FINANCIAL EFFICIENCY ANALYSIS: EMPIRICAL EVIDENCE FROM THE EMERGING STOCK MARKET

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Abstract

The purpose of this research is to analyze the financial effectiveness of listed companies in the Indian stock market during the period 2016–2021 to identify which organizations have achieved a combination of technologically viable factors and products that maximize profit, taking into account the limitation of inputs. The methodology used is the data envelopment analysis (DEA), a non-parametric procedure that uses the linear programming technique for the evaluation of the relative efficiency of a set of productive units. The results obtained through the DEA model indicate that during the period 2016–2021 there were on average 17 efficient units per year (under the BCC model), representing 26.82% of the total number of listed companies in the Indian stock market; of these companies, six were efficient during all the years of the period analyzed. Moreover, the study concludes that an operational measure such as efficiency is established as an indicator of support for investment decision-making, complementing the traditional indicators of financial analysis. It is expected that this work will open the way to new research in which the DEA methodology is used to evaluate financial efficiency in other stock markets and the consideration of two-stage network DEA models can be considered.

Keywords: Stock Market, Efficiency Analysis, Inputs, Productivity, Outputs

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1. INTRODUCTION

Investment decision-making has traditionally followed a process of analysis of both economic and financial variables of the organizations under interest, through indicators and the interpretation of their financial statements. However, attention is rarely focused on analyzing variables of companies' operations, such as efficiency, a concept that is generally associated with a relationship between means–input and ends–output and could be more appropriate for making a better decision since it

indicates the optimization — or not — of the resources used to obtain certain established results. In this sense, the efficiency of an organization would be given by obtaining the maximum productivity according to the resources used or, analogously, a given level of production, using a minimum amount of resources. Efficiency analysis, therefore, takes into account the resource allocation problem, which is defined as the ability to combine inputs and outputs in optimal proportions, in light of prevailing prices, to minimize production costs.

For organizations seeking higher levels of competitiveness, efficiency-oriented management is required, because if financial performance is not measured and resources are not managed, there is no improvement in results. Furthermore, the company will obtain what it measures and recognizes, taking into account the relationship between the means employed and the ends obtained. Listed companies are no strangers to this premise, since obtaining good operating results, expressed through efficiency, translates into good financial results that consolidate them in the stock market, and additionally turn efficiency measures into support indicators for investors' decision-making, complementing the traditional ratios of financial analysis.

It is difficult to identify the most efficient company in the stock market because many variables are related to measuring the companies' performance. Investors can sometimes make a lot of money by taking advantage of observable trends in stock price series. Nowadays, identifying the most efficient company based solely on stock price is extremely difficult. Investors use a variety of techniques to maximize their return while minimizing their investment risk. Firms and stakeholders benefit from increased financial efficiency. The firm's resource utilization is determined by its financial efficiency. Financial efficiency is not achieved by wasting resources. Shareholders expect their money to be used effectively and efficiently in the company. Efficiency measurement is particularly important in policymaking because it facilitates the efficient allocation of capital across diverse productive sectors in an economy. If the company is efficient, the stock price provides an accurate signal to investors. In this way, efficiency promotes stock market liquidity and economic growth while also encouraging long-term investment. Inefficiency, on the other hand, leads to higher costs and fluctuating stock prices. The current economic growth creates a series of challenges for organizations, requiring a greater effort to remain productive and thus achieve greater market competitiveness. According to the logic of corporate growth, businesses must make efforts to grow their market share, invest in human resources, and maintain fixed assets, all of which may have an impact on their degree of efficiency and help them comply with organizational goals. One of the most difficult problems that finance managers face today is increasing financial efficiency. Given the significance of the issues, the researcher has made an effort to investigate financial efficiency.

In the case of India, the analysis of its stock market is relevant, given its characteristics. In the first instance, because this market is characterized by its large size (more than 7400 companies, as of April 2021), high diversification, high level of negotiations, high representation in the country's gross domestic product (GDP), and high dynamics of entry of new issuers, compared to other stock markets in the region. Being a relatively large stock market, it poses a scenario of special interest for the detailed study of its particularities, especially its efficiency levels, as well as for risk analysis and decision-making. On the other hand, very little research focuses on the efficiency of the Indian stock market (Arshinova, 2011; Zamani, Beegam, & Borzoian, 2014; Jothimani, Shankar, & Yadav, 2017; Arasu, Kannaiah, Christina, & Shabbir, 2021), notwithstanding the growing scientific literature for the country on financial efficiency analysis in different economic sectors, such as health, education, financial and industrial (Arunkumar & Ramanan, 2017; Alam & Rastgi, 2019; Sinha, 2021). The aforementioned context establishes this work as an important topic in the relevant literature and clarifies its motivation.

