“Financial fortitude: Indian pharmaceutical sector’s performance before and during COVID-19 using fuzzy AHP & TOPSIS”

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FINANCIAL FORTITUDE: INDIAN PHARMACEUTICAL SECTOR'S PERFORMANCE BEFORE AND DURING COVID-19 USING FUZZY AHP & TOPSIS

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Abstract

The COVID-19 pandemic has significantly impacted the financial performance of various sectors across the globe, including the Indian pharmaceutical industry. This study aims to evaluate the financial performance of ten Indian pharmaceutical companies listed in the S&P BSE Healthcare Index over two distinct periods: before COVID-19 (2018–2020) and during the pandemic (2020–2022). A hybrid multicriteria decision-making (MCDM) approach, integrating the Fuzzy Analytic Hierarchy Process (FAHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), is employed to assess companies based on five key financial dimensions and several performance indicators. Results indicate that profitability, valuation, and growth ratios were the most critical dimensions, with weights of 0.21 each, followed by liquidity (0.19) and efficiency (0.18). Furthermore, among the companies evaluated, Divis Labs and Abbott India emerged as top performers, both during and before the pandemic, with Divis Labs registering closeness coefficients of 0.871 and 0.814 during 2020–2021 and 2021–2022. The findings highlight the financial resilience of these companies, offering valuable insights for stakeholders in formulating strategies to sustain financial stability during future crises.

Keywords operations research, multi-criteria, ratios, financial analysis, investors, evaluation, weights, ranking, decision-making

JEL Classification C44, G11, G30

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INTRODUCTION

The swift and unprecedented outbreak of the Novel Coronavirus paralyzed global economies, plunging many into severe economic downturns. Nations dependent on global trade, exports/imports, external funding, and tourism felt the pandemic's devastating impact most acutely. Industries worldwide experienced significant growth meltdowns, further exacerbating the plight of the poorest countries (Singh & Neog, 2020). India's battle against the virus was marked by enormous health and economic challenges with the nationwide lockdown triggering an economic collapse. Amid this turmoil, the Indian pharmaceutical industry emerged with fortitude, quickly recovering from the shock and offering a beacon of hope (Behera & Rath, 2021). COVID-19 catalyzed change, transforming and modernizing the industry to meet public needs. The industry mobilized resources, addressed supply chain disruptions, and scaled up the production of critical medicines. In addition, government policies, such as incentives for research and development, streamlined approval processes, and the Production Linked Incentive (PLI) scheme, fostered a conducive environment for growth and innovation (IndBiz, 2021).

The sector's critical role in combating COVID-19, coupled with substantial investments in research and development, has significantly enhanced its standing on the global stage. As a result, the Indian pharmaceutical industry attracted increased investor interest, driven by its growth potential and critical role in the global health crisis. Additionally, its commitment to sustainable and ethical practices has made it an attractive option for socially responsible investors (Keswani & Dhingra, 2023).

Although the sector has shown promising growth potential, it is imperative to scrutinize its financial performance, in the aftermath of COVID-19 to ascertain whether the companies have demonstrated financial resilience during the pandemic. This assessment is vital for comprehending a company's robustness and preparedness to face future challenges such as COVID-19, and it will also aid stakeholders in making well-informed decisions.

1. LITERATURE REVIEW

The Indian pharmaceutical sector, a pivotal player in global healthcare, has long been recognized for its significant contributions to both domestic and international markets. With the onset of the COVID-19 pandemic, this industry became a critical component in the global response to the crisis, providing essential medicines, vaccines, and treatments. The resilience shown by the sector during the pandemic underscored its ability to adapt and maintain operational efficiency amidst global disruptions (Gupta, 2020).

During the pandemic, the financial performance of industries gained significant attention as researchers sought to assess the impact of economic disruptions on various sectors. Globally, sector-specific studies revealed diverse financial outcomes. For example, a study on Sharia Banks revealed that factors like the financing-to-deposit ratio and capital adequacy ratio were significant determinants of performance during the pandemic (Ichsan et al., 2021). Similarly, research on Indonesia's livestock industry showed that profitability, revenue, and firm size were influential factors, while the poultry sector's financial health remained relatively stable (Gaisani et al., 2021). In contrast, the logistics industry in countries like Germany, Korea, and the UK experienced negative financial performance during COVID-19 (Atayah et al., 2022). Moreover, 96% of Indonesian tourism and hospitality firms faced financial challenges, demonstrating how the pandemic adversely impacted this industry (Soleha et al., 2022).

In India, smaller oil and gas corporations saw more growth than larger firms during the pandemic (Ali, 2022), while the hospitality, consumer, and tourism sectors in India were significantly disrupted. The construction industry witnessed a reduction in its expenses (Alsamhi et al., 2022), and the consumer durable industry experienced a notable increase in liquidity due to the pandemic, suggesting a surge in domestic production to meet immediate demand (Soni & Sharma, 2022). Additionally, it was reported that COVID-19 decreased profitability but enhanced liquidity, solvency, and economic value added in certain Indian public sector banks (Anithabose & Gnanaraj, 2023). Furthermore, the evaluation of the financial performance of India's telecommunications sector encompassing analysis of key indicators, such as profitability, liquidity, solvency, efficiency, and growth ratios, highlighted a constructive stimulus of the pandemic on the sector's financial status, indicating its ability to adapt and thrive amidst challenging circumstances (Bi et al., 2023). These findings indicate that the pandemic's financial effects varied across industries and underscore the need for industry-specific analysis. Despite the extensive analysis of the financial performance across various Indian industries during COVID-19, there remains a significant void in research addressing the financial performance of the Indian pharmaceutical sector during this period. This void is particularly striking given the sector's pivotal role in combating the pandemic and sustaining the nation's healthcare infrastructure.

