Print ISSN: 2288-4637 / Online ISSN 2288-4645
doi:10.13106/jafeb.2022.vol9.no1.0299

The Effect of Green Transformation on the Operating Efficiency of Green M&A Enterprises: Evidence from China*

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Received: September 30, 2021 Revised: December 05, 2021 Accepted: December 15, 2021

Abstract

Environmental protection has been infused into the development of numerous fields by the Chinese government. The government's implementation of green development has also shifted its focus to green transformation and governance of high-polluting companies. In the context of green and sustainable development, this study employs DEA data envelopment analysis to compare the operating efficiency of listed firms that implemented Green Mergers and Acquisitions (M&A) in China in 2018. The conclusions of this study are as follows: First, China's green M&A enterprises are unevenly dispersed among the country's east, middle, and western regions. Second, compared to before the implementation of Green M&A, operational efficiency has improved in most industries. Third, the difference in Green M&A across industries is generally favorable, showing that most organizations have improved their operational performance as a result of Green M&A implementation. In 2018, however, the gap in operating efficiency is more negative. Fourth, whereas the eastern and western areas' operational efficiency has improved as a result of Green M&A, the central region's has not. Based on this conclusion, this study makes recommendations for China's future sustainable development of heavily polluted firms.

Keywords: Sustainable Development, Green M&A, Operational Efficiency, DEA Analysis

JEL Classification Code: G34, M41, P47, Q01

***Acknowledgements:**
Research on Performance Evaluation and Promotion Path of China's New Urbanization High-quality Development (2020GGJS092).

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1. Introduction

The extensive economic development model has resulted in major environmental issues over the years. The release of pollutants from industrial expansion causes severe haze weather in the winter, indicating that China's environmental pollution control faces numerous challenges. To attain substantive governance goals, the government and businesses will take more practical steps to continuously develop a sustainable governance system. China declared in 2020 that carbon dioxide emissions will be capped by 2030 and the country would strive for carbon neutrality by 2060. The Chinese government's future development will adhere to the basic principles of environmental protection, encourage the achievement of global sustainable development goals, and contribute to world ecological security. This demonstrates the Chinese government's resolve and confidence in the face of global environmental protection and structural change in the industrial sector. To attain this lofty aim, every Chinese company that consumes energy must

address the critical CSR issues of lowering carbon emissions, conserving resources, and reducing pollution emissions (Qin et al., 2021). To form a green development and lifestyle, the government must firmly implement the most stringent environmental protection laws and regulations.

The 18th National Congress of China designated "green development, circular development, and low-carbon development" as a major development concept in 2012, marking the start of the green transformation of Chinese firms' production modes. China's green strategy has progressed to the point where environmental regulatory laws are being combined with green industrial programs. The Chinese government has created increasingly stricter industry pollution standards, as well as a set of emission reduction targets, programs, and laws. In terms of green industry policies, the government took action to encourage the development of a low-carbon economy and industries through preferential tax policies and technological innovation incentives to enable enterprises to take the initiative to achieve green transformation (Zhang et al., 2020). Under the dual policies of environmental regulation policies and green industrial policies, businesses are selecting Green M&A as a key approach to achieving green transformation under external pressure and internal motivation. Green M&A has become a crucial alternative for many organizations to actively meet the government's regulatory obligations and achieve sustainable corporate development. Green M&A are increasingly favored by the capital market and listed firms and have become an essential choice for corporate green investment, as the continual growth of ecological civilization construction deepens. The green operating costs of businesses would eventually climb as a result of China's increasingly strict environmental regulations. Is Green M&A capable of fully achieving the desired development goals, and what impact does it have on the company's business performance? Is there a difference in the performance improvement of listed businesses that have implemented Green M&A in different regions and industries? As a result, based on data from Chinese listed businesses in 2018, this study will examine the influence of Green M&A on their operating performance and give actual evidence to answer the following issues.

2. Literature Review

2.1. New Sustainable Development Concept

For many years, China's economic progress has been based on resource use and environmental consequences. The environment, water supplies, and soil have all been severely contaminated, and the ecosystem is extremely vulnerable. In 2013, the Chinese government said that the development of ecological civilization has been classified as one of China's five primary construction goals, despite the highly polluted haze weather. The Chinese government committed to a path of green and sustainable development in 2015, seeing reversing environmental deterioration and enhancing environmental quality as a critical challenge for fostering ecological environmental governance. Pollution prevention and control has become an important national strategy to promote the realization of higher quality and more efficiency.

The Chinese government forces polluting enterprises to adapt their production processes, adjust their industrial structure, and follow current technical and industrial development trends. Encourage businesses to make a concerted effort to generate green GDP and recognize the significance of green development. In the meantime, it has accelerated system innovation, enhanced the pollution control system, developed environmental protection rules and regulations, intensified pollution enforcement, and raised the cost of pollution infractions.