Therefore, this research article focuses on analyzing the financial effectiveness of listed companies in the Indian stock market from the period 2016–2021. The methodology used is the data envelopment analysis (DEA), a non-parametric procedure that uses the linear programming technique for the evaluation of the relative efficiency of a set of productive units. This model is relevant for the proposed analysis, given the availability of historical data of listed organizations that allow retrospective modeling, checks and simulations, which validate or invalidate various decisional paths and reevaluate investment strategies of managers today.

In recent years, academic research on financial efficiency analysis has shifted to data envelopment analysis. Nowadays, efficiency analysis is critical because measuring corporate performance involves a large number of variables (input and output).

This article is structured as follows: after this first introductory section, several research precedents (national and international) on the analysis of efficiency in the financial sector are presented, with special attention to the stock market in Section 2. Section 3 describes the DEA methodology, as well as the selected inputs and outputs, the population under study, and the model's orientations. Section 4 analyzes the results obtained, corresponding to the number of efficient units and the average efficiency score of the companies studied; likewise, the incidence of the types of scale used is determined. Section 5 discusses the results obtained, contrasting the findings of this research with those of other similar studies identified in the literature review.

Finally, in Section 6, some conclusions drawn from the results of the research are presented, which may become a point of reference for listed companies in the Indian stock market that plan to improve their financial performance. Likewise, the space is generated to encourage the development of other research that seeks to analyze, from other perspectives, the efficiency of the Indian stock market, contributing to the construction of rigorous literature on this subject in the country and, eventually, in other countries with a lack of studies of this nature.

2. LITERATURE REVIEW

The concept of efficiency is given as the relationship between the inputs and outputs of a productive system, expressed as a ratio. This concept indicates optimization of the resources used to obtain certain established results, when defining efficiency as the ability to achieve an end using a desirable relationship between factors and productive resources, that is, maximizing production with a given level of resources or minimizing resources given a level of production to be achieved. Nowadays, companies are in a permanent search for the optimization of their organizational performance in an increasingly competitive environment. That is, to achieve the highest profit with the lowest use of resources or, in other words, to achieve the highest productivity of their inputs and/or a minimum cost in obtaining the product. Based on the above, a large number of authors have undertaken the task of conducting relevant research that analyzes the efficiency of public and private organizations belonging to different sectors of the economy from a financial perspective. In the international context, and for efficiency analysis, papers using DEA continue to be the most popular in the scientific literature. A total of 10,300 research articles published between 1978 and 2016 showed that worldwide the financial sector is in the 10th position among the 26 most analyzed sectors, above others of great interest, such as tourism, insurance companies, automotive industry, construction, etc. Similarly, the DEA model has been used to evaluate and analyze financial performance in other economic sectors, such as tourism (Shero, Al Otaiba, Schatschneider, & Hart, 2021), education (Kohl, Schoenfelder, Fügener, & Brunner, 2019; Yousefi Nayer, Fazaeli, & Hamidi, 2022), healthcare (Mardani, Zavadskas, Streimikiene, Jusoh, & Khoshnoudi, 2017; Olejnik, Żółtaszek, & Olejnik, 2021), energy (Baran, Wysokinski, Staš, Samolejová, & Lenort, 2016), metallurgy, among others.

Within the financial sector, research that focuses on the banking sector stands out; here we can highlight the work of Kumar and Singh (2014) in India; Řepková (2014) in the Czech Republic; Milenkovíc, Radovanov, Kalaš, and Horvat (2022) in Balkan countries; Gardijan Kedžo and Tuškan Sjauš (2021) in Croatia; and, in a broader sense, the work of Mohd Khan, Samsudin, and Islam (2017), in which the financial efficiency of the banking sector was evaluated in southeast Asian countries, to perform comparative analysis, taking into account the financial efficiency of a country and the size of its stock market. Another noteworthy research, a product of the literature review, is that of Tsolas (2015), the author who applied the DEA methodology to study the financial performance of a group of companies from Greece. In this paper, a comprehensive approach is made to the relative efficiency of multiple inputs and outputs of a group of companies from Greece, through financial data from the balance sheet of such companies. Among the main results of this work, it was found that operational efficiency is not related to effectiveness.