In the analysis of financial performance, research has led to the development of more robust and accurate approaches, reducing errors associated with conventional methods like ratio analysis. One such approach is the adoption of Multi-Criteria Decision Making (MCDM) techniques. Further, among the

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MCDM techniques, the Fuzzy Analytic Hierarchy Process (FAHP) and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) are particularly noteworthy. The key reason behind this is that they offer a structured and systematic approach to handling multiple, often conflicting, criteria, leading to more informed and reliable decision-making outcomes (Başaran & Haruna, 2017). The fusion of FAHP and TOPSIS has demonstrated remarkable versatility and applicability in diverse contexts, including financial performance assessment. For instance, in examining third-party logistics service providers, this approach has provided a comprehensive framework to evaluate various criteria and rank potential providers based on their performance (Kumar & Singh, 2012). Similarly, when evaluating potential wind farm sites, the method has accounted for uncertainties and stakeholders' expertise, leading to more informed decision-making (Otay & Jaller, 2020). Furthermore, employing the TOPSIS algorithm within fuzzy programming has proven to enhance decision-making under uncertain conditions, resulting in tangible benefits such as cost savings and quality improvements across multi-criteria models (Halicka & Gola, 2024). In the context of urban water diversion projects, where fuzzy evaluation index values and incomplete index weight assignments pose challenges, this approach has boosted optimization efforts by providing a structured framework for decision-making (Fan et al., 2020). The framework has also made its contribution to choosing appropriate techniques for making decisions based on subjective judgments in the industrial sector (Liu et al., 2020). Moreover, the resourcefulness of these techniques extends to various domains and applications. It has been successfully applied in prioritizing employability criteria, emphasizing the importance of soft skills for students entering the workforce, and in the evaluation of retail stores (Bhattacherjee et al., 2024; Mortazavi & Seif Barghy, 2024). Additionally, it is utilized in the plastic industry to choose the most effective plastic recycling technology (Vinodh et al., 2014). Also, its usage extends to the assessment of the financial prowess of the banking industry (Seçme et al., 2009). The framework is also employed in the stock selection of financial indices (Jana et al., 2024).

In the realm of the Indian pharmaceutical industry, the MCDMs are utilized mainly to address supply chain issues. Nikhil et al. (2017) illustrated a methodology for prioritizing pharmaceutical supply chain challenges using the fuzzy analytic hierarchy process (FAHP), highlighting a systematic approach to identifying the most critical issue for resolution. Ganguly and Kumar (2019) identified and ranked a series of crucial resiliency strategies for supply chains using the FAHP in the Indian pharma sector. Further, Modibbo et al. (2022) ranked the Indian pharma companies' suppliers based on the Fuzzy-Topsis technique. Vishwakarma et al. (2023) modeled the barriers of the Indian pharmaceutical supply chain using FAHP. Concerning the application of FAHP-TOPSIS, there is a dearth of research focused on evaluating the financial performance of Indian pharmaceutical companies, as most existing studies have applied these techniques primarily to address supply chain issues.

While MCDM techniques such as FAHP and TOPSIS offer a sophisticated and multi-dimensional approach to financial performance assessment, traditional methods like financial ratios remain integral to understanding firm stability and soundness. Financial ratios have been used for a long time to assess the performance of firms. Extensive literature underscores the widespread use of financial indicators in assessing firm stability and soundness. Financial ratios serve as reliable indicators of a company's financial characteristics and performance, aiding in predicting future outcomes (Barnes, 1987). They assist investors in discerning between well-performing and underperforming firms (Ak et al., 2013). Hilkevics and Semakina (2019) categorized ratios based on stakeholders such as owners, workers, managers, society, creditors, and investors. Key financial ratios in financial studies include profitability, liquidity, efficiency, and growth which are supported by scholars like Akhtar (2018), Anthony et al. (2019), and Nguyen et al. (2020) in their studies. Moreover, a substantial body of research on financial performance analysis utilizing MCDMs has also incorporated these ratios, as seen in studies by Shaverdi et al. (2014), Safaei Ghadikolaei et al. (2014), Moghimi and Anvari (2014), and Alimohammadlou and Bonyani (2017). The integration of these ratios in various studies has imparted immense and holistic information about different financial elements to different business process stakeholders that are proven to be of great value. In recent times, contemporary ratios such as valuation ratios have gained more importance due to their association with predicting equity returns (Iltas et al., 2017; Bustani et al., 2021). These ratios offer an understanding of how investors perceive the company's potential for future growth, its ability to generate earnings, and its overall attractiveness for the investment (Venkata Lakshmi Suneetha & Aithal, 2024). However, the reviewed literature indicates that the studies on financial performance, particularly those employing MCDMs, often lack the inclusion of valuation ratios.

In conclusion, while the existing research has explored the pandemic's impact on the financial prowess of various industries worldwide and Indian industries such as oil and gas, tourism, and construction, the financial performance of Indian pharmaceutical companies, which played a crucial role in managing the pandemic, remains under-researched. Given its significant role and strong investor confidence, a detailed examination of the pharma companies' performance before and during the pandemic is essential. This analysis will provide insights into their resilience and guide investment and strategic decisions. Additionally, although FAHP and TOPSIS have shown their effectiveness in various domains, their application to Indian pharmaceutical companies remains unexplored. Thus, this study aims to fill this gap by using FAHP and TOPSIS to assess the financial performance of chosen companies, focusing on their resilience during COVID-19, and incorporating valuation ratios for a more nuanced evaluation.

2. METHODS

In this segment, the methodological framework of FAHP and TOPSIS is elaborated. Additionally, the study period and data collection procedures are highlighted. The data collection section also explains the hierarchical structure used for performance evaluation.