2.2. Concept of Green M&A

Green mergers and acquisitions are those that are focused on acquiring innovative technologies, developing clean production, improving energy efficiency, producing green products and services, and enhancing green competitive advantages (Salvi et al., 2018). Its ultimate purpose is to meet the production and operation needs of government-regulated businesses, as well as to successfully minimize pollutant emissions, lower company environmental costs, and optimize resource allocation. Realize the integration of business's economic and environmental benefits. (Lu, 2021). In short, Green M&A refers to listed companies to obtain the advanced technology and management experience they need. In essence, Green M&A and environmental protection investments belong to the green investment behavior of enterprises, which can enable enterprises to quickly obtain clean energy and green technology. Green M&A has a strong purpose to meet the social responsibility and green development of enterprises and achieve a win-win situation between enterprise development and environmental protection (Li et al., 2019). Based on this context, this study defines green mergers and acquisitions as corporate mergers and acquisitions performed with the goal of reducing emissions and implementing a green strategy. Mergers and acquisitions to acquire energy-saving, water-saving, and emission-reduction technology, as well as mergers and acquisitions to transform into other low-pollution, low-water, and low-energy businesses, are included in this category.

More industries have begun to update their development technologies through Green M&A in the context of the construction of an ecological civilization. This study will attempt to determine the impact of green mergers and acquisitions on the performance of various businesses.

In today's strong market rivalry, gaining technological advantages is critical for businesses (Jin et al., 2019). Green M&A and restructuring are important techniques for absorbing innovative technology and retaining competitiveness, according to the report. Environmental management factors have a strong direct effect on firm value (Soedjatmiko et al., 2021). Enterprises find it difficult to fully rely on their own R&D capabilities to meet their technological innovation needs in development and advancement (Li et al., 2021b). Green mergers and acquisitions are a critical component of development transformation and industrial upgrading. Companies, on the one hand, use Green M&A to convey signals to society that they are actively protecting the environment and taking on social duties, thereby obtaining social recognition and retaining their reputation and market position (Deng et al., 2013). Green M&A, on the other hand, allows businesses to buy green technologies directly, saving money and allowing them to rearrange their business models (Chen et al., 2018). Maintaining or consolidating technology innovation capabilities has become a critical link in the production and operation of businesses, prompting an increase in the number of organizations merging and acquiring to boost their technological innovation capabilities. To assist businesses in achieving market occupation, fulfilling social duties, and meeting the government's development goals to profit.

2.3. Green M&A and Operating Efficiency of Companies

The research on China's Green M&A enterprises has been completed. The value of a corporation is influenced by its environmental performance (Wahidahwati & Ardini, 2021). Green M&A may assist businesses in transforming and upgrading their operations, promoting effective corporate sustainable development strategies, and guiding and stimulating corporate environmental governance decisions. Green M&A can assist businesses in promoting environmental protection investment, recovering operational sustainability, improving their qualifications for getting government preferential policies, and increasing their ability to bear risk in the course of their operations. Corporations will be able to better regulate the distribution of key resources as a result of green M&A by heavily polluting companies in areas where the Chinese government has stronger policy interventions (Lu, 2021). According to research, enhanced central government control and personnel intervention can greatly improve environmental performance. The variables of corporate Green M&A were also examined in the study. It took into account the most important factors, such as premium characteristics and the success of the major mergers. Green M&A have different corporate performances under the influence of different environmental protection systems, according to the findings, and there is an "inverted U-shaped" relationship between the government's environmental regulation policies and companies' choice of green mergers and acquisitions.

Whether green M&A can truly strengthen China's company development capacity. Green M&A, according to experts, refers to economic actions such as mergers and acquisitions by businesses to acquire green resources and develop green technology (Jin, 2014). According to a study, corporations use technology mergers and acquisitions to acquire resources, expand their markets, and sustain competitive advantages. It also created a Green M&A performance rating methodology that took into account environmental, economic, and social factors (Liang, 2020). Through the examination of the economic and social outcomes of Green M&A transactions involving publicly traded corporations in high-energy-consuming industries. Green M&A can greatly increase a company's economic performance, according to empirical evidence (Gao, 2019). Green M&A firms acquire the target firm's core technology, obtaining green competitive advantages and achieving technical innovation (Zhou, 2014).

Green M&A based on property rights transactions is a powerful tool for companies looking to integrate technology internally. It is capable of not only acquiring the target company's superior technology and converting it into its technical capabilities but also of breaking through the company's own internal technology research and development cycle. Effectively compensate for the company's lack of technological innovation skills (Liu et al., 2014). Green M&A can help corporations acquire environmentally friendly innovative technologies, raise corporate green environmental protection investment, and eventually improve corporate performance, according to the findings of another study. A previous study looked into the link between corporate Green M&A and green economic development, using the major merging company's ROA as a measurement indicator after a successful acquisition. The findings revealed that, when compared to other mergers and acquisitions, Green M&A has improved the financial and operating performance of the major mergers and acquisitions, as well as the ROA results of companies that do Green M&A. At the same time, the impact of Green M&A on companies' sustainable development capabilities is investigated, and the findings show that Green M&A can lead to lower overall governance costs, improved resource allocation efficiency, improved corporate performance, reduced environmental pressure, and improved corporate social image (Salvi et al., 2018).

