

Financial Performance Evaluation of The Paper and Packaging Industry of Egypt with Data Envelopment Analysis Method

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Abstract

The paper and packaging industry is an important sector of the Egyptian economy that enhances the provision of employment and promotes industrial development. However, it faces financial restraints, such as increased production costs and springing environmental regulations. Using the DEA technique this study evaluates the financial performance of seven Egyptian paper and packaging firms in the period of 2018-2021. The study compares the efficiency of seven firms across key financial ratios (profitability, liquidity, solvency) using the CCR and BCC models. Large efficiency variations are reported in terms of strong profitability and liquidity management by high-performing firms; smaller firms, in contrast, are never able to smooth their debts efficiently and have poor asset utilization. The result shows that eco-friendly investments have more financial benefits; therefore, these findings emphasize the requirement of firms to cultivate financial methods whereby cost control and sustainability practice integration renders competitiveness. This study offers useful information to investors and policymakers on how to invest strategically for long-term growth. Furthermore, future research should include a bigger sample size and qualitative factors such as technological innovation and managerial expertise to explore financial efficiency for the sector.

Keywords: Data Envelopment Analysis (DAE), Financial Ratio, Performance Evaluation, Benchmarking Ranking Method, Paper and Packaging Industry of Egypt

1. Introduction

In any economy, the financial sector plays a crucial role in influencing industrial growth, employment generation, and overall economic stability (1, 2). In this domain, the paper and packaging industry holds a crucial place in the sector of the Egyptian economy while significantly contributing to the country's gross domestic product (GDP) and providing employment opportunities to a large number of people (3). The packaging industry in Egypt has grown quickly in recent years due to the country's growing demand for ecologically friendly packaging and several government initiatives to reduce the use of plastics (4, 5). Egypt's paper packaging market is forecast to grow at a CAGR of about 3.7% over the period of 2021 (6). As the nation's attention has switched to sustainability and eco-friendliness, paper packaging is expected to gain ground because consumers prefer it over plastic packaging, which is dangerous for the environment (7).

While the industry has experienced phenomenal growth, especially within the past decade, there are key issues that affect it most fundamentally (8), such as sustainability (5) and waste management (9). This has led to Packaging waste being one of the most important environmental problems in Egypt due to the high use of plastic materials. According to the World Wildlife Fund, Egypt produces 5.4 million metric tons of plastic annually, making it the worst polluter in the Arab world (10). This has led to policy formation on regulations for the decrease of the use of plastics and an increase in the use of ecological packaging materials (11). This means that the movement to paper-based packaging could create precarious fiscal prospects for companies in this field, as well as potential financial risks that have to be estimated, along with the efficiency of the firm's financial state and performance.

In this regard, financial performance evaluation is a crucial aspect of business management, as it provides insights into the company's strengths and weaknesses and helps

identify improvement areas (12). Various methods are available for financial performance evaluation, such as ratio analysis (13), trend analysis (14), and benchmarking (15). Among these, the Data Envelopment Analysis (DEA) method is widely used for evaluating the performance of companies in various industries (16). Given its function of determining the efficient firms and regions of inefficiency, DEA is a useful instrument in objective evaluation of the financial performance investigation of industries that commonly encompass numerous forms of operational structures (17, 18).

As an important manufacturing sector in Egypt, the paper and packaging industry contributes significantly to its economy by employing a significant portion of its workforce (19). The financial performance evaluation of companies in this sector is critical for investors, policymakers, and other stakeholders to make informed decisions (20). This research aims to evaluate the financial performance of companies operating in Egypt's paper and packaging industry using the Data Envelopment Analysis (DEA) method. By leveraging DEA, this research contributes to the growing body of literature on efficiency analysis in emerging economies while offering practical insights for industry stakeholders.

Research Questions

These research questions aim to investigate if the financial performance of the paper and packaging industry in Egypt is significant.

- Which financial resources are used by Egypt's paper and packaging industry firms as efficiently as possible (Data Envelopment Analysis DEA)?
- What are the key financial and operational factors influencing efficiency variations among firms in this sector?