2.1. FAHP methodological framework

The Analytical Hierarchy Process (AHP), pioneered by Saaty (1980), is a widely used method for aiding decision-making processes that involve multiple criteria. AHP helps in synthesizing complex decision-making processes by quantifying the relative importance of various choices based on decision-maker's evaluations (Russo & Camanho, 2015). Despite being extensively utilized, AHP has been subject to criticism due to its inability to accurately emulate human thought processes and to generate inconsistent decision outputs (Kahraman et al., 2004; Whitaker, 2007; Pérez et al., 2006; Kabir & Hasin, 2011). To address these limitations, the FAHP, an extension of AHP, was developed. FAHP incorporates fuzzy logic, first proposed by Zadeh in his fuzzy set theory proposal, to handle uncertainties in decision-making (Zadeh, 1965). Fuzzy logic offers a structured approach to addressing ambiguity and sustainability (Andriantiatsaholiniaina et al., 2004). The integration of fuzzy sets has proven effective in dealing with uncertainties, subjective assessments, and vagueness (Banerjee & Pal, 1996). In practice, trapezoidal and triangular fuzzy numbers are commonly used, with triangular fuzzy numbers (TFNs) being favored due to their computational simplicity. TFNs, represented as (q, r, s), denote the smallest, most promising, and largest possible values, respectively, of a fuzzy event. This study uses TFNs to facilitate various operations, where key operations include:

a) Addition:

If two positive triangular fuzzy numbers are described as (q_1, r_1, s_1) and (q_2, r_2, s_2), then,

$$(q_1, r_1, s_1) \oplus (q_2, r_2, s_2) = (q_1 \oplus q_2, r_1 \oplus r_2, s_1 \oplus s_2), \quad (1)$$

b) Multiplication:

$$(q1, r1, s1) \oplus (q2, r2, s2) = (q1 \oplus q2, r1 \oplus r2, s1 \oplus s2), \quad (2)$$

c) Inversion:

$$(q_1, r_1, s_1) - 1 \approx (1/s_1, 1/r, 1/q_1). \quad (3)$$

Based on the triangular fuzzy number, a new strategy for dealing with pair-wise comparison scales was pioneered by Chang (1992). Further, in the year 1996, Chang presented the extent analysis technique for calculating the synthetic extent value of pairwise comparisons (Chang, 1996). Since

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then, the FAHP method has been proven to be an effective solution for addressing the practical difficulties in the multi-attribute-decision making problem. The fundamental trait of FAHP lies in its capability to account for the uncertainty inherent in human modes of thinking, thereby assisting in the systematic and streamlined resolution of research challenges. FAHP considers the pair-wise comparisons of the various alternatives regarding the different criteria to provide decision assistance for multicriteria decision issues. The extent AHP, introduced originally by Chang (1996), has been applied in this study.

The extent analysis approach proposed by Chang (1996) facilitates a comprehensive evaluation of each potential outcome, considering its objectives. This process yields P extended analysis values for every choice, denoted in equation (4), corresponding to the set of final rankings $Z = (z_1, z_2, z_3, ..., z_n)$ and the set of objects $X = (x_1, x_2, x_3, ..., x_n)$.

$$P_{zi}^1,\ P_{zi}^2,\ P_{zi}^3,\ldots,P_{zi}^m,\quad i=1,2,3,\ldots,n, \tag{4}$$

where P^j_{zi} (j = 1, 2, 3, ..., m) are the TFN's. The extent analysis method involves several sequential steps, which are mentioned below:

Step 1: Calculation of Fuzzified Synthetic Extent Numbers.

In this step, the fuzzified synthetic extent number for each object is determined by aggregating the fuzzy values associated with the pairwise comparisons. The values are normalized to account for the overall contributions from all alternatives, resulting in a comprehensive evaluation for each object.

Step 2: Definition of the Degree of Possibility.

This step defines the degree of possibility that one fuzzy number is greater than or equal to another. This is done by finding the highest point at which the membership functions of the two fuzzy numbers intersect. The intersection height indicates the strength of the possibility relationship, helping to compare the two fuzzy sets.

Step 3: Calculation of Degree of Possibility for Convex Fuzzy Numbers.

For a set of convex fuzzy numbers, the degree of possibility that a certain value exceeds these numbers is calculated. This involves determining the minimum possibility value among all comparisons, which indicates how likely it is that one fuzzy number surpasses the others. This comparison helps in establishing a weight vector for all alternatives based on their relative performance.

Step 4: Normalization of Weight Vectors.

The final step involves normalizing the weight vectors derived from the previous calculations. This results in a set of non-fuzzy values that represent the relative importance of each alternative. Normalization ensures that the weights are comparable and appropriately scaled for further analysis.

2.2. TOPSIS process

TOPSIS has gained popularity among scholars for decision-making purposes in recent years. Introduced by Hwang et al. (1981), TOPSIS offers the advantage of assigning specific weights to evaluate all parameters collectively. This method relies on the concept of positive and negative ideal solutions, making it a favored choice in financial studies due to its user-friendly nature. In the present scenario, TOPSIS is utilized to evaluate and rank the fiscal performance of companies, accounting for both pre-COVID-19 and COVID-19 periods. This ranking is grounded on the relative significance of financial performance indicators determined through FAHP analysis and the financial data of the companies. The TOPSIS procedural stages are described below:

Step 1: A normalized decision matrix is obtained by applying the following equation:

$$r_{ij}=\frac{w_{ij}}{\sqrt{\sum_{j=1}^{j}w_{ij}^2}},\quad j=1,2,3,\ldots,J, \tag{5}$$

Step 2: Obtaining the weighted normalized decision matrix by:

$$V_{ij}=w_i\cdot r_{ij},\quad j=1,2,3,\ \ldots,\ J,\quad i=1,2,3,\ldots,n, \tag{6}$$

Step 3: Calculating the positive and negative ideal solution by:

$$B^* = \{v_1^*, v_2^*, v_3^*, ..., v_n^*\}, \quad (7)$$

$$B^- = \left\{v_1^-, v_2^-, v_3^-, ..., v_n^-\right\}. \quad (8)$$

Step 4: The formulas to compute the distance of each alternative from positive and negative ideal solutions are:

$$Y_i^* = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^*\right)^2}, \quad j = 1,2,3,..., J, \quad (9)$$

$$Y_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2}, \quad j = 1,2,3,..., J, \quad (10)$$

Step 5: The closeness coefficient (CC_0) of every alternative is determined by:

$$CC_0 = \frac{Y_i^-}{Y_i^* + Y_i^-}, \quad i = 1,2,3,...,J, \quad (11)$$

Step 6: Alternatives are sorted according to their CC_0 values, with the alternative demonstrating the highest CC_0 value being positioned at the foremost rank, followed by others arranged in descending order of their CC_0 values.