Based on this backdrop, this study uses corporate Green M&A as the research object and does a DEA analysis on Green M&A performance. By obtaining the content of mergers and acquisitions announcements from publicly

traded firms in various industries, this study examines the sample companies' mergers and acquisitions in depth. Green M&A refers to mergers and acquisitions that adhere to energy conservation, emission reduction, and the introduction of green innovative technology. After screening the companies that belong to Green M&A, we obtain their financial data. Then select the input and output indicators to measure and evaluate the DEA efficiency of the company's operating efficiency. This research provides an empirical reference for companies to choose Green M&A strategies.

3. Data and Research Methods

3.1. Data Sources

This study uses listed businesses in nonferrous metals, electricity, coal, and other industries as research samples to collect data on mergers and acquisitions in China in 2018. From the CSMAR database, select mergers and acquisitions data. Set Chinese listed A-share mergers and acquisitions data as the primary selection samples, then use keywords based on the main merging firms to find companies that fulfill the characteristics of Green M&A. Using the CSMAR database, collect published financial data from listed businesses' annual and CSR reports, and use DEA analysis to assess the impact of Green M&A on their operating efficiency. Green M&A was chosen based on the mergers and acquisitions target and background, as well as the major business scope and corporate development strategy of both parties to the mergers and acquisitions, as reported in the event information announcement. Among them, mergers and acquisitions transactions are three types: asset acquisition, asset replacement, and merger. Both the main merged company and the target company are Chinese domestic firms. Corporate mergers and acquisitions have been completed, and samples with missing financial data or incomplete announcement data have been eliminated. Companies whose major merger is with a financial business should be eliminated. Exclude sample companies whose mergers and acquisitions have failed to pass a general meeting of shareholders, the China Securities Regulatory Commission, or have been canceled for other reasons.

In China, 12,237 publicly traded companies completed mergers and acquisitions in 2018, with 69 percent of them succeeding. A total of 82 companies that successfully completed Green M&A were screened out by searching the M&A announcement for the terms "energy saving," "environmental protection," and "green." After filtering, remove companies with blank SELLER and BUYER fields, delete smaller M&As that occurred in the same year, and keep the larger transactions. Finally, 46 enterprises that are eligible to promote green production have been maintained.

3.2. DEA Model Design

Regarding the DEA model, Charnes, Cooper, and Rhodes first proposed the CCR model -1978 (Charnes et al., 1979). Later, Banker et al. (1984) changed the assumption of the return to scale in the CCR model and became the BCC model (Banker et al. 1984). So far, the most representative DEA models are CCR, BCC, FG, and ST models. The FG model assumes diminishing returns to scale, and the ST model assumes increasing returns to scale. In the DEA model, the relative efficiency of enterprises is distributed in the interval (0,1), and the value of enterprises with better efficiency is closer to 1. DEA can calculate distribution efficiency and technical efficiency, the latter can be decomposed into scale efficiency and pure technical inefficiency. Each model has two forms: Input-oriented and Output-oriented. The model can be set to constant return to scale (CRS) and variable return to scale (VRS) (Shah et al., 2019).

This research selects the CCR model, selects the input and output data of the Green M&A company to calculate, obtains the enterprise CRS and VRS, and uses CRS divided by VRS to obtain the Scale Efficiency Score. Suppose the model has n decision-making units, and each decision-making unit has m types of inputs, which represents the consumption of "resources" by the decision-making unit. And has s types of output, which represent the economic output of the decision-making unit after consuming resources. X_{ij} represents the i-th input of the j-th decision-making unit j, and Y_{rj} represents the r-th output of the j-th decision-making unit j. V_i is the weight coefficient of the i-th input indicator, U_r is the weight coefficient of the r-th output indicator. Denoted as:

$$x_j = \left(x_{1j}, x_{2j}, \cdots, x_{mj}\right)^T ; y_j = \left(y_{1j}, y_{2j}, \cdots, y_{sj}\right)^T ;$$
$$v = \left(v_1, v_2, \cdots, v_m\right)^T ; u = \left(u_1, u_2, \cdots, u_s\right)^T ;$$

Among them, $i = 1, 2, \ldots, m$; $r = 1, 2, \ldots, s$; $j = 1, 2, \ldots, n$. For the weight coefficient $v \in E^m$, $\omega = tv$ and $u \in E^s$, $u = tu$. The efficiency evaluation index of decision-making unit j is $h^j = \sum_{r=1}^{s} u_r y_{rj} \Big/ \sum_{i=1}^{m} v_i x_{ij}$. Choose appropriate weighting coefficients V and U, so that $h^j \le 1$, $j = 1, 2, \ldots, n$, When evaluating the efficiency of $j_0 \left(1 \le j_0 \le n\right)$ decision-making units, taking the weight coefficients V and U as variables, taking the efficiency index of the j_0 decision unit as the target, and constraining the efficiency index $h_j \le 1, j = 1, 2, \cdots, n$ of all decision units, the following linear programming CCR model is formed:

$$\left(P_{C^2R}\right)\begin{cases}\max u^T\ y_{j0}=v_{\mathrm{p}}\\ s.t.\omega^T x_j-u^T y_j\geq 0, j=1,2,\cdots n,\\ \omega^T x_{j0}=1\\ \omega\geq 0, u\geq 0.\end{cases}$$

If the optimal solution ω^0 and u^0 of the linear programming satisfy $V_P=u^{0T}y_{j0}=1$, then the decision unit j_0 is effective for weak DEA; if there is $\omega^0>0$, $u^0>0$ satisfies $V_P=u^{0T}y_{j0}=1$ in the optimal solution, then the decision unit j_0 is effective for DEA (CCR).

