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A New Integrated Approach for Evaluating Sustainable Development in the Electric Vehicle Sector

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ABSTRACT

This study develops an innovative value creation process for the electric vehicle (EV) industry. First, this study conducts data envelopment analysis to measure the innovation, operation, and market efficiency performance of the EV industry. Second, this study conducts bootstrapped truncated regression to explore the impact of environmental, social, and governance (ESG) factors on the performance of the EV industry. Third, this study uses the classification & regression tree (CART), random forest, and eXtreme gradient boosting (XGBoost) algorithms to assist managers in identifying the key predictive variables for further classification and prediction. Results reveal significant differences in innovation performance across five industry sectors, among which the charging pile system sector exhibits the highest average value, and the battery system sector exhibits the lowest average value. The truncated regression analysis shows that innovation performance in Taiwan's EV industry is significantly influenced by energy management, data security, employee information statistics, and control over equity and board seats. Corporate governance transparency positively impacts operational performance, while energy and water management enhance market performance, with product quality and safety having a negative effect on market performance. This study identifies the relative importance of the classification attribute variables based on the classification rules of the target attributes by conducting further analysis with the CART decision model and constructs an optimal prediction model.

1. Introduction

Human activities have increased greenhouse gas emissions and global warming, which has caused severe environmental damage and exerts a profound impact on society and the economy. In response to worsening environmental conditions, the 26th Conference of the Parties to the United Nations Framework Convention on Climate Change was held in Glasgow, United Kingdom, in November 2021, during which various nations and enterprises set goals for the "2030 Emission Reduction Target" and "Zero Carbon Economy." Specifically, the participants established the "Zero Emission Vehicle Commitment" for major automobile markets to achieve 100% net-zero emissions from cars and vans by 2035 and planned to expand the initiative to other regions by 2040 to reduce carbon emissions by approximately 100 million tons annually [20]. The global demand for electric vehicles (EVs) is growing rapidly and reached a scale of one million units in 2017, with sales expected to surpass 10 million units annually by 2022 [78]. Taiwan, which is located at the core of the global technology manufacturing network, boasts a comprehensive automotive industry structure with a complete supply chain. In addition to possessing technical advantages in the electronics industry, Taiwan demonstrates strong export competitiveness in the automotive parts market. Taiwan's EV industry features an integrated supply chain, from materials to sales and service, with numerous companies involved. The observation of global innovation trends can provide insights into potential business opportunities.

The concept of environmental, social, and corporate governance (ESG) first appeared in reports by over 20 financial institutions under the United Nations in 2004. ESG refers to how enterprises and investors integrate environmental, social, and governance factors into their business models [36]. Sustainable business practices have continued to reinforce overall corporate trends since the COVID-19 pandemic [30, 79]. Many companies have begun to transform and shift their economic

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