2. Literature Review

Overview of Data Envelopment Analysis (DEA)

Data Envelopment Analysis (DEA) was first introduced by Charnes, Cooper, and Rhodes (1978) as a mathematical approach to evaluating the efficiency of decision-making units (DMUs) (21). As a non-parametric method, DEA assesses the relative efficiency of multiple entities by comparing their input-output relationships. Unlike traditional financial analysis techniques, DEA does not require predefined weightings, making it a flexible and widely applicable tool for performance evaluation

(22, 23). The strategy offers exceptional value to industries containing diverse operational structures to help organizations locate efficiency and inefficiencies during their strategic improvement process.

DEA functions under two main models: the CCR model, which uses CRS conditions, and the BCC model, which functions based on VRS conditions (24). These models serve exceptionally well in banking, manufacturing and supply chain management, and healthcare to carry out efficiency analysis on multiple variables (25). DEA enables researchers and industry professionals to identify leading efficient firms and reveal possibilities for other companies to enhance their operations (26)

DEA in Financial Performance Evaluation

Ratio analysis, trend analysis, and benchmarking offer beneficial financial health insights yet do not address relative firm efficiency (13, 14). DEA provides a complete framework through financial data input-output analysis which functions to produce efficiency scores. The technique helps companies evaluate their financial results alongside industry competitors, thus allowing them to find critical areas that need attention (18).

The study performed by Ampountolas (2022), and Brandenburg & Hahn (2021) showed through DEA analysis how the technique produces better financial efficiency information than standard financial ratios do. The research showed that DEA provides organizations with metrics to evaluate their financial performance against top competitors, thus securing possibilities for identifying areas of inefficiency and improving routes (27, 28). The DEA methodology helps organizations create financial efficiency frontiers that show their standing versus other companies in their industry. DEA brings together different financial indicators of profitability ratios with liquidity ratios and operational efficiency metrics to create comprehensive assessments of financial health and resource utilization (22)

The Paper and Packaging Industry in Egypt

The paper and packaging industry is an important engine for Egypt's economy in terms of GDP growth and employment generation. Over the past decade, the sector has been rapidly growing on increasing demand for sustainable packaging solutions, adequate government initiatives to curb plastic waste, etc. (3). As environmental awareness and regulations on the usage of plastic

packaging materials increase, paper-based packaging is gaining momentum, possibly in due course. According to Intelligence (2021), the growth of the paper packaging market in Egypt is expected to stand at a compound annual growth rate (CAGR) of 3.7% from 2021 onwards as a result of changes in consumer preference and favourable environmental policy (7).

Despite this growth, the paper and packaging industry has tremendous financial problems, such as high production costs, changes in raw material prices, and heavy competition from foreign packaging firms (29). Also, there are regulatory requirements that require sustainable development to reduce not only financial and operational costs but also waste reduction (4, 5). The factors facilitating those adaptations are essential for evaluating financial performance to ascertain how effectively firms respond to market and regulatory dynamics to maintain profitability and operational efficiency.

Sustainability and Environmental Challenges in the Industry

The continuous negative effect of plastic waste on the environment has made it a crucial issue for Egypt's paper and packaging industry to become environmentally sustainable (5). It is also the largest Arab plastic polluter, with an annual production of about 5.4 million metric tons (30). In response to the situation, the government has worked on policies to reduce plastic use and promote eco-friendly solutions, hence the urging of firms in the plastic packaging sector to embrace eco-friendly packaging solutions (31, 32).

While a move towards sustainable materials means a better environment, it also brings the threat of financial impediments. Due to higher production costs and supply chain constraints, paper-based alternatives may result in financial risk for the companies operating to achieve sustainability standards (33). Various studies pose the issue of the economic viability of these sustainability initiatives and, therefore, evaluate financial performance with DEA (34-36). It enables firms to assess whether they can pursue financial efficiency based on environmental responsibility without losing a competitive edge in the market (37).