In turn, Hoe, Jinn, Siew, and Hai (2018) conducted a comparative analysis of efficiency in companies in the construction sector in Malaysia; research that applied a DEA model from which financial ratios and the risk factor were incorporated in the function of evaluating the performance of the companies understudy in the period of study. Martins, Vaz, and Alves (2021) applied the same methodology to 570 hotel companies in Portugal, to measure financial efficiency. In both papers, it was found that efficient units tend to be large or small financial institutions in terms of asset size.

It is also important to note that the DEA methodology is widely accepted in the international scientific community for the evaluation of financial performance in companies listed in stock markets. Just to mention a few cases, the research work of Salehi and Mousavi Shiri (2016), uses a DEA model to analyze the financial effectiveness of companies listed on the Tehran Stock Exchange, Iran's largest stock market. In this paper, a comparative analysis is made between the results obtained from the application of the model and some financial variables such as return on investment, residual income, return on sales, earnings per share, and cash flows to partners, among others. Authors such as Rezaie, Majazi Dalfard, Hatami-Shirkouhi, and Nazari-Shirkouhi (2013), Hirad (2014), Salehi and Mousavi Shiri (2016), Jamshidi, Sanei, and Mahmoodirad (2020), and Sarfaraz et al. (2022), likewise developed research where DEA was used to measure financial performance and efficiency in Iranian stock market.

In China, considered the second-largest stock market in the world and the fourth with the largest number of listed companies (Liu & Zhan, 2019), the DEA methodology has also been used to measure financial efficiency. The work of Liu and Zhan (2019), authors who analyzed the financial performance of 39 companies listed on the Shanghai and Shenzhen stock exchanges, using a two-stage DEA model, in which financial variables such as return on investment, return on assets, asset turnover, current ratio, leverage ratio, and risk were measured. Among the main results of this research, it was found that there are significant differences in the efficiency levels of the companies analyzed, depending on the productive sector to which they belong; thus, it was observed that the industries of the health sector, information and communication technologies, and the energy sector have an outstanding performance compared to the other sectors studied.

Other authors such as Li, Crook, and Andreeva (2017), Xu, You, and Shao (2020), and Fukuyama and Tan (2022) have also used DEA models to analyze the financial effectiveness of companies listed on the Chinese stock market. As well to the Shanghai Stock Exchange, research has been carried out to measure efficiency in other of the world's most important stock exchanges; among these, we can mention works that focus on the New York Stock Exchange, NYSE (Ulus, Köse, Ertek, & Sen, 2006), NASDAQ (Seo & Sharma, 2012), the Hong Kong Stock Exchange (Yi, Chang, Xing, & Chen, 2019) and the Tokyo Stock Exchange (Sueyoshi & Goto, 2021). It is also worth noting work focuses on stock exchanges in several countries, such as the United States (Edirisinghe & Zhang, 2007, 2010; Powers, 2000), India (Jothimani et al., 2017), Taiwan (Chen, 2008), Malaysia (Ling & Kamil, 2009; Arsad, Isa, & Nabilah Mohd Shaari, 2019), and Iran (Ahmadzade, Fazli, Khosroanjom, & Mavi, 2011).

In the case of India, it is possible to highlight several studies that use DEA analysis to assess the financial efficiency of companies across several industries. The work of Guha, Bandyopadhyay, and Upadhyay (2014) uses DEA to rank the stock performance of Indian firms using statistical characteristics based on Sensex's monthly closing price from 2005 to 2012. Shetty and Basri (2018) examine data from 12 insurance companies from 2012 to 2016 to determine the technical performance of life insurance distribution channels. The efficiency scores were calculated using DEA, which took into account two inputs and two outputs. There is no substantial difference in the efficiency rankings of banking services and traditional agents, according to the research. Siddiqui and Das (2019) used DEA to examine the efficiency performance of the top 10 Indian life insurers from 2012–2013 to 2016–2017. The research sheds light on the operating features and efficiencies of Indian life insurers from 2013 to 2017, providing valuable insights for policymakers, practitioners, and decision-makers. The work of Ghosh, Dey, Guha, Jana, and Sarkar (2021) consists of a study of life insurance companies. Using a set of inputs and outputs, DEA is used to determine the efficiency of these insurance organizations. Likewise, other research works have been developed using the DEA model to measure financial efficiency in other Indian sectors, such as the pharmaceutical industry (Saranga, 2007), derivatives market (Kumar, Roy, Saranga, & Singal, 2010), cement industry (Mandal & Madheswaran, 2011) and sports (Ghosh et al., 2021).