2.3. Study period & data collection

The central objective of this study is to analyze and compare the financial stability of the Indian pharmaceutical sector before and during COVID-19. Consequently, the study segments its periods based on the declaration issued by the World Health Organization (WHO) in March 2020, officially acknowledging COVID-19 as a pandemic (WHO, 2020). Accordingly, the financial years from April 2018 to March 2020 are designated as the pre-COVID-19 era, while the financial years from April 2020 to March 2022 are identified as the COVID-19 period. The division of time horizons based on the WHO's announcement of the COVID-19 health crisis as a pandemic was chosen for several reasons that directly relate to the research question. Firstly, the WHO declaration in March 2020 marked a pivotal moment globally, signifying the recognition of COVID-19 as a widespread and severe health crisis. By aligning the time division with this significant event, a clear demarcation between the periods before and after the pandemic's formal recognition is created. This division allows us to examine how the financial performance of the Indian pharmaceutical sector is shaped by the onset of the pandemic, providing insights into its resilience and responsiveness to external shocks. Additionally, aligning the time division with a globally recognized milestone such as the WHO's declaration enhances the relevance and applicability of the research findings. Stakeholders and decision-makers can better contextualize the industry's performance within the broader framework of the pandemic, facilitating informed decision-making processes.

To apply FAHP, firstly the decision criteria, represented by financial ratios, and the sample companies were identified for the study. For evaluation purposes, 5 key ratios were selected: profitability, liquidity, efficiency, valuation, and growth ratios. Further, a total of 14 sub-criteria were chosen. The study selected ten companies listed on the S&P BSE Healthcare Index based on their market capitalization, which ranged from ₹389,000 crores to ₹31,631 crores. The key characteristics of these companies are detailed in Table A1 of Appendix A. Additionally, Table 1 presents the selected ratios for the decision criteria and the list of sample companies. The hierarchical structure for evaluating financial performance, illustrated in Figure 1, was constructed based on existing literature.

The data on financial indicators were collected from the financial statements of ten Indian pharmaceutical companies, utilizing the MoneyControl platform (Money Control, 2024). Opinions from three specialists – a Chartered Accountant who specialized in auditing pharmaceutical companies, a Creditor, and a Stock Market Investment Advisor – were solicited through a questionnaire. At the outset, each decision-maker evaluated the comparative significance of one factor over another utilizing the linguistic scales proposed by Eyüboglu & Çelik (2016). Experts were chosen to reflect the diverse expectations of stakeholders in assessing the significance of financial ratios through pairwise comparisons. To mitigate potential biases and enhance the reliability of pairwise comparisons, a collaborative decision-making approach based on FAHP was adopted. Subsequently, the FAHP technique was applied to compute the relative weights of the decision criteria.

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Table 1. Decision criteria and list of sample companies

Main Criteria	Symbol Used	Sub-Criteria (Financial Ratios)
Profitability Ratios (PR)	E1	Net Profit Margin Ratio (NPM)
		Return on Equity Ratio (ROE)
		Return on Assets Ratio (ROA)
		Return on Capital Employed Ratio (ROCE)
Liquidity Ratios (LR)	E2	Current Ratio (CR)
		Quick Ratio (QR)
Efficiency Ratios (ER)	E3	Inventory Turnover Ratio (ITR)
		Debtors Turnover Ratio (DTR)
		Asset Turnover Ratio (ATR)
Valuation Ratios (VR)	E4	Price to Book Ratio (PBR)
		EV/EBIDTA Ratio (EVIDTAR)
Growth Ratios (GR)	E5	Earnings Per Share Growth Ratio (EPS)
		Book Value Growth Ratio (BVG)
		Revenue Growth Ratio (RG)

List of Sample Companies
Sun Pharmaceuticals
Divis Labs
Cipla
Dr. Reddy's Labs
Torrent Pharma
Zydus Lifesciences
Abbott India
Alkem Labs
Biocon
Lupin

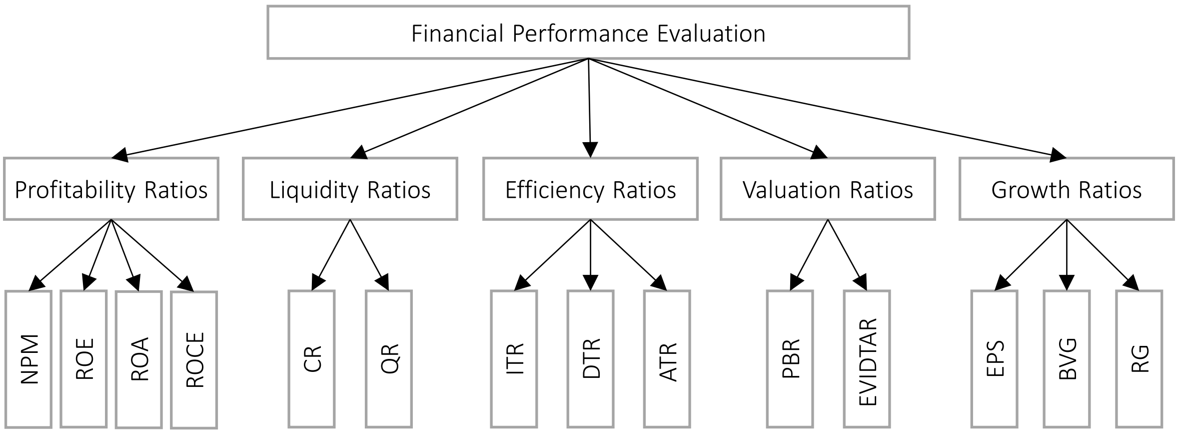

Figure 1. The hierarchical structure of the proposed model

3. RESULTS

This section provides a detailed analysis and synthesis of findings obtained through applying FAHP and TOPSIS. It begins by presenting the results derived from expert assessments and subsequently delves into quantitative analyses. Firstly, the assessments provided by the three experts are encapsulated in the matrices denoted as $DM1$, $DM2$, and $DM3$.

$$DM1 = \begin{array}{c} \\ E1 \\ E2 \\ E3 \\ E4 \\ E5 \end{array} \begin{array}{c} \begin{array}{ccccc} E1 & E2 & E3 & E4 & E5 \end{array} \\ \begin{bmatrix} 1 & 1 & 3 & 1/5 & 5 \\ 1 & 1 & 5 & 1/7 & 1/3 \\ 1/3 & 1/5 & 1 & 1/5 & 1 \\ 5 & 7 & 5 & 1 & 1/3 \\ 1/5 & 3 & 1 & 3 & 1 \end{bmatrix} \end{array}, \quad (12)$$

$$DM2 = \begin{array}{c} \\ E1 \\ E2 \\ E3 \\ E4 \\ E5 \end{array} \begin{array}{c} \begin{array}{ccccc} E1 & E2 & E3 & E4 & E5 \end{array} \\ \begin{bmatrix} 1 & 1/3 & 5 & 7 & 1/5 \\ 3 & 1 & 3 & 1/7 & 3 \\ 1/5 & 1/3 & 1 & 3 & 1/5 \\ 1/7 & 7 & 1/3 & 1 & 1/3 \\ 5 & 1/3 & 5 & 3 & 1 \end{bmatrix} \end{array}, \quad (13)$$

$$DM3 = \begin{array}{c} \\ E1 \\ E2 \\ E3 \\ E4 \\ E5 \end{array} \begin{array}{c} \begin{array}{ccccc} E1 & E2 & E3 & E4 & E5 \end{array} \\ \begin{bmatrix} 1 & 5 & 1/3 & 5 & 3 \\ 1/5 & 1 & 5 & 1/3 & 1/7 \\ 3 & 1/5 & 1 & 5 & 3 \\ 1/5 & 3 & 1/5 & 1 & 1/3 \\ 1/3 & 7 & 1/3 & 3 & 1 \end{bmatrix} \end{array}. \quad (14)$$

Next, a fuzzy pairwise comparison matrix is formulated, illustrated in Table 2, by amalgamating assessments from three decision-makers using equation (15). This method entails converting pair-wise comparison values of decision-makers into triangular fuzzy numbers.

$$l_{ij} = \min_k \{a_{ijk}\}, m_{ij} = \frac{1}{k}\sum_{k=1}^{k} b_{ijk}, u_{ij} = \frac{1}{k}\sum_{k=1}^{k} b_{ijk}. \quad (15)$$

After establishing the fuzzy comparison matrix, the weights of the main and sub-criteria are estimated using the Fuzzy Analytic Hierarchy Process (FAHP) framework. The synthesized values and their comparisons are presented in Table 3, which summarizes the computed weights of the primary criteria. These weights are then normalized to facilitate comparison. Further, the weights of the ancillary criteria are calculated similarly. The findings are shown in Table 4.

Table 4. Calculated sub-criteria weights

Sub-criteria	Weights
NPM	0.24
ROE	0.25
ROA	0.25
ROCE	0.26
CR	0.69
QR	0.31
ITR	0.33
DTR	0.35
ATR	0.31
PBR	0.51
EVIDTAR	0.49
EPS	0.53
BVG	0.36
RG	0.12

Once the weights for both the primary and secondary criteria are established, the financial ratios of the companies are normalized using the TOPSIS approach. Each sub-criteria weight is then multiplied by its corresponding normalized value to create the weighted normalized matrix. The cumulative values for each primary criterion are computed by summing the values of all related secondary criteria. Subsequently, the total value of each main criterion for each year is multiplied by its respective main criteria weight to derive the overall weighted values of the primary factor, as presented in Table 5.

Table 2. Fuzzy comparison matrix

Criteria	E1			E2			E3			E4			E5		
E1	1.00	1.00	1.00	0.33	2.11	5.00	0.33	2.78	5.00	0.20	4.07	7.00	0.20	2.73	5.00
E2	0.20	1.40	3.00	1.00	1.00	1.00	3.00	4.33	5.00	0.14	0.21	0.33	0.14	1.16	3.00
E3	0.20	1.18	3.00	0.20	0.24	0.33	1.00	1.00	1.00	0.20	2.73	5.00	0.20	1.40	3.00
E4	0.14	1.78	5.00	3.00	5.67	7.00	0.20	1.84	5.00	1.00	1.00	1.00	0.33	0.33	0.33
E5	0.20	1.84	5.00	0.33	3.44	7.00	0.33	2.11	5.00	3.00	3.00	3.00	1.00	1.00	1.00

Table 3. Computed synthesized values, and normalized main criteria weights

Synthesized Value Criteria Symbol	Synthesized Values	Main-Criteria	Weights Before Normalization	Normalized Weights
SE1	(0.024, 0.257, 1.285)	d(E1)	1.00	0.21
SE2	(0.052, 0.164, 0.689)	d(E2)	0.88	0.19
SE3	(0.021, 0.133, 0.689)	d(E3)	0.84	0.18
SE4	(0.054,0.215, 1.024)	d(E4)	0.96	0.21
SE5	(0.056, 0.231, 1.173)	d(E5)	0.98	0.21