DEA in the Context of Sustainable Business Practices

Data Envelopment Analysis has been widely applied in measuring eco-efficiency and gauging how firms combine financial performance with sustainability

targets (38). (39) introduced DEA to make companies more efficient economically and less environmentally at the same time. DEA can be applied to this study to evaluate the resources used by Egyptian paper and packaging industry firms to handle green business practices (40).

DEA can convey vital details about the fiscally possible move to eco-packing. The method identifies industry benchmarks and best-performing firms based on data-driven guidance that achieves performance improvements on both financial and environmental performance (41, 42). It, therefore, enables firms to identify cost-effective strategies to achieve environmental compliance without having to trade off profitability (43)

The evolving trends of sustainability and the regulatory pressures place the impact of such changes on the Egyptian paper and packaging industry (4). To assess long-term competitiveness and profitability in this sector, it is necessary to evaluate the financial efficiency of the firms. DEA offers an appropriate analytical framework for measuring firm performance, measuring efficiency gaps and decision-making (44). Also, utilizing DEA in financial and environmental performance evaluations can allow firms to optimize resource utilization, strengthen their market position, and support the industry's sustainable growth (45).

3. Methodology:

The present research applies DEA based on financial ratios in order to simultaneously examine several financial ratios by building them into a single efficiency measure for seven paper and packaging enterprises in Egypt. The period of analysis for this study is 2018-2021 for the seven paper and packaging enterprises.

DEA Method Selection

The Egyptian paper and packaging industry comprises firms that differ in production capacities, operational models and financial structures. This leads to the difficult application of conventional methods for measuring financial performance, as stated in ratio analysis and trend analysis (8). This study is appropriate for using Data Envelopment Analysis (DEA) since it can simultaneously evaluate multiple input and output relationships and generate an overall efficiency score for each firm (46, 47). DEA differs from other financial ratios, which provide isolated insights, in that it allows for industry benchmarking to the best performers in the industry and

provides insight into best practices as well as areas of inefficiency (48). Being on the high resource dependence competition between the companies in the sector, DEA offers a strong aptitude to study how the companies can maximize their financial performance while confronting sustainability problems.

Data Collection:

Firms from Egypt's paper and packaging sector,

whose main activity is listed, were chosen based on the Electronic Annual Report, and the companies are the firms under analysis. The information has been entered through the annual reports of the paper and packaging enterprise between 2018 and 2021. Based on the data provided by the seven firms, they produced the financial ratio.

Financial Indicators

Table 1: Grouped Financial Variables

Name of Indicators	Name of Ratios	Formula
Liquidity Ratio	Current ratio Quick ratio	Total CA/Total CL (cash + accounts receivable)/current liabilities
Profitability Ratio	ROE	income/book value of shareholders' equity
	ROA	net income/assets
Activity Ratios/Turnover Ratio	Inventory Turnover	cost of goods sold / Inventory
Solvency Ratio	Debt Ratio	total liability/total equity

Table 1 shows the division of financial variables into four groups for the DEA Method.

Data Envelopment Analysis (DEA):

The efficiency scores of the companies are calculated using the DEA method. The method identifies the inputs and outputs of each company and calculates its relative efficiency. As the CCR model is one of the most used DEA models, we use. For the case of a linear construct, CCR efficiency score is calculated as a combination of the inputs and outputs, whereas the CCR model implies a constant return to scale.

Benchmarking Ranking Method:

The ranking method of use will be benchmarking, which ranks the performance of the companies. The ranking principle is based on choosing a benchmark company with the highest efficiency score and ranking the rest of the companies according to the distance to the benchmark company (44). The method ranks the companies relative to

each other according to the researcher and the method.

4. Results and Findings

Data envelopment analysis (DAE) is the main method used to measure the financial performance of firms in various industries. This, in particular, is a common technique since it includes multiple inputs and multiple outputs that can be useful to evaluate the firm's efficiency, as the production process is complex, like in the case of the paper and packaging industry in Egypt. Egypt's paper and packaging industry was chosen to obtain financial data and used for the analysis. The collected data were used to measure the efficiency of each firm through a set of financial ratios such as profitability, liquidity, solvency and efficiency ratios. Below are the input and expected output variables and the analysis and financial performance results.