It is not easy to judge the effectiveness of decision-making units in practical applications. A mathematical model for judging the validity of DEA can be constructed by introducing the concept of non-Archimedean infinitesimal, making the application of the CCR model simpler and more practical. Let ε be a non-Archimedean infinitesimal (Non-Archimedean), which is less than any positive number and greater than 0, so the CCR model that introduces a non-Archimedean infinitesimal ε is obtained as follows:

$$\left(P_\varepsilon\right)=\begin{cases}\max u^T y_0=v_{p\varepsilon},\\ s.t.\omega^T x_j-u^T y_j\geq 0, j=1,2,\cdots,n,\\ \omega^T x_0=1,\\ \omega\geq\varepsilon\hat{e}, u\geq\varepsilon e\end{cases}$$

The dual problem is:

$$\left(D_\varepsilon\right)=\begin{cases}\min\left[\theta-\varepsilon\left(\hat{e}^T s^-+e^T s^+\right)\right]=v_{D_\varepsilon},\\ s.t.\sum_{j=1}^n x_j\lambda_j+s^-=\theta x_0,\\ \sum_{j=1}^n y_j\lambda_j-s^+=y_0\\ \lambda_j\geq 0, s^-\geq 0, s^+\geq 0, j=1,2,\cdots,n.\end{cases}$$

Where $\hat{e}^T=(1,1,\cdots,1)$ is an m-dimensional trace, $e^T=(1,1,\cdots 1)$ is a p-dimensional vector, $s^+=(s_1^+,s_2^+,\cdots,s_m^+)$ and $s^-=(s_1^-,s_2^-,\cdots,s_m^-)$ is a slack variable, θ represents relative efficiency, DMU_j total efficiency value, and $0\leq\theta\leq 1$.

In the above CCR model, suppose the optimal solution of linear programming is λ^0, s^{-0}, s^{+0}, θ^0. If $\theta^0=1$, and $s^{-0}=0$, $s^+=0$, then the decision-making unit is DEA effective, and technology and scale reach an effective state at the same time, which means that the sample in the model has the best resource allocation efficiency and input elements combination, output scale. Prove that the company's resources have been fully utilized. If $\theta^0=1$, but there is at least one s_i^{0-} greater than 0 or s_r^{0+} greater than 0, the decision-making unit is weak DEA effective, indicating that technical efficiency and scale efficiency have not reached the best efficiency at the same time. Specifically, if s_i^{0-} is greater than 0, indicating that s_i^{0-} in the i-th resource input is not fully utilized; while s_r^{0+} is greater than 0, it means that there is s_r^{0+} between the r-th output scale and the maximum output scale insufficient, the output scale has not reached the optimal efficiency; On the contrary, if $\theta<0$, the decision-making unit DMUj is not DEA effective, indicating that the technical efficiency and scale efficiency of resource allocation have not reached the optimal state, that is, the resource allocation efficiency is low.

3.3. Data and Variable Setting

The basic data for this study comes from Shenzhen Guotaian Information Technology Co., Ltd.'s CSMAR database. Based on the Green M&A data of China's listed A shares in 2018, which included listed businesses in the non-ferrous metals, electricity, coal, and other industries as the primary sample. Then, for an analysis of operating efficiency, select data from those companies' annual reports.

On the one hand, the following input indications are chosen: Total liabilities divided by total assets yields the asset-liability ratio. It may show the company's long-term investment in its business assets. Both the current and quick ratios are used to show fund liquidity, which can indicate an organization's ability to invest in its own operations. In addition to inventory, the account receivable turnover rate is an essential indicator of a company's current assets, and it might represent the company's investment capability. The average salary growth rate is a company's response to its human capital investment status.

The output indicators, on the other hand, are chosen as follows: Inventory turnover rate and return on total assets are two indicators of a company's financial health. The percentage rate of the company's after-tax profit divided by the net assets is the return on net assets. The percentage of gross profit in sales revenue is referred to as gross profit margin. The company's operating performance is reflected in the profit rate of its principal business and the turnover rate of its total assets.

A comparison of the five-year comprehensive operating efficiency scores of the selected Green M&A sample companies was carried out using the DEA model described above. The difference evaluation model is used to investigate the impact of Green M&A by comparing the average operational efficiency of the two years before and after. In 2017, China's 19th National Congress said that the country is on the verge of implementing the concept of green development. Based on this context, this study examines the 2018 Green M&A firms as a sample.