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Table 5. Total weighted values of primary criteria

Company	2021–2022				
	PR	LR	ER	VR	GR
Sun Pharmaceuticals	0.003	0.016	0.039	0.093	–0.077
Divis Labs	0.295	0.123	0.044	0.059	0.100
Cipla	0.159	0.078	0.046	0.035	0.053
Dr. Reddy's Labs	0.103	0.040	0.043	0.039	0.006
Torrent Pharma	0.170	0.028	0.043	0.055	0.006
Zydus Lifesciences	0.009	0.027	0.039	0.029	–0.015
Abbott India	0.303	0.059	0.121	0.090	0.034
Alkem Labs	0.193	0.029	0.053	0.043	0.037
Biocon	0.016	0.074	0.026	0.044	–0.042
Lupin	–0.011	0.040	0.040	0.080	–0.068
Company	**2020–2021**				
Sun Pharmaceuticals	0.029	0.027	–0.033	0.093	–0.039
Divis Labs	0.082	0.103	–0.045	0.071	0.097
Cipla	0.049	0.070	–0.049	0.038	0.006
Dr. Reddy's Labs	0.050	0.045	–0.047	0.047	0.005
Torrent Pharma	0.056	0.028	–0.042	0.063	0.050
Zydus Lifesciences	–0.059	0.028	–0.041	0.045	0.034
Abbott India	0.090	0.066	–0.113	0.101	0.028
Alkem Labs	0.076	0.036	–0.054	0.042	0.068
Biocon	0.017	0.076	–0.037	0.063	–0.029
Lupin	0.027	0.069	–0.041	0.041	0.074
Company	**2019–2020**				
Sun Pharmaceuticals	0.054	0.022	0.035	0.058	0.054
Divis Labs	0.087	0.099	0.040	0.059	0.087
Cipla	0.061	0.067	0.045	0.028	0.061
Dr. Reddy's Labs	0.080	0.050	0.047	0.046	0.080
Torrent Pharma	0.061	0.021	0.045	0.068	0.061
Zydus Lifesciences	–0.021	0.022	0.037	0.038	–0.021
Abbott India	0.092	0.076	0.117	0.141	0.092
Alkem Labs	0.077	0.033	0.063	0.058	0.077
Biocon	0.036	0.058	0.029	0.054	0.036
Lupin	0.025	0.087	0.041	0.028	0.025
Company	**2018–2019**				
Sun Pharmaceuticals	0.025	0.016	0.029	0.100	0.085
Divis Labs	0.101	0.103	0.041	0.059	0.072
Cipla	0.061	0.075	0.049	0.041	0.042
Dr. Reddy's Labs	0.049	0.057	0.046	0.055	0.077
Torrent Pharma	0.056	0.022	0.045	0.075	0.061
Zydus Lifesciences	0.041	0.016	0.040	0.057	0.044
Abbott India	0.098	0.063	0.111	0.084	0.050
Alkem Labs	0.066	0.034	0.065	0.057	0.034
Biocon	0.038	0.046	0.035	0.056	0.067
Lupin	0.051	0.092	0.043	0.031	0.003

Furthermore, by choosing the highest and lowest values for each criterion, the positive and negative ideal outcomes are ascertained. The distance of each company from these ideal solutions is then calculated for each criterion. Next, the closeness coefficient (CCo) for each company is computed. Based on these values, the ranks of each firm are established for both the pre-COVID-19 and COVID-19 periods, as outlined in Table 6. The four-year evolution of the firms' financial accomplishments is illustrated in Figure 2.

The outcome of the FAHP analysis in Table 3 has revealed that profitability, valuation, and growth ratios, each with a weight value of 0.21, are the most critical criteria for assessing the financial well-being of the Indian pharmaceutical sector both pre and during COVID-19. Further, the liquidity ratio closely trails behind with a weighted score of 0.19, while the efficiency ratio holds the least weight of 0.18. Among the fourteen supplemental criteria, the current ratio has the highest relative weight with a score of 0.69, whereas revenue growth has the lowest with a score of 0.12 (Table 4). These insights are crucial for pharmaceutical companies to monitor key financial dimensions to sustain through catastrophic events like a pandemic. The application of TOPSIS (Table 6) indicates that Abbott India had the highest closeness coefficient before COVID-19, with values of 0.715 in 2018–2019 and 0.696 in 2019–2020, securing the top rank in financial performance. Conversely, Zydus Lifesciences had the lowest scores in 2018–19 (CC_0 = 0.275) and Lupin reported the lowest score in 2019–2020 (CC_0 = 0.082). Sun Pharmaceuticals performed well before the pandemic but dropped to ninth place in 2020–2021 and 2021–2022. Dr. Reddy's Labs also saw a decline in ranking during the pandemic. Cipla's performance fluctuated, placing it eighth in 2019–2020 but it delivered average results during the pandemic. Torrent Pharma maintained mid–level performance throughout the study period, ranking between fifth and sixth. Further, Alkem Labs improved significantly from 2018–2019, reaching second and third positions during the pandemic. Divis Labs excelled during the pandemic, achieving top rankings with closeness coefficients of 0.871 and 0.814, and performed well before the pandemic too. Biocon consistently underperformed throughout the study period. Overall, Divis Labs, Abbott India, and Alkem Labs