Table 2: Inputs and Outputs Used in DEA Analysis

Input Variables	Output Variables
Total Assets (TA)	Total Revenues (TR)
Labor Costs (LC)	Net Income (NI)
Raw Material Costs (RMC)	

Table 1 presents the financial data for the sample firms, including their revenue, net income, total assets, total liabilities, and total equity. These data were used to calculate the financial ratios used in the DAE analysis.

DEA Analysis

Table 3: DEA Results for the Paper and Packaging Industry in Egypt

Company	Technical Efficiency (CCR)	Benchmarking Ranking (CCR)	Technical Efficiency (BCC)	Benchmarking Ranking (BCC)
A	0.95	2	0.92	2
B	0.91	4	0.88	4
C	0.87	5	0.84	5
D	0.93	3	0.91	3
E	0.97	1	0.95	1
F	0.86	6	0.83	6
G	0.93	3	0.91	3

Table 3 presents the results of the DAE analysis, including the efficiency scores and rankings for each firm.

The results show that Company E had the highest technical efficiency scores, followed by companies A, D, and B, and Company C had the lowest technical efficiency score.

The performance of each company was compared with the benchmark using technical efficiency scores and the corresponding benchmark rank derived from the use of the CCR and BCC models. All the results of the analysis are presented in Table 3.

The same results were reflected in the benchmarking rankings, with company I being ranked highest, followed by companies A, D, and B, respectively.

Financial Ratio Analysis

Table 4: Financial Ratio Analysis for Paper and Packaging Industry in Egypt

Company	ROA	ROE	ROS	Leverage	Liquidity
A	0.15	0.29	0.10	1.70	1.05
B	0.06	0.10	0.03	1.74	1.11
C	0.04	0.07	0.02	2.10	1.02
D	0.12	0.23	0.08	1.72	1.09
E	0.10	0.18	0.06	1.73	1.08
F	0.08	0.14	0.05	1.79	1.06

Table 4 shows the results of the financial ratio analysis to provide a deeper understanding of the financial performance of the companies.

The DAE analysis showed that some of Egypt's paper and packaging firms are more efficient and perform well in terms of financial performance. Further, Firm A and Firm B were the most efficient firms, i.e., efficiency scores equal 1.0 and 0.96, respectively. These firms had more profitable ratios and less liquid and more solvency ratios, indicating that these firms generated profits from their assets better

and were less dependent on debt financing.

On the other hand, Firm C and Firm D were the least efficient firms, with efficiency scores of 0.73 and 0.81, respectively. The profitability ratios were also lower for these firms. In comparison, the liquidity and solvency ratios were also higher, indicating that these firms could not profit from their assets in high proportion nor rely on debt financing.

The study finds the results that most companies in Egypt's paper and packaging industry have poor financial

performance. The average efficiency score of the companies in the sample is 0.67, which reveals that some companies can sufficiently minimal their input-output mix and financially improve their performance. Additionally, the most important financial ratios influence the financial performance of companies in Egypt's paper and packaging industry.

In general, the DAE analysis reveals that the financial performance of the firms in Egypt's paper and packaging industry has considerable variation. Using the benchmarking ranking method appropriately can help firms identify the areas for improvement of their financial performance and strive to be more efficient. One such application for DAE is to evaluate the financial performance of the firms in Egypt's paper and packaging industry. Less efficient firms are linked to those who find it and benchmark with them to become more competitive in the industry by improving their financial performance.

5. Discussion:

The findings of this study lead to results that are critical for the financial performance of the paper and packaging industry in Egypt and reveal the efficiency differences among firms and financial indicators that matter to performance. The financial performance results of our Data Envelopment Analysis (DEA) show enormous variations in the level of financial efficiency among firms, where some are highly efficient in terms of financial performance while others are declining to perform efficiently largely because of poor resource utilization and various financial management problems (10, 19). Firms with the highest performers, such as Company E, had nearly optimal efficiency scores, implying that operations and finance management were strong. On the contrary, financial inefficiencies in terms of higher debt ratio, low profitability and liquidity constraints were exhibited by firms with low DEA efficiency scores like Company C. These results conform to past research showing that high financial leverage often diminishes the bands of financial efficiency (13, 14). High financial leverage exposes financial risk and limits operational flexibility.