4. Results

4.1. Regional Distribution of Green M&A

The regional distribution of China's Green M&A enterprises is depicted in Figure 1. The eastern zone has 29 businesses, while the central and western regions each have nine and eight. The regional distribution of the status quo in China's industries is closely tied to such results. Manufacturing, extractive industry, construction, and other industries make up China's secondary industry. Commerce, banking, and other non-material production sectors make up the tertiary industry. Most secondary industries in China pollute the environment more than tertiary industries. According to research, the bigger the fraction of secondary industries, the higher the energy consumption intensity and the higher the SO_2 emissions (Zhao et al., 2018).

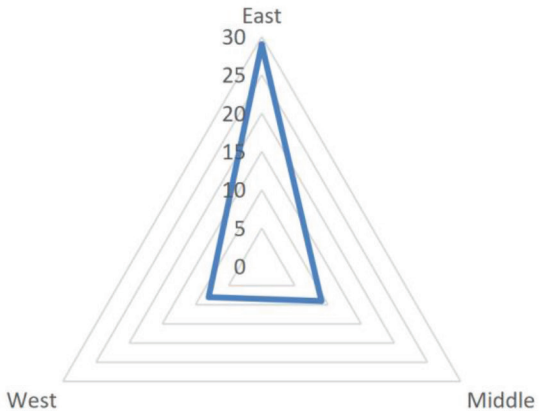

Figure 1: Regional Distribution of Green M&A Companies

Eastern China's tertiary sector is very developed; for example, according to the China Statistical Yearbook in 2018, the secondary and tertiary industries in Beijing, which is located in eastern China, account for 0.55 and 6. In Xinjiang, western China, the secondary and tertiary industries are 0.33 and 1.98, respectively. The efficiency of corporate economic development is better than other regions, thanks to an improved industrial structure and a fast-growing emergent industry. Furthermore, businesses are extremely aware of pollution management and green environmental protection. For example, in recent years, Zhejiang Province in eastern China has continued to adjust its industrial structure, increasing investment in environmental protection, improving environmental laws and regulations, implementing green economic development policies, and guiding heavy-polluting industries with overcapacity toward green upgrades. In the central and western regions, however, industrial technology and ecological regulations lag behind. As a result of these economic conditions, the middle and western areas have fewer corporations engaging in Green M&A than the eastern regions.

4.2. Industry Distribution and Efficiency Results of Green M&A Companies

4.2.1. Operating Efficiency of Green M&A in Different Industries

Table 1 shows that the operating efficiency of Green M&A in 9 industries has generally improved. The average efficiency before Green M&A was 0.94 and 0.95, while those reached 0.96 and 0.97 after. However, the operating efficiency in different industries is represented differently.

First, since 2016, the efficiency of the non-ferrous metals and manufacturing industries has steadily declined, reaching

Table 1: The Estimated Operating Efficiency of Green M&A Companies in Different Industries from 2016 to 2020

Industries	2016	2017	2018	2019	2020	Samples
Non-ferrous metals	0.967	0.975	0.917	0.958	0.971	13
Manufacturing industry	0.978	0.938	0.914	0.979	0.971	9
Ecological environment	0.955	0.917	0.987	0.970	0.952	8
Electric power	0.945	0.992	0.975	0.960	0.993	4
Construction industry	0.876	0.940	0.916	1.000	0.942	2
Coal industry	0.909	0.979	0.877	0.884	0.951	2
Fuel gas	0.878	0.775	1.000	1.000	0.898	2
Information equipment	0.819	1.000	1.000	1.000	1.000	2
Other industries	0.901	1.000	0.931	1.000	0.961	4
Total	0.943	0.952	0.940	0.970	0.965	46

a low point in 2018, but rebounding after the Green M&A. The "Three-Year Action Plan for Winning the Blue Sky Defense War" was launched by China in 2018. By 2020, it will be necessary to minimize air pollution emissions to achieve high-quality economic development. This document underlined the importance of fiercely optimizing the industrial structure and substantially reducing air pollution emissions. The government demands that strong corporate environmental protection and energy consumption restrictions be implemented and enforced in important areas. While manufacturing processes in major industries such as steel and non-ferrous metals should be decarbonized, the eco-environmental department should step up in-depth treatment of waste residue treatment, storage, and transportation.

Second, following the conclusion of Green M&A, the power industry's efficiency has continued to increase. From 0.94 in 2016 to 0.99 in 2020, the efficiency increased. Various distributed power production projects are funded, and corporations are required to boost the supply of clean and low-carbon power as part of government efforts to green coal-fired power. Following the development trend, power providers have boosted infrastructure construction for photovoltaic and wind power generation. Shanghai Electric Power, for example, has continually updated its development in recent years, focusing on solar power generation and distributed power generation, respectively. It received approval for steam cycle units with a capacity of 750,000 kilowatts, as well as new energy projects including photovoltaics and offshore wind power.