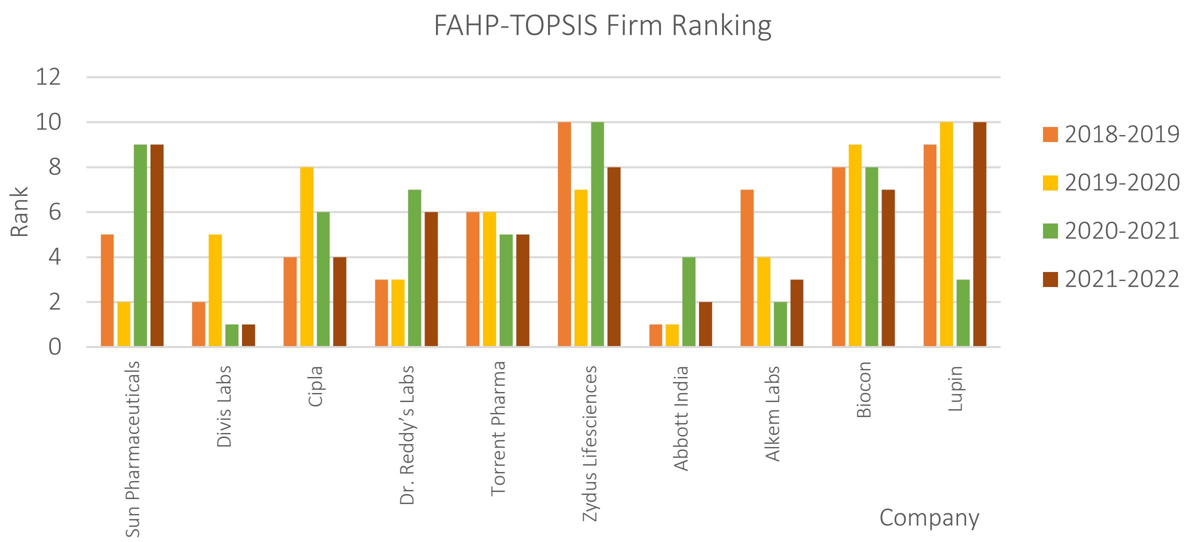

Figure 2. FAHP-TOPSIS ranking of the Indian pharmaceutical sector based on their financial efficiency before and during COVID-19

Table 6. Ranking of firms following calculated CCo values

Company	2018-2019	2019-2020	2020-2021	2021-2022	Rank Before Covid-19		Rank During Covid-19	
	CC_o	CC_o	CC_o	CC_o	2018-2019	2019-2020	2020-2021	2021-2022
Sun Pharmaceuticals	0.432	0.489	0.438	0.153	5	2	9	9
Divis Labs	0.625	0.271	0.871	0.814	2	5	1	1
Cipla	0.436	0.214	0.532	0.548	4	8	6	4
Dr. Reddy's Labs	0.469	0.436	0.513	0.362	3	3	7	6
Torrent Pharma	0.409	0.250	0.614	0.493	6	6	5	5
Zydus Lifesciences	0.275	0.232	0.355	0.164	10	7	10	8
Abbott India	0.715	0.696	0.615	0.795	1	1	4	2
Alkem Labs	0.388	0.383	0.653	0.570	7	4	2	3
Biocon	0.384	0.137	0.441	0.178	8	9	8	7
Lupin	0.372	0.082	0.630	0.137	9	10	3	10

demonstrated strong financial resilience during the pandemic and did well even before COVID-19. The outcome suggests that these companies have robust financial fundamentals and are likely to sustain when confronted with similar challenges in the future. Thus, these stocks are recommended for portfolio construction.

4. DISCUSSION

In the past few years, the Indian pharmaceutical sector has witnessed considerable transformation, especially during the COVID-19 pandemic. As one of the most critical sectors in ensuring public health and economic stability during the crisis, the pharmaceutical industry drew substantial attention from investors, analysts, and policymakers. The economic challenges posed by the pandemic highlighted the necessity for a deeper evaluation of companies' financial resilience and performance.

An extensive review of published research underscores the critical importance of financial performance metrics in evaluating the resilience and sustainability of companies. In the context of the present study, profitability, liquidity, efficiency, growth, and valuation ratios were chosen. Further, expert insights were obtained from a Chartered Accountant, a Creditor, and a Stock Market Investment Advisor, while the hybrid MCDM methods were applied to evaluate five main criteria and fourteen sub-criteria. The objective was

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to create a comprehensive performance evaluation framework by using FAHP to determine the weights and TOPSIS to rank the alternatives.

The findings emphasized the importance of profitability, valuation, and growth ratios in evaluating the financial performance of pharmaceutical firms. These metrics not only offer a clear picture of a company's financial health but also help gauge its long-term sustainability. Consistent with the studies of Moghimi and Anvari (2014) and Ertuğrul and Karakaşoğlu (2009), profitability and growth ratios remain central to financial assessment models that employ MCDM approaches. However, this study introduces a new perspective by highlighting the previously underappreciated role of valuation ratios in evaluating financial performance.

Strategically, the above-mentioned findings highlight the need for companies to prioritize initiatives that enhance profitability, maintain favorable valuations, and support sustainable growth. These goals can be achieved by implementing cost-control measures, pursuing innovation-driven growth opportunities, expanding markets, and optimizing pricing strategies to improve margins.

Among the sub-criteria, the current ratio surfaced as a particularly critical metric, indicating its role in assessing short-term financial stability. This finding aligns with traditional financial theories that stress liquidity management as a foundation for operational stability. The importance of maintaining a balanced current ratio for liquidity management cannot be overstated, as it provides companies with the flexibility to weather short-term financial shocks.

The TOPSIS results reveal that Sun Pharma experienced a significant decline in performance during the pandemic compared to the pre-COVID-19 era, while Divis Laboratories and Abbott India maintained strong performance both before and during the pandemic, underscoring the resilience of their financial foundations during the challenging time. These firms have not only managed to sustain operations during the pandemic but also exhibited consistent financial performance, making them attractive to growth-oriented investors looking for stocks capable of weathering future economic challenges. This suggests that investors could build more resilient portfolios by targeting companies with proven financial stability.

