	33.04
Pharma	1268.6	317.0	100461.1	738.5	1999.5	1261.1	0.22	-0.92	17.32
Power	146.8	23.7	565.1	103.0	201.1	98.1	0.64	-0.68	51.04

for generating profits and shows productivity of the company.

$$ROE = \frac{Netcompaniesequity - Equitypreferred}{Totalcompaniesworth} \quad (1)$$

3.2 Book value per share (BVPS-E_2)

This derivative may be employed as tool to govern sectors equity respect to the present value of a sector (stock price).

$$BVPS = \frac{Totalequityheldbytheinvestor}{Totalnumberofshares} \quad (2)$$

3.3 Price to earn ratio (PE ratio-E_3)

It is a predominant financial derivative to assess a company valuation. This ratio evaluates earnings gained per share. Mathematical equation of PE ratio can be given as follows:

$$PEratio = \frac{Worthofacompanypershare}{Earnings\ (intotal)\ pershare} (3)$$

Generally, investors endeavor to estimate the growth or predict if a company is undervalued or overvalued based on erstwhile trends by using PE ratio
.

3.4 Price to book ratio (PB ratio-E_4)

PB ratio is a convenient tool for valuating sectors or companies which obey homogeneous valuations of an asset. Investors consider historical data for predicting rise in asset price. It can be defined as the ratio between current asset cost in the market and value of asset (net). This ratio can be explicitly given.

$$PBratio = \frac{Currentassetcostinthemarket}{Assets - Liabilitiesintotal} (4)$$

4. Fuzzy Technique for Order of Preference by Similarity to Ideal Solution

Even though the statistical measures shown in Table 3, have significance, the decisions using these statistics may not credible. This economic scenario was observed in 2008 [5]. From the presented statistics in Table 3, stock market is shows positive trends like positive skewness, right kurtosis etc, which was in contrast with the economic situation in 2008 [5]. Therefore, there is a great need to develop a holistic approach to reduce the uncertainty associated with these decisions. In this study, Multi-criteria decision making technique is used in developing this approach.

For past several years, multiple criteria decision making under uncertain environment became a choice in making an appropriate decision. For portfolio management, there are different theories and approaches like Multiattribute utility theory, goal programming, Rough set theory, Outranking relations and Preference disaggregation for managing the portfolio. These approaches utilize methods such as AHP, MACBERTH, ELECTRE, PROMETHEE, UTA, UTADIS, MHDIS and other techniques[6]–[10]. But many of these methods are proved to end with undesirable results which led to evolution of Fuzzy TOPSIS[11]–[13].

The attributes of all the considered criteria as discussed in section 3, for the selected sectors is collected from literature and is shown in Table 2. From the statistics presented in Table 2, it is evident that the attributes are crisp and hence are ineffective for dealing real life applications. Since a wide range of criteria are considered in evaluating the sector, weightage for each of the criteria is considered, which is evaluated using the principle of Analytical Hierarchy Process.

Later considering the evaluated weights, the cumulative dominance of each sector is evaluated using Fuzzy TOPSIS. The advantage is not only restricted to the order of priority but also conveys the optimal investment percentage an individual can invest in a particular sector. Evaluation of performance index is discussed in subsequent section.

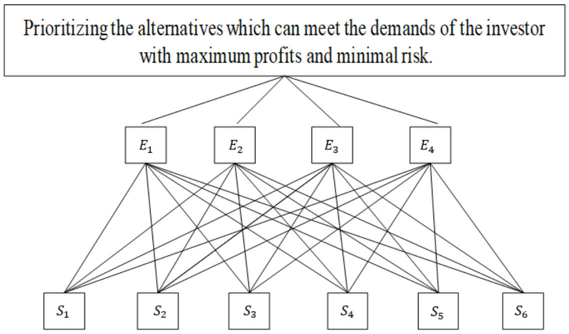

Figure 3. Pictorial representation of impact of sectors by taking 4 criteria

Analysis using Fuzzy TOPSIS

The Analysis of Fuzzy TOPSIS can be classified in five steps:

Note: Throughout this section, $i = 1,2,\ldots,m$ and $j = 1,2,\ldots,n$ for generalized matrix

Step 1: Criteria weight evaluation.