3. METHODOLOGY

There is a considerable volume of published academic literature that examines various techniques for evaluating financial efficiency. There are parametric approaches as well as non-parametric methods for efficiency estimation. Data envelopment analysis is the most popular non-parametric method. As a result, different studies used different methods for financial efficiency analysis. Decision tree techniques (Öcal, Ercan, & Kadioglu, 2015; Mittal, Khanduja, & Tewari, 2017), artificial neural networks (Ecer, 2013; Ashour, Jamal, & Helmi, 2018; Rivas, González-Briones, Hernández, Prieto, & Chamoso, 2021), Tobit regression (Mujasi, Asbu, & Puig-Junoy, 2016; Amore & Murtinu, 2021; Asker & Aydin, 2021) and generalized linear models (Bunyaminu & Issah, 2012; Bou-Hamad, Anouze, & Larocque, 2017) were used to measure financial efficiency.

The main benefit of DEA is that no prior assumptions regarding the analytical form of the production function are needed. Because DEA permits efficiency to change over time, does not require prior function type determination, and has the properties of measuring multiple inputs and multiple outputs, it is a better method for organizing and analyzing data than other approaches.

To calculate the financial effectiveness of companies listed in the Indian stock market, the methodology used is DEA, a non-parametric technique for the analysis of relative efficiency that allows comparing the current outputs of a decision-making unit (DMU) against what they could obtain in their optimal frontier, given the inputs used. This mathematical programming technique was initially introduced by Charnes, Cooper, and Rhodes (1978) to calculate the relative technical efficiency index, thus solving a mathematical optimization program. The DEA methodology belongs to the so-called frontier methods, in which the output is evaluated concerning the production functions, understood as the technical relationship that transforms factors into products; that is, the maximum level of outputs achievable with a certain combination of inputs, or the minimum level of inputs necessary for the production of a certain level of outputs.

The main advantages of the DEA methodology include its greater flexibility compared to econometric methods, which can incorporate measurement errors and uncontrolled variables; in addition, the data determine what the function is. In this sense, it is not necessary to establish an initial functional form, since the efficiency of a productive unit is defined concerning the observed units with the best performance. Another element to highlight is that the analysis focuses on the identification of the best behavior instead of the average behavior, as it is treated from an econometric approach, for example, in a regression analysis. This also means that the results are limited only to the data analyzed, and therefore at no time can inferences be made concerning the universe of data.

For this research, a combination of models is considered: a) the DEA-CCR, developed by Charnes et al. (1978) and which uses yields at constant scales and b) the DEA-BCC, developed by Banker, Charnes, and Cooper (1984), which considers yields at variable scales; both with an output orientation, that is, the model works under the assumption that the DMUs seek to achieve the maximum expansion of outputs at a given level of inputs. In the end, the scale efficiency model is calculated, which is the quotient between DEA-BCC and DEA-CCR. A DMU will be considered efficient when the result obtained is equal to 100. The mathematical approaches to calculate efficiency using DEA for each of the models are presented below.

The model is formalized by assuming that there are n DMUs to be evaluated, each of which consumes m different inputs to produce s different outputs. The DMU_j uses an amount of $X_j = x_{ij}$ inputs ($i = 1, \dots, m$) and produces an amount of $Y_j = y_{kj}$ outputs ($k = 1, \dots, s$). The matrix sxn of the output measure is denoted by Y, and the mxn of the input measure is denoted by X. It is further assumed that $x_{ij} \geq 0$ and $y_{kj} \geq 0$.