An important policy implication of this study is the identification of companies with solid financial performance. By analyzing financial metrics such as ROA, ROCE, NPM, and CR, firms that have demonstrated significant financial resilience were identified. Policymakers can leverage these findings to craft targeted policies and initiatives to foster growth and encourage investment in these companies, attract foreign investments, and drive collaborations that benefit the broader economy.

From a management perspective, the insights provided by this analysis enable Indian pharmaceutical companies to benchmark their performance against top-performing peers. This can help identify areas of financial weakness and competitive gaps, offering a basis for strategic adjustments that enhance competitiveness. Additionally, the findings offer valuable guidance to policymakers and government agencies aiming to support the pharmaceutical sector.

This study aligns with the Pharmaceuticals Vision 2030, which aims to transform India into a global pharmaceutical manufacturing and innovation leader. By evaluating the financial performance of companies within the sector, this study provides valuable insights for policymakers and investors seeking to strengthen the pharmaceutical industry's resilience and competitiveness.

The framework utilized can serve as a foundational model for pharmaceutical sectors globally, enabling firms to assess their fiscal performance under various economic conditions and facilitating more informed strategic decision-making. Looking to the future, several avenues for further research emerge from this study. One promising direction is the integration of qualitative metrics, such as market perception and management quality, alongside quantitative financial ratios. Such a comprehensive approach would allow for a more nuanced understanding of financial performance, particularly in sectors where intangible assets like reputation and leadership play critical roles. Additionally, expanding expert consensus by involving a broader spectrum of professionals in the evaluation process could provide more diverse perspectives, thereby enhancing the robustness of financial assessments. There is also potential for conducting comparative studies across industries and nations using MCDM approaches. Such comparisons would provide a clearer picture of how pharmaceutical companies perform relative to counterparts in other sectors and regions, offering key insights into best practices that can be adopted globally. Finally, exploring alternative MCDM methods, such as Vise Kriterijumska Optimizacija I Kompromisno Resenje (VIKOR), Elimination and Choice Expressing Reality (ELECTRE), Decision-Making Trial and Evaluation Laboratory (DEMATEL), and Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE), could refine the analysis. These methods offer unique strengths and may yield more precise outcomes, contributing to the accuracy and reliability of financial performance assessments in the pharmaceutical sector.

CONCLUSION

This study aimed to evaluate the financial performance of ten Indian pharmaceutical companies listed in the S&P BSE Healthcare Index during two distinct periods: before COVID-19 (2018–2020) and during the pandemic (2020–2022), using a hybrid MCDM approach. The primary objective was to develop a reliable framework for assessing financial performance, offering investors and stakeholders valuable tools for making informed decisions. FAHP and TOPSIS methodologies were applied to analyze key financial metrics, including profitability, liquidity, efficiency, valuation, and growth ratios. The results emphasize the critical role of profitability, valuation, and growth ratios in evaluating pharmaceutical firms' financial strength and sustainability. Further, applying the TOPSIS method has identified Divis Laboratories and Abbott India as consistent top performers during the study period, reflecting their robust financial stability. This study makes several key contributions to the existing literature: first, by employing a hybrid FAHP-TOPSIS approach to evaluate financial resilience in the Indian pharmaceutical industry; and second, by offering a multidimensional evaluation framework that helps investors make informed decisions; and third, by emphasizing the inclusion of valuation ratios to the FAHP-TOPSIS in assessing financial performance. Overall, the findings provide actionable insights for investors, company management, and policymakers, supporting the development of strategies to navigate an evolving economic landscape. Future research could explore alternative MCDM methods to further enhance the robustness of financial evaluations and expand the applicability of this framework in other sectors or economic contexts.

AUTHOR CONTRIBUTIONS

Conceptualization: Sonia Lobo, Sudhindra Bhat.
Data curation: Sonia Lobo.
Formal analysis: Sonia Lobo.
Investigation: Sonia Lobo.
Methodology: Sonia Lobo.
Project administration: Sudindra Bhat.
Resources: Sonia Lobo.
Software: Sonia Lobo.
Supervision: Sudhindra Bhat.
Validation: Sudhindra Bhat.
Visualization: Sonia Lobo, Sudhindra Bhat.
Writing – original draft: Sonia Lobo.
Writing – reviewing & editing: Sonia Lobo, Sudhindra Bhat.

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APPENDIX A

Table A1. List of investigated companies and their key characteristics

Company Name	Domain specified in S&P BSE Healthcare	Key Specializations	Market Capitalization (Approx in Crores) As of March 31, 2024
Sun Pharmaceuticals	Branded Medicines	Diversified Specialty and Generics Portfolio, active pharmaceutical ingredients (APIs), branded formulations	₹389,000
Divis Labs	API / Generic Pharmaceuticals	Leading manufacturer of API, custom synthesis	₹91,531
Cipla	Branded Medicines	Respiratory, cardiovascular, anti-infective, and critical care therapeutics	₹121,000
Dr. Reddy's Labs	Branded Medicines	Pharmaceutical Ingredients (API), generics, branded generics, biosimilars and over-the-counter pharmaceutical products	₹102,000
Torrent Pharma	Branded Medicines	Cardiovascular, CNS, gastrointestinal, diabetology, and	₹88,082
Zydus Lifesciences	Branded Medicines	Vaccines, biosimilars, APIs, new chemical entities (NCEs)	₹101,000
Abbott India	Branded Medicines	Diabetes care, vascular, diagnostics, and pharmaceuticals,	₹57,754
Alkem Labs	Branded Medicines	Generics, nutraceuticals, APIs, biosimilars	₹59,133
Biocon	Branded Medicines	Biosimilars, generics	₹31,631
Lupin	Branded Medicines	Biologics, and novel biologics	₹73,729

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