Third, the coal industry's efficiency in 2018 was 0.87, whereas it will be 0.95 in 2020. It demonstrates that the coal industry's development has improved as a result of Green M&A. After significant development has produced environmental contamination, China's coal sector, as traditional energy industry, must evolve toward an environmentally friendly and clean coal use path. The Chinese government requires the coal sector to improve its coal production method and technology. Under the needs of national low-carbon governance, coal companies focused more on research and development of clean coal technologies. The quality of cleaned coal and the process of coal preparation technology have both increased over time, and coal preparation equipment development has grown more efficient. Coal preparation technology has gradually become more automated and informatized. Fourth, the gas industry is down about 0.1 percent in 2020 compared to 2019. The reason for this could be that the industry was affected by the lockdown for more than three months during the pandemic in 2020. China has seen industrial shutdown, roadblocks, travel restrictions, and public gatherings. This has resulted in a major drop in gas demand in areas such as manufacturing, transportation, and catering (Cihan, 2022).

Table 2: Evaluation Results of DEA Mean Difference in the Operating Efficiency of Green M&A Companies in a Different Industry from 2016 to 2020

Industries	$S_{2018}–S_{2017}$	$S_{2018}–S_{2016}$	$S_{2019}–S_{2017}$	$S_{2019}–S_{2016}$	$S_{2020}–S_{2017}$	$S_{2020}–S_{2016}$	$S_1–S_2$
Non-ferrous metals	–0.058	–0.050	–0.017	–0.009	–0.004	0.004	–0.007
Manufacturing industry	–0.024	–0.064	0.041	0.001	0.033	–0.006	0.017
Information equipment	0.000	0.181	0.000	0.181	0.000	0.181	0.090
Fuel gas	0.225	0.122	0.225	0.122	0.123	0.020	0.122
Ecological environment	0.071	0.033	0.053	0.015	0.035	–0.003	0.025
Coal industry	–0.101	–0.031	–0.095	–0.025	–0.027	0.042	–0.026
Mineral products	–0.275	–0.055	0.000	0.219	–0.156	0.064	0.032
Construction industry	–0.024	0.039	0.060	0.124	0.002	0.065	0.063
Service industry	0.000	0.121	0.000	0.121	0.000	0.121	0.061
Electric power	–0.017	0.030	–0.032	0.014	0.002	0.048	0.008
Wholesale business	0.000	0.054	0.000	0.054	0.000	0.054	0.027
Water resource	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sum of all industries	–0.204	0.378	0.235	0.817	0.007	0.589	0.412
Average by industry	–0.017	0.032	0.020	0.068	0.001	0.049	0.034

Note: S represents the Green M&A operating efficiency score; $S_{2018}–S_{2017}$ represents the DEA difference between the relevant two years; $S_1–S_2$ represents the difference between the average value of the two years before and after Green M&A.

4.2.2. The Result of the Efficiency of Green M&A in Different Industries

This study compares the averages of Green M&A firms in various sectors to determine the overall difference, to thoroughly assess the operating efficiency changes of Green M&A companies in various industries. Table 2 below summarises the findings.

To begin with, the difference in operating efficiency in 2018 is more negative than it was before to Green M&A. In the year of implementing Green M&A in 2018, companies were impacted by a variety of circumstances and were unable to modify their development path in a timely manner. As a result, the good effects of Green M&A could not be immediately fed back into their development capacities.

Second, in 2019 and 2020, the difference in operational efficiency is generally positive, with a maximum improvement difference of 0.2 compared to the previous year. This demonstrates that corporations have quickly altered their development strategy following Green M&A. Enterprises have effectively increased their own development capacities and operating efficiency by absorbing the technology and equipment brought in through Green M&A.

Third, the average difference between the two years prior to Green M&A and the two years following it is often positive. Among these, the fuel gas industry's operating efficiency has grown greatly, to 0.12. Because China has chosen a green development path and created a demand for low-carbon energy, the use of fuel gas as green energy that is easy to store and transport has gradually expanded. It has the qualities of flexibility as a fuel for power generation and can play the role of altering power generating capacity with the help of the new power system. As clean renewable energy, fuel gas is very important for building a modern energy system (Zhu et al., 2016). As a result, in the fuel gas industry, both market demand and national policy guidance play a positive role.

Fourth, Green M&A has increased the operating efficiency of the construction industry, manufacturing industry, information equipment, service industry, environmental environment, and other industries. The efficiency of information equipment, the service industry, and the construction industry have all grown greatly, demonstrating that Green M&A can boost the enterprise's overall development level and capabilities.

Fifth, there is a negative difference between the nonferrous metals and coal industries before and after Green M&A. Although the efficiency of the non-ferrous metals and coal industries has increased since the previous article, the overall comparison demonstrates that operating efficiency after the Green M&A is still lower than before. In recent years, the nonferrous metals industry has struggled with irrational industrial structure and overcapacity, while high-tech green smelting has technological flaws and lacks significant support from industry (Zhong et al., 2021). China proposed the "de-coaling" policy in 2018, which calls for a steady reduction in coal production scale and output. Encourage businesses to create coal deep processing projects, promote coal production technology upgrades, and phase out obsolete production capacity (Shi et al., 2021). The high cost of coal industry upgrading, as well as investments that cannot be recouped in a reasonable amount of time, have resulted in a development halt.