BCC-output envelope model:

$$\begin{gathered} Max\ \ y_j + \varepsilon(\sum_{k=1}^{s} t_k + \sum_{i=1}^{m} s_i) \\ \sum_{j=1}^{n} \lambda_j x_{ij} = x_{ij} - s_j \quad (i = 1,2, \dots, m) \\ \sum_{j=1}^{n} \lambda_j x_{ij} = y_j y_{kj} + t_k \quad (k = 1,2, \dots, s) \\ \sum_{j=1}^{n} \lambda_j = 1 \\ \lambda_j, s_j, t_k \geq 0 \quad \forall\, j, i, k \\ y_j libre \end{gathered} \tag{1}$$

CCR-output envelope model:

$$\begin{gathered} Max\ \ y_j + \varepsilon(\sum_{k=1}^{s} t_k + \sum_{i=1}^{m} s_i) \\ \sum_{j=1}^{n} \lambda_j x_{ij} = x_{ij} - s_j \quad (i = 1,2, \dots, m) \\ \sum_{j=1}^{n} \lambda_j x_{ij} = y_j y_{kj} + t_k \quad (k = 1,2, \dots, s) \\ \lambda_j, s_j, t_k \geq 0 \quad \forall\, j, i, k \\ y_j libre \end{gathered} \tag{2}$$

The model has a production function that considers three input variables: *inventory*, *net property, plant and machinery*, and *investment*; and an output variable: *operating profit*. The inputs and outputs considered for the model correspond to those usually considered in the literature for the evaluation of efficiency in the financial field, as observed in the works of Edirisinghe and Zhang (2007, 2008) and Frijns, Margaritis, and Psillaki (2012) in the international context; and Ghosh et al. (2021) in the national context. Table 1 shows the description of each of the variables of the production function.

Sixty-nine (69) DMUs are selected, which are the companies listed on the Indian stock market (population understudy). These organizations are classified by the Indian Stock Exchange into 6 economic sectors, within which the industrial sector has the largest share, with 56.52%. As a source to obtain the financial reports of the companies listed in the Indian stock market for the period 2016–2021, the Bloomberg L.P. platform is used.

Those companies that did not submit financial reports in any of the years considered in the study (2016–2021) were assigned a value of zero (0) in the final efficiency. This does not mean that they have not been efficient in the allocation of their resources, but that, not reporting their information, prevents the measurement of their efficiency; therefore, the value of zero (0) serves as a penalty within the model; the companies with this condition reached 5 for the study period. Table 2 presents a summary of the characteristics of the DEA model used in this research.

Table 1. Inputs and outputs variables

Type	*Variable*	*Description*
Output	*Operating profit*	It includes the amounts received and/or caused as a result of the activities developed in compliance with the corporate purpose of the company through the delivery of goods or services, as well as dividends, participations, and other income from financial intermediation, as long as it is identified with the main corporate purpose of the economic entity.
Inputs	*Inventory*	Includes all those items, materials, supplies, products, and renewable and non-renewable resources, to be used in transformation, consumption, rental, or sale processes within the ordinary course of business of the economic entity.
	Net property, plant, and machinery	This includes all the accounts that record assets of any nature owned by the economic entity, to use them permanently for the development of the normal course of business or that are owned for the support they provide in the production of goods and services, by definition not intended for sale in the ordinary course of business and have a useful life of more than one year.
	Investment	Includes accounts that record investment in shares, quotas or equity interests, securities, commercial papers, or any other negotiable document acquired by the economic entity on a temporary or permanent basis, to maintain a secondary liquidity reserve, establish economic relations with other entities or comply with legal or regulatory provisions.

Source: Authors' elaboration.

Table 2. Characteristics of the DEA model

Parameters	*Explanation*
Orientation	Oriented to maximize outputs
Type of return to scale	DEA-CCR model (returns to constant scales)
	DEA-BCC model (returns to variable scales)
DMU	Listed companies in the Indian stock market
Number of DMUs	64
Output	Operating profit
Inputs	Inventory
	Property, plant, and machinery
	Investment

Source: Authors' elaboration.

4. RESULTS

The results show that, during the period 2016–2021, there were an average of 17 efficient units per year under the BCC model, which represent 26.82% of the total number of listed companies in the Indian stock market. An increasing trend is also identified during the first years (2016–2019), with 2018 and 2019 being periods in which there were more efficient units, both with 20, representing 31.25% of the total DMU; in 2020 this trend is broken, and some organizations that had been a reference during the first years leave the group of efficient companies, such as JSW Steel Ltd., Bharat Elec, Paramone, ACC, and Autoline Ind; therefore, there are 14 efficient DMUs until 2021, when there is the lowest number of efficient companies, with 12, representing 18.75% of the organizations evaluated. In addition, it should be noted that 6 companies were efficient during the entire period of analysis (2016–2021), namely: Orient Green, Krypton, Sudal Ind, Standard Batter, Atlanta, and Alphageo.