Criteria weights are determined by taking the mean of expert committee

Table 4. Criteria evaluation (Crisp rating)

	ROE (%)	***BVPS***	***PE Ratio***	***PB Ratio***
ROE (%)	1.00	2.00	0.14	0.17
BVPS	0.50	1.00	0.13	0.14
PE Ratio	7	8.00	1.00	1.00
PB Ratio	6	7.00	1.00	1.00

Step 2: Fuzzifying decision matrix

For m alternatives which are sectors $S_i$in our study along with n evaluative criteria $E_j$decision matrix is constructed followed by its fuzzification to get a generalizedfuzzified decision matrix which is given by "Eq.(5)"

$$\tilde{D} = \begin{pmatrix} \tilde{x}_{11} & \cdots & \tilde{x}_{1n} \\ \vdots & \tilde{x}_{ij} & \vdots \\ \tilde{x}_{m1} & \cdots & \tilde{x}_{mn} \end{pmatrix} \quad (5)$$

where $\tilde{x}_{ij}$ represents the triangular fuzzy number of j^{th} criteria w.r.t i^{th} alternative which can be given as $\tilde{x}_{ij} = (p_{ij}, q_{ij}, r_{ij})$.

The fuzzified scale from crisp values can be evaluated from Table 5.

Table 5. Crisp values and corresponding fuzzified scale

Crisp Rating	**Definition of judgment**	**Corresponding Triangular fuzzy numbers (TFN)**
1	Negligible dominance	(0, 0, 1)
2	Strongly weak dominance	(0, 1, 2)
3	Very weak dominance	(1, 2, 3)
4	Weak dominance	(2, 3, 4)
5	Medium weak dominance	(3, 4, 5)
6	Fair dominance	(4, 5, 6)
7	Medium good dominance	(5, 6, 7)
8	Good dominance	(6, 7, 8)
9	Demonstrative dominance	(7, 8, 9)
10	Strongly good dominance	(8, 9, 10)
11	Absolute dominance	(9, 10, 10)

Generally depending on the nature of criteria, the considered criteria as classified into benefit or cost criteria are classified. The decision matrix $\tilde{D}$ is shown in Table 3. Later, the criteria weights and criteria of each alternative isfuzzified using Table 5 and the fuzzified matrix is shown in Table 6 of page 5.

Step 3: Evaluating the weighted normalized Fuzzy decision matrix

Since the data of $\tilde{D}$ can be obtained from different sources, there is a great need to normalize the matrix to acquire a dimensionless matrix to compare various criteria. Further, in this study, $\tilde{G} = [\tilde{g}_{ij}]$ represents the normalized fuzzy decision matrix where $\tilde{g}_{ij}$ is the normalized fuzzy value which can be obtained by the fuzzy operations given by "Eq. (6)".

Table 6. Fuzzy decision making matrix

Sectors	C_1	C_2	C_3	C_4
S_1	(0,0,1)	(0,1,2)	(9,10,10)	(4,5,6)
S_2	(7,8,9)	(0,0,1)	(2,3,4)	(9,10,10)
S_3	(9,10,10)	(9,10,10)	(0,0,1)	(7,8,9)
S_4	(0,0,1)	(4,5,6)	(0,0,1)	(0,0,1)
S_5	(2,3,4)	(0,1,2)	(5,6,7)	(5,6,7)
S_6	(1,2,3)	(3,4,5)	(0,0,1)	(0,1,2)

Table 7. Normalized fuzzy decision making matrix

Sectors	C_1	C_2	C_3	C_4
S_1	(0,0,0.1)	(0,0.1,0.2)	(0.9,1,1)	(0.4,0.5,0.6)
S_2	(0.7,0.8,0.9)	(0,0,0.1)	(0.2,0.3,0.4)	(0.9,1,1)
S_3	(0.9,1,1)	(0.9,1,1)	(0,0,0.1)	(0.7,0.8,0.9)
S_4	(0,0,0.1)	(0.4,0.5,0.6)	(0,0,0.1)	(0,0,0.1)
S_5	(0.2,0.3,0.4)	(0,0.1,0.2)	(0.5,0.6,0.7)	(0.5,0.6,0.7)
S_6	(0.1,0.2,0.3)	(0.3,0.4,0.5)	(0,0,0.1)	(0,0.1,0.2)

Table 8. The final weighted normalized fuzzy decision matrix

Sectors	C_1	C_2	C_3	C_4
S_1	(0,0,0.032)	(0,0.009,0.039)	(0.105,0.0179,0.416)	(0.135,0.281,0.463)
S_2	(0.055,0.135,0.287)	(0,0,0.019)	(0.023,0.054,0.166)	(0.303,0.562,0.772)
S_3	(0.071,0.169,0.319)	(0.049,0.090,0.197)	(0,0,0.042)	(0.236,0.449,0.695)
S_4	(0,0,0.032)	(0.021,0.045,0.118)	(0,0,0.042)	(0,0,0.077)
S_5	(0.016,0.051,0.128)	(0,0.009,0.039)	(0.058,0.107,0.291)	(0.169,0.337,0.540)
S_6	(0.008,0.034,0.096)	(0.016,0.036,0.098)	(0,0,0.042)	(0,0.056,0.154)