4.2.3. Results of the Efficiency of Green M&A Companies in Different Regions

China has stated that to shoulder global governance responsibilities, it must adhere to the construction of a resource-saving and green productivity-improving infrastructure (Zhang, 2021). The government also pushes businesses to actively absorb modern technologies and hasten the conversion of research breakthroughs into industrial technological capabilities (Cheng et al., 2021). Green M&A is one of the paths to corporate upgrading because it necessitates a focus on updating conventional industries and resource utilization efficiency, as well as the use of innovative technologies to transform obsolete production capacity. By modernizing industrial equipment and incorporating new manufacturing knowledge, many Chinese enterprises have laid a solid foundation for their own long-term growth. The business's registration location was collected from the public company bulletin to determine whether the development capacities of companies in different regions of China have increased as a result of Green M&A. The company's location is classified into east, center, and west based on geographic location and economic status. We need to determine whether the operating efficiency of enterprises in various regions of China has improved as a result of Green M&A.

Table 3 depicts the differences in operating efficiency among several Green M&A enterprises in China's three key economic regions. Green M&A has enhanced enterprise operating efficiency, showing that green M&A has boosted enterprise development ability. According to the S_1-S_2 data, the operational efficiency of firms in the eastern region has greatly improved, reaching a maximum of 0.2, while the efficiency improvement of enterprises in the central and western regional areas is 0.06 and 0.1. The four companies in central and eastern are not expected to enhance their efficiency, and the different result is 0 or even negative. This suggests that enterprises were unable to change their business development models in a timely manner in the year of Green M&A and that the asset adjustment brought about by Green M&A may not have a positive impact on the company's development capacities. Firms in the eastern area improved their business development efficiency in

Table 3: The Results of the Operating Efficiency Difference of Some Green M&A Companies in China's Three Major Economic Regions from 2016 to 2020

Stock Code	Regions	$S_{2018}–S_{2017}$	$S_{2018}–S_{2016}$	$S_{2019}–S_{2017}$	$S_{2019}–S_{2016}$	$S_{2020}–S_{2017}$	$S_{2020}–S_{2016}$	$S_1–S_2$
603315	East	–0.014	–0.448	0.434	0.000	0.434	0.000	0.217
002911	East	0.228	0.122	0.228	0.122	0.228	0.122	0.175
300664	East	0.221	0.121	0.221	0.121	0.221	0.121	0.171
300055	East	–0.169	–0.043	0.000	0.126	0.000	0.126	0.063
002297	Center	–0.275	–0.055	0.000	0.219	–0.156	0.064	0.032
600546	Center	–0.005	–0.005	0.000	0.000	0.000	0.000	0.000
600295	Center	0.000	0.000	–0.047	–0.047	0.000	0.000	–0.023
300187	Center	0.000	0.000	–0.216	–0.216	–0.387	–0.387	–0.301
300692	West	0.221	0.121	0.197	0.097	0.221	0.121	0.159
603080	West	0.221	0.121	0.221	0.121	0.017	–0.083	0.069
603843	West	0.121	0.121	0.121	0.121	0.004	0.005	0.063
000862	West	0.000	0.061	0.000	0.061	0.000	0.061	0.030

Note: S represents the Green M&A operating efficiency score; $S_{2018}–S_{2017}$ represents the DEA difference between the relevant two years; $S_1–S_2$ represents the difference between the average value of the two years before and after Green M&A.

Table 4: Operating Efficiency Difference of Green M&A Listed Companies in China's Three Major Economic Regions in 2016–2020

Regions	$S_{2018}–S_{2017}$	$S_{2018}–S_{2016}$	$S_{2019}–S_{2017}$	$S_{2019}–S_{2016}$	$S_{2020}–S_{2017}$	$S_{2020}–S_{2016}$	$S_1–S_2$
East	–0.027	–0.018	0.025	0.034	0.031	0.040	0.033
Center	–0.031	–0.007	–0.029	–0.005	–0.060	–0.036	–0.033
West	0.064	0.061	0.043	0.040	0.027	0.024	0.033

2019 and 2020, whereas the majority of enterprises in the central region failed to increase their operational efficiency. In response to the government's green development concept, firms have advocated reform and improvement of their own development since the 2017 National Congress. To meet their responsibilities for low-carbon development, companies aggressively introduce low-carbon technologies that can produce cleaner production and improve innovation-driven technologies (Li et al., 2021b). Another finding was that investing in research could help manufacturing's total factor productivity growth. This study discovered that different regions' implementation of green M&A had varying consequences on their own development.

The operating effectiveness of Green M&A in China's three key economic areas is shown in Table 4. The eastern and western regions' operating efficiency has improved as a result of Green M&A, but the central region has not. It implies that green M&A has diverse effects on company operational efficiency in different economic regions, reflecting China's regional imbalance in green economy growth capacities. The benefits of green development resources are reasonably clear in the western region, whereas the strain on green development in the central region is stressed. According to the "China Economic Green Development Report 2018", the overall score of China's economic green development is gradually decreasing from the southeast coastal area to the northwest.