On the other hand, based on the individual efficiency results of each DMU, the average efficiency score or joint efficiency for each of the years is obtained. During the period 2016–2021, the average joint efficiency for the Indian stock market is 47.24. The joint efficiency reaches its maximum value in 2016 (53.78), and from there similar values are obtained until 2019, and for the years 2020 and 2021 joint efficiencies are presented below the results of the previous years: 38.93 and 38.14, respectively. This last value is the minimum mean score for the period of analysis, which is explained by the fact that during these last two periods there is a higher concentration of DMUs that obtain efficiency scores between 0.00 and 0.10. Table 3 synthesizes the main results for the years 2016–2021: the mean efficiency score, the standard deviation, the minimum score, the number of efficient units and the corresponding percentage share among the population, the number of units with returns at decreasing scales (DRS) and the number of units with returns at increasing scales (IRS); all these for the CCR, BCC and EE models.

Table 3. Results of the DEA analysis in the period 2016–2021

Year	*Results*	*CCR model*	*BCC model*	*Efficiency of scale (EE)*
2016	Mean	32.57	53.78	55.24
	Standard deviation	37.73	37.37	39.40
	Minimum value	0.15	0.19	0.72
	Number of efficient units	9	18	18
	% of efficient units	14.06	28.13	28.13
	Number of DRS units		7	
	Number of IRS units		39	
2017	Mean	35.62	52.29	58.27
	Standard deviation	41.91	38.88	40.35
	Minimum value	0.08	0.16	0.56
	Number of efficient units	12	19	17
	% of efficient units	18.75	29.69	26.56
	Number of DRS units		13	
	Number of IRS units		32	
2018	Mean	32.04	49.53	53.99
	Standard deviation	41.78	39.87	43.26
	Minimum value	0.11	0.12	0.58
	Number of efficient units	14	20	18
	% of efficient units	21.88	31.25	28.13
	Number of DRS units		8	
	Number of IRS units		36	
2019	Mean	26.18	50.80	32.35
	Standard deviation	39.59	39.75	40.60
	Minimum value	0.02	0.23	0.02
	Number of efficient units	10	20	15
	% of efficient units	15.63	31.25	23.44
	Number of DRS units		3	
	Number of IRS units		41	
2020	Mean	21.45	38.93	42.34
	Standard deviation	36.00	37.95	40.10
	Minimum value	0.06	0.20	0.24
	Number of efficient units	9	14	17
	% of efficient units	14.06	21.88	26.56
	Number of DRS units		2	
	Number of IRS units		48	
2021	Mean	19.32	38.14	34.97
	Standard deviation	35.71	37.51	42.07
	Minimum value	0.02	0.06	0.20
	Number of efficient units	8	12	17
	% of efficient units	12.50	18.75	26.56
	Number of DRS units		1	
	Number of IRS units		51	

Source: Authors' elaboration.

Once the above results have been analyzed, they are contrasted with the average scores obtained by the EE, a measure that allows eliminating the effect of the scales of the results obtained through the BCC model; that is, the EE allows obtaining efficiency scores regardless of the type of scale used by the DMUs. In the case of the Indian stock market for the period 2016–2021, the results of the EE show few differences with the scores obtained through the BCC model, except 2019, so it can be said that the type of scale of the companies is not a determining factor in the efficiency result obtained if the particularity of that year is taken into account when the difference between the results shows that when eliminating the effect of the scales, a considerable improvement in the joint efficiency is observed.

5. DISCUSSION

The comparisons of efficiency indexes between different studies should be taken with great caution because, first, efficiency is measured concerning the best practice frontier of each sample, that is, the indexes show intra-sample dispersion; and, second, the choice and definition of resources (inputs) and products (outputs) may differ between studies. Despite these limitations, the exercise of making comparisons is relevant for the contextualization of the results obtained. For this article, the findings of the following studies that applied DEA to measure financial efficiency in populations with similar characteristics and contexts to that of this research, i.e., companies listed in the stock markets of Iran (Ahmadzade et al., 2011), India (Jothimani et al., 2017) and Malaysia (Arsad et al., 2019), have been taken into account.