Table 9. Generalised mean

Sectors	C_1	C_2	C_3	C_4
S_1	0.010625	0.016116	0.233043	0.293006
S_2	0.159165	0.006553	0.081059	0.545776
S_3	0.186334	0.112048	0.013858	0.46011
S_4	0.010625	0.061665	0.013858	0.025736
S_5	0.06468	0.016116	0.152134	0.348708
S_6	0.045783	0.050278	0.013858	0.070201

Table 10: Alternative distance and relative closeness index

Sectors	d^+	d^-	$\widetilde{R}_k$	$\widetilde{R}_k$	Ranking
S_1	0.593653	0.655367	0.475295	0.524705	4
S_2	0.358884	0.997969	0.264497	0.735503	1
S_3	0.453915	0.892788	0.337057	0.662943	2
S_4	1.09472	0.110361	0.90842	0.09158	6
S_5	0.482272	0.667982	0.419274	0.580726	3
S_6	0.998963	0.148815	0.870345	0.129655	5

$$\tilde{g}_{ij} = \begin{cases} \left(\frac{p_{ij}}{z_j^+}, \frac{q_{ij}}{z_j^+}, \frac{r_{ij}}{z_j^+}\right) if x_j is benefit criteria \\ \left(\frac{z_j^-}{p_{ij}}, \frac{z_j^-}{q_{ij}}, \frac{z_j^-}{r_{ij}}\right) if x_j is cost criteria \end{cases} \quad (6)$$

where z_j^+ and z_j^- represents the greatest and the least values of j^{th} criteria respectively.

Normalizing fuzzy decision matrix by "Eq. (6)", the normalized fuzzy decision matrix is evaluated to be Table 7.
Let $\tilde{O} = [\tilde{o}_{ij}]$ represents the weighted normalized decision matrix then $\tilde{o}_{ij} = \tilde{g}_{ij} \otimes B_j$ where B_j is the final weighted value of j^{th} criteria. Table 8 represents the final weighted normalized fuzzy decision matrix.

Step 4: **Formulating Fuzzy positive ideal solution (FPIS) and Fuzzy negative ideal solution (FNIS).**

Let I_+ and I_- denotes FPIS and FNIS respectively then by weighted normalized fuzzy decision matrix, FPIS, and FNIS cab be given by "Eq.(7)".

$$\left.\begin{array}{l} I_+ = (\tilde{o}^+{}_1 \tilde{o}^+{}_2 \ldots \tilde{o}^+{}_n) \\ I_- = (\tilde{o}^-{}_1 \tilde{o}^-{}_2 \ldots \tilde{o}^-{}_n) \end{array}\right\} \quad (7)$$

where $\tilde{o}^+{}_i$ and $\tilde{o}^-{}_i$ represent greatest and smallest generalized mean fuzzy numbers respectively. For any fuzzy number $\tilde{x}_{ij} = (p_{ij}, q_{ij}, r_{ij})$, the generalized mean [14] is obtained by "Eq. 8".

$$M(\tilde{o}_{ij}) = \frac{r_{ij}^2 - p_{ij}^2 - p_{ij}q_{ij} + q_{ij}r_{ij}}{[3(r_{ij} - p_{ij})]} \quad (8)$$

And generalized mean of the six evaluated sectors over the criteria can be observed from Table 8, shown in Page 5.

Step 5: Obtain a hierarchy of sectors by computing distance from FPIS or FNIS

After obtaining I_+ and I_- , The alternative distances ($d^+$and d^-) are evaluated by the method of area compensation as by "Eq. (9)".

$$\left.\begin{array}{l} \tilde{d}^+{}_k = \sum_{j=1}^{m} d(\tilde{o}_{ij}, \tilde{o}^+{}_j) \\ \tilde{d}^-{}_k = \sum_{j=1}^{m} d(\tilde{o}_{ij}, \tilde{o}^-{}_j) \end{array}\right\} \quad (9)$$

A relative index $\tilde{R}_k$ based on closeness is calculated combining $d^+$and d^- as "Eq. (10)"

$$\tilde{R}_k = \frac{\tilde{d}^-{}_k}{\tilde{d}^+{}_k + \tilde{d}^-{}_k} \quad (10)$$

Table 10, represents the relative closeness index of alternatives along with the final ranking.Automobiles sector outpaces other sectors

can be observed by the cumulative scores of Table 10. To take advantage of this dominance, it is suggested to invest in Automobile sector followed by IT, pharma, banking, oil and power.