Green M&A companies in the eastern region have broken through the stagnant stage in 2019 and 2020 respectively, after experiencing the lagging stage of development in 2018. In comparison to the preceding Green M&A, there was a positive increase in operating efficiency, and the overall performance gap grew by 0.03. The eastern half of China was the first to embrace the new sustainable development idea, which has led to a low-carbon road in heavily polluted industries. The eastern coastline economic zone has served as a green ecological barrier in the eastern region, with a very high level of urbanization and a relatively complete industrial scale. Under the guidance of the government, certain heavily polluted listed businesses implement green

circular development strategies, strengthen industrial upgrading, and raise their technological level. According to the data, the green development indexes of the eastern Chinese provinces of Zhejiang, Guangdong, and Jiangsu were among the top three in China in 2018. This shows that the increase in operational efficiency brought about by Green M&A in eastern China is backed up by sound policy.

Enterprise efficiency in the central region, on the other hand, has not increased, with a -0.06 percent difference between 2017 and 2020. It demonstrates that implementing Green M&A has had no positive impact on the operating efficiency of businesses. The central region's industrial growth mode is more extensive than the eastern and western areas. In central China, there are several historic industries, such as the traditional steel industry in Heilongjiang Province and the traditional coal industry in Shanxi Province. And the steel and coal industries are the most developed in these regions' linked industries. These Chinese central provinces are currently grappling with the challenges of industrial restructuring, resource optimization, and green development transformation. Traditional industrial industry change takes longer and costs more money than other industries. As a result, enterprise operational efficiency lags behind that of other regions, and it has not increased over time during the transformation process.

Following the implementation of Green M&A, the operating efficiency of enterprises in the western region improved. The operating efficiency growth difference is 0.06 in 2018, the year that Green M&A was adopted. It suggests that green M&A has increased the operating efficiency of firms in western China. The strong atmospheric pressure difference, for example, is beneficial to the creation of wind energy, and the higher altitude with thin cloud cover is conducive to solar radiation in western China's green natural resources. With the basis of wind and solar energy resources in place, businesses in need of energy transformation have more options for green development. High-tech businesses can amass more knowledge and boost knowledge transformation into technology (Liu et al., 2021). The new technology introduced by Green M&A will accelerate the development of firms in a short period of time due to the wester's comparatively low technological level. It has exhibited a high rate of return on investment with the assistance of the state's policy on the western area.

5. Discussion and Conclusion

This study examines and evaluates the operating efficiency of China's listed firms that have executed Green M&A in 2018, in light of the Chinese government's encouragement of green and sustainable development. The following are the findings of this study: To begin with, China's green M&A enterprises are unevenly distributed among the country's east, center, and western regions. Second, compared to before the implementation of Green M&A, operational efficiency has usually improved in most industries. Finally, the difference in Green M&A across industries is generally favorable, showing that most businesses have improved their operational performance as a result of implementing Green M&A. In 2018, however, the gap in operating efficiency is more negative. Fourth, whereas the eastern and western areas' operational efficiency has improved as a result of Green M&A, the central region's has not.

Provide some evidence for corporations to continue implementing green M&A strategies, and make the following recommendations, based on China's present green development.

To begin, we can see that the number of Green M&A companies in China's central and western areas is lower than in the country's eastern regions. This is primarily due to a lack of motivation in the central and western areas to update their industrial structures. Because industrial upgrading necessitates a significant amount of capital investment, a lack of financial support will stifle enterprise green development. To promote scientific and technological development, the government should create laws that encourage enterprises to develop core and innovative technologies with their own intellectual property rights. Heavy polluting industries must hasten the adoption of intelligent technologies in a range of fields. According to the findings of the study, foreign direct investment has a positive impact on pollution (Ha & Nguyen, 2021), as a result, firms in central and eastern China may consider introducing foreign investment.

Second, after organizations implement Green M&A, focus on improving operational efficiency. To improve the governance of pollutants, the government should adopt rules and regulations for businesses to reduce environmental hazards and strengthen environmental supervision, as well as to improve ecological compensation and environmental protection punishment mechanisms. To promote Green M&A, promote the transformation of enterprise production methods through policy incentives and offer preferential policies based on regional distinctions. Simultaneously, subsidies should be granted to companies that opt to implement Green M&A to assist them in surviving in the early stages. Enterprises should comply with the demands of the ecological civilization-building era, and rationally use their own advantages to ameliorate the high-polluting industry model. And, to realize the goal of corporate green transformation, make full use of national preferential policies, actively learn from advanced regions, and promote green industries in accordance with local conditions.

Third, encourage the entire society to adopt a green production and lifestyle to pursue a path of sustainable development. In terms of pollution control, the government set up strict pollution control rules and shut down high-polluting businesses as soon as possible. This

may compel businesses to pursue green transformation and sustainable development strategies. Enterprises must resolutely perform their environmental protection responsibilities and construct an environmentally friendly enterprise while formulating their own development strategy. Firms should expand commercial collaboration with technologically advanced enterprises and absorb the latest production methods while developing their own technological innovation capabilities. Businesses can achieve their environmental goals using green M&A strategies and use green technology to achieve sustainable growth.

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