First of all, it is worth mentioning that, within the DEA methodology, the use of the duality of models (CCR and BCC) and the calculation of the EE, to determine the incidence of scale (constant and variable) in the results, is a procedure regularly used in works that measure the financial efficiency of listed companies in stock markets in different countries. In this study, in agreement with the reference works, the results of EE present few differences with the scores obtained using the BCC and CCR models (Table 3), except for the year 2019. The above indicates that the type of scales used in the application of the model is not usually a determinant of financial efficiency. Concerning the results related to the number of efficient units, it was determined that the average number of efficient units during the period 2016–2021 is 26.82% of the total number of listed companies in the Indian stock market, a result that is below the average number of efficient units of the mentioned benchmarks, whose number of efficient units on average is 42.80% of the total number of DMUs.

According to the literature review, one of the reasons that may explain the low number of efficient units in the Indian stock market, compared to other markets of the same nature, is economic growth. That is, the higher the percentage of growth of a country, the amount of efficient units also tends to increase (Davidovic, Uzelac, & Zelenovic, 2019). In this sense, India's average economic growth during the period of analysis was 3.26%, while in the countries reviewed (Iran and Malaysia) it averaged 3.81%; the above according to data from the World Bank's official platform. Additionally, for the research, the year 2021 — when the lowest amount of efficient units is obtained during the period of analysis — coincides with the lowest economic growth in India (1.35%). This situation is also present in the work of Mohd Khan et al. (2017), authors who argue that in years of economic crisis it is common for the number of efficient units to decrease, according to the economic context of the country.

Regarding the average efficiency score, it is observed that the joint efficiency of the listed companies in the Indian stock market during the period 2016–2021 is 47.24, a performance that is below the average of the joint efficiency scores of the studies reviewed in this section (80.03). Furthermore, in the present study the average efficiency score between 2016 and 2019 was on average 51.6 and decreases for the last two years: 38.93 and 38.14 for 2020 and 2021, respectively, negatively affecting the overall average. These results follow the same logic established previously, as the country's average economic growth between 2016 and 2019 reached 4.07%, while for 2020 and 2021 it averaged 1.7%.

6. CONCLUSION

This work aimed to analyze the financial effectiveness of listed companies in the Indian stock market to identify which organizations have achieved a combination of technologically viable factors and products that maximize profit, taking into account the limitation of inputs. The results obtained through the DEA model indicate that during the period 2016–2021 there were on average 17 efficient units per year (under the BCC model), representing 26.82% of the total number of listed companies in the Indian stock market; of these companies, 6 were efficient during all the years of the period analyzed. In addition, during the analysis period, the stock market achieved an overall efficiency — or average score — of 47.24, and when compared to the average scale efficiency score (46.19) — a measure that allows eliminating the effect of the scale used in the efficiency scores — it shows that the type of scale employed by the firms has no bearing on the efficiency result obtained. The results concerning the efficient units and the average efficiency scores, when compared with the results of other studies carried out in companies listed in other stock markets, show that the companies under study have low levels of financial efficiency, which are accentuated by the Indian economic crisis of 2020 and 2021, the period in which there is the lowest GDP growth in the decade.

The efficiency evaluation through the proposed DEA model made it possible to identify efficient companies within the national stock market, which can become a reference for the rest of inefficient organizations, through the identification and implementation of financial practices that allow for obtaining better results. Additionally, an operational measure such as efficiency is established as an indicator of support for investment decision-making, complementing the traditional indicators of financial analysis.

Additionally, it should be borne in mind that the results and conclusions obtained must be limited to the period of analysis and the spatial delimitation of the business units used (DMU), also taking into account the particularities of the model (choice and definition of resources (inputs) and products (outputs)); so the use of other companies or another time series, or the choice of another productive function, can provide different results. According to the above, the exercise of comparing the efficiency indices obtained with the results of the studies taken as references is presented as the main limitation, considering what is stated in the discussion section.

Finally, it is expected that this work will open the way to new research in which the DEA methodology is used to evaluate financial efficiency in other stock markets, in addition, as a strategy to strengthen the model, both the incorporation of new input and output variables to the productive function and the consideration of two-stage network DEA models can be considered.

This research work provides the Indian stock market and the academic and business community with a novel and practical methodological technique to determine the financial efficiency of listed companies in the country. Methodological alternatives for the determination of efficiency and the incorporation of variables will be the subject of future work.

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