5. Conclusion

BSE SENSEX is significantly growing year by year and is expected to grow at much faster pace due to exceptional GDP growth rate of India and hence its suitable time for investors to have a well-diversified sectored portfolio. Prioritizing sectors in right proportions is must, for healthy portfolio. A vigilant assessment of parameters are made by choosing fuzzy TOPSIS. This study also provide the significance of important parameters that can give more returns and an opportunity to have a healthy portfolio by analyzing the performance of major six sectors during the past five years. The findings of study infers that all sectors have positive skewness with IT sector possessing high value of skewness along with low positive kurtosis and oil sector with high skewness and high kurtosis. Besides these, the rest four sectors have negative kurtosis with pharma sector attaining the least. Further, it is observed that all the sectors don't follow a particular trend and are highly volatile with Automobiles sector outpaces others in volatility. The order of priorities are observed in terms of cumulative scores and found that Automobiles sector to be the dominant than other sectors by a huge margin followed by IT and pharma sector. The remaining sectors are lagging far behind in performance. Automobiles is observed to be the dominant, which is followed by IT, pharma, banking, oil and power. Furthermore, the hierarchy drawn, and the relative dominance help for optimal investment, and can aid proportional investments in future.

Acknowledgments

P Satya would like to thank DST-FIST vide SR/FST/MSI-090/2013(C) for providing Infrastructure support and UGC for providing financial support under JRF programme (Ref. No: 22/12/2013(ii)EU-V with Sr. No. 2121341012).

References

[1] S. Menon, "A Comparative Study of the indian stock Market with TWO international stock markets between 2012-17," *International*

Journal of Engineering Technology Science and Research, vol. 5, no. 3, p. 14, Mar. 2018.
[2] S. POSHAKWALE, “Evidence on Weak Form Efficiency and Day of the Week Effect in the Indian Stock Market,” *FINANCE INDIA*, vol. 10, no. 3, p. 12, Sep. 1996.
[3] Z. Bodi, *Investments*. Tata McGraw-Hill Education, 2009.
[4] U. T. MARA, “Power Comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling Tests.,” *Journal of Statistical Modeling and Analytics*, vol. 2, no. 1, p. 13, 2011.
[5] J. Campbell and L. Hentschel, “No News is Good News: An Asymmetric Model of Changing Volatility in Stock Returns,” National Bureau of Economic Research, Cambridge, MA, w3742, Jun. 1991.
[6] S. Agarwal, “Scale efficiency with fuzzy data,” *International Journal of Business and Systems Research*, vol. 11, no. 1–2, pp. 152–162, 2017.
[7] Y. C. Erensal, T. Öncan, and M. L. Demircan, “Determining key capabilities in technology management using fuzzy analytic hierarchy process: A case study of Turkey,” *Information Sciences*, vol. 176, no. 18, pp. 2755–2770, Sep. 2006.
[8] S. K. Jha and H. Puppala, “Prospects of renewable energy sources in India: Prioritization of alternative sources in terms of Energy Index,” *Energy*, vol. 127, pp. 116–127, May 2017.
[9] C. Kahraman, Ed., *Fuzzy multi-criteria decision making: theory and applications with recent developments*. New York, NY: Springer, 2008.
[10] C. Zopounidis and M. Doumpos, “Multi-criteria decision aid in financial decision making: methodologies and literature review,” *Journal of Multi-Criteria Decision Analysis*, vol. 11, no. 4–5, pp. 167–186, Jul. 2002.
[11] M. Dağdeviren and İ. Yüksel, “Developing a fuzzy analytic hierarchy process (AHP) model for behavior-based safety management,” *Information Sciences*, vol. 178, no. 6, pp. 1717–1733, Mar. 2008.
[12] A. I. Chatzimouratidis and P. A. Pilavachi, “Multicriteria evaluation of power plants impact on the living standard using the analytic hierarchy process,” *Energy Policy*, vol. 36, no. 3, pp. 1074–1089, Mar. 2008.
[13] M. M. Kalban, “Decision support for energy conservationpromotion: an analytic hierarchy process approach,” *Fuel and Energy Abstracts*, vol. 45, no. 5, p. 365, Sep. 2004.
[14] X. Wang and H. K. Chan, “A hierarchical fuzzy TOPSIS approach to assess improvement areas when implementing green supply chain initiatives,” *International Journal of Production Research*, vol. 51, no. 10, pp. 3117–3130, May 2013.