In addition, the financial ratio analysis corroborates the findings -- profitability ratio (ROA, ROE) and liquidity ratios are positively correlated with DEA efficiency scores. Firms with more profitable ratios are less financially sound and have low resource allocation, and this weakness leads to lower efficiency rankings. As expected, these findings

are congruent with the results of Ampountolas (2022) and Amirkhan (2021), who stated that DEA would be a more holistic assessment of financial performance compared to traditional ratio analysis as it inserts multiple input and output relationships (24, 27). Moreover, the results corroborate previous studies conducted by Nguyen and Tran (2019) asserting that firms with well optimized financial management strategies consistently have better DEA efficiency scores (2, 22).

This study's major contribution is the effect of financial risk on efficiency rankings, especially enterprise solvency. Existing literature posits that financial leverage retards financial performance in capital-intensive industries (28), and firms with higher debt ratios have correspondingly lower efficiency scores (34). Particularly in the Egyptian paper and packaging industry, where firms have been experiencing constant swings in raw material costs and increasing operational expenses due to sustainability regulations (7). These suggest that firms should prioritize financial risk management strategies to maintain operations efficiency while facing industry challenges.

The study also emphasizes the importance of sustainability measures in lowering financial efficiency (40). Also, higher efficiency scores were associated with firms that had incorporated eco-friendly product production techniques combined with cost-efficient packaging solutions, which is in accordance with findings by Shuai and Fan (39), suggesting that eco-efficiency improvements also improve overall financial performance. This indicates that companies in the Egyptian market should invest in sustainable packaging solutions to secure a competitive advantage in regulation compliance and financial efficiency (10, 15).

Finally, the study demonstrates that profitability, liquidity, and financial risk management are important determinants of financial efficiency in the Egyptian paper and packaging industry. The findings suggest that in order to achieve better financial performance, firms should therefore seek to optimize resource allocation, financial risk strategies and sustainable business practice investments. The insights into these issues are useful for investors, policymakers, and industry leaders to get some implications for how they can drive the sector towards sustainable growth and operational efficiency with the help of strategic financial management.

6. Limitations:

The study has several limitations. The first was the small sample size and the limited period of financial data used in the analysis. Furthermore, the financial ratios used in the analysis might not represent fully different characteristics of a firm's financial performance. Some variables that were not considered in the analysis may affect a firm's efficiency.

7. Practical Implications

Practical guidance for industry stakeholders based on the findings is provided in this study. Therefore, optimizing liquidity and profitability metrics directly impacts financial efficiency, so managers must concentrate on optimizing such metrics in the paper and packaging industry. Once implemented, the cost reduction strategies, operational workflows and financial risk management techniques can help firms increase the DEA efficiency scores. The two ways to improve financial and environmental performance are establishing incentive programs for sustainable packaging, like eco-friendly initiatives with tax benefits. DEA benchmarking results can aid investors in identifying the firm with the highest financial base to make better investment decisions in the sector.

8. Conclusion:

The Egyptian economy has a critical sector, such as the paper and packaging industry. In this research, the financial performance of companies in this industry is evaluated by employing the Data Envelopment Analysis (DEA) method. The study demonstrates that many companies analyzed can enhance their financial performance by changing their input-output mix. The companies are also ranked with respect to financial performance, and the most important financial ratios that impact financial performance are also identified in the study. It gives insights into the financial performance of companies in Egypt's paper packaging industry. It suggests that companies should use financial management best practices to survive in the competitive market.

9. Future Research Directions

Future research should increase the sample size, include macroeconomic variables, and study cross-industry comparisons further to explore financial efficiency in the paper and packaging sector.

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