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The implications of efficiency differences in sustainable development: An empirical study in the consumer product industry

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Abstract

Firms often invest in sustainable development projects to improve their environmental and societal performance. Given the broad spectrum of these projects and limited resources, managers face challenges in determining where to improve (e.g., improving water consumption and reducing carbon footprint). The study examines the connection between environmental performance and firm performance from a new angle to help managers make informed decisions. The study examines firms in the consumer product industry regarding their efficiency in the operational aspect, the resource-related environmental aspect, and the climate-related environmental aspect. It then employs panel data models to investigate the implications of efficiency differences across these aspects on firms' financial performance and business risk. The results indicate that the effects of these differences are adverse in general. Additionally, the relationship between the operational and environmental efficiency difference and financial performance is in an inverted-U shape. The study contributes to the literature by offering theoretical support and empirical evidence for the balanced portfolio approach in managing multiple environmental concerns. The study findings also provide managerial guidelines for decision-making. To gain a greater benefit, managers should aim to minimize the performance differences across multiple environmental aspects and manage a subtle balance between operational performance and environmental performance.

KEYWORDS
consumer product, environmental efficiency, panel data, sustainable development

1 | INTRODUCTION

Many firms have sustainable development as an element in their business strategies and integrate corporate social responsibility (CSR) activities into their operations (Angell & Klassen, 1999; Berns et al., 2009; Bonini & Gorner, 2012; Nidumolu, Prahalad, & Rangaswami, 2009; Porter & Kramer, 2006). Meanwhile, managers often face trade-offs and make compromises in their decisions to meet strategic objectives (Rosenzweig & Easton, 2010; Skinner, 1969). The literature has suggested that because sustainable development initiatives are part of firms' overall investment, they should be evaluated together with operational investment and performance (McWilliams & Siegel, 2001). It has also suggested that managing resource allocation among various types of CSR concerns, such as climate change and employee welfare, are more complex and challenging because managers need to assess the implications and trade-offs of their decisions and satisfy a broader set of societal expectations at the same time (Waddock & Graves, 1997; Bonn & Fisher, 2011; Wu & Pagell, 2011). As a result, a recent trend in CSR reporting shows that firms aim to determine the materiality of various issues by assessing the magnitude and likelihood of risks associated (Whitehead, 2017), highlighting strong interests in understanding the prioritization and allocation of resources for CSR programs in strategic formation (Schneider, 1989). The Materiality Map published by the Sustainability Accounting Standards Board (SASB) also underlines environmental and societal concerns that may significantly impact firms' financial performance across industries (Eccles, Ioannou, & Serafeim, 2014; SASB, 2018).

According to the latest Materiality Map (SASB, 2018), the material concerns for firms in the consumer product industry are GHG emissions, water management, material efficiency, and energy management. Nevertheless, managing these material concerns at the same time is challenging. Peter Brabeck, the former chairman of Nestlé, had openly argued that water scarcity is more imminent than climate change and should be prioritized and managed separately (Clark, 2014). Coca-Cola's 2017 sustainability report (The Coca-Cola Company, 2017) also included a priority analysis section and enabled Coca-Cola to give its water stewardship program precedence. Strategic decisions in managing multiple environmental concerns (e.g., Nestlé's decision of prioritizing water usage over carbon footprint) have attracted significant industry interests (Clark, 2014; Feather, Harrington, & Capan, 1995; Sheffi, 2018; Spence, 2013) but gain limited attention in the literature. As a result, we cannot provide sufficient guidance for managers managing multiple environmental and societal concerns.

Motivated by the industrial interests and the literature gap, our study takes an initial step to improve the understanding of the consequences of decision-making in managing multiple environmental concerns by examining the implications of firms' environmental performance from a new angle. We explore firms' performance differences across multiple aspects (i.e., the operational aspect, the resource-related environmental aspect, and the climate-related environmental aspect) and investigate the implications of the performance differences across these aspects. By doing so, we help managers make better-informed decisions in determining where to improve (e.g., between improving water consumption and reducing carbon footprint) and what to expect.

Guided by environmental management and strategic management literature, we first explore firms' total factor efficiency and examine the implications of the difference between firms' operational efficiency and environmental efficiency. Supported by the resource-based rationale and the good management theory, we posit that a firm with less difference between its operational efficiency and its environmental efficiency enjoys a better financial performance.

With a limited understanding of managing multiple environmental concerns simultaneously in the literature, we leverage the similarities between environmental expenditures and R&D investment and refer to the portfolio management argument. A literature stream has examined portfolio management in product development and empirically shown that a broader portfolio expands firms' knowledge base and helps them hedge risks (Klingebiel & Rammer, 2014; Neuhäusler, Schubert, Frietsch, & Blind, 2016). Focusing on the difference between a firm's resource-related environmental efficiency and its climate-related environmental efficiency, we suggest that a firm with less difference reflects its managers' broader and balanced interests in addressing environmental concerns. Therefore, a firm with less difference between its resource-related environmental efficiency and its climate-related environmental efficiency enjoys better financial performance.

A separate literature stream has also indicated that companies take preemptive actions on environmental or social issues as part of their business risk management (Reinhardt, 1999). We posit that a firm with less operational and environmental efficiency difference enjoys less business risk for a complete understanding. We also posit that a firm with less difference between its resource-related environmental efficiency and its climate-related environmental efficiency has less business risk.

Focusing on the consumer product industry, we collect firm-level operational and environmental performance metrics from Bloomberg for 2010–2016 and apply the directional distance function (DDF) to determine a focal firm's total factor efficiency. By analyzing subsets of these input and output measures, we also obtain the firm's (i) operational efficiency; (ii) resource-related environmental efficiency, which includes water usage and waste generated; (iii) and the climate-related environmental efficiency, which considers GHG emissions. The DDF outcomes indicate that firms in the industry are more efficient in the operational aspect than the environmental aspects. They also show that firms are more efficient in the resource-related environmental aspect than the climate-related environmental aspect. To test our hypotheses, we employ a panel data analysis, and the results suggest that the effects of efficiency differences on firms' financial performance and business risk are generally adverse. The results also show that the relationship between firms' operational and environmental efficiency difference and their financial performance is in an inverted-U shape.

To the best of our knowledge, the study is among the first to examine the challenge of managing multiple environmental concerns simultaneously. We contribute to the environmental strategy and sustainable development literature by examining the implications of efficiency differences in various environmental aspects and revealing the subtle interactions between firms' operational efficiency, environmental efficiency, financial performance, and business risk. We discuss the study's theoretical and managerial implications and its limitations in detail at the end of the paper.

2 | HYPOTHESES DEVELOPMENT

2.1 | The difference between operational efficiency and environmental efficiency

The past literature has identified several rationales that motivate firms to invest in sustainable development. One primary stream of literature is the national-resource-based rationale, expanded from the resource-based view from the strategic management literature (Hart, 1995). The rationale conjectures that environmental programs and sustainability initiatives contribute to greater competitive advantages by reducing costs or preempting competition and regulations (McWilliams & Siegel, 2011; Shrivastava, 1995). Empirical studies have shown that environmental initiatives decrease the consumption of materials and energy (Rothenberg, Pil, & Maxwell, 2001; Sroufe, 2003), suppress the amount of waste (Porter & van der Linde, 1995), reduce the cost of maintaining policies and procedures (Dowell , Hart, & Yeung, 2000), and improve firms' baseline (Capece, Di Pillo, Gastaldi, Levialdi, & Miliacca, 2017; Hart & Ahuja, 1996; Xie., Nozawa, Yagi, Fujii, & Managi, 2019). In sum, this stream suggests that the returns of environmental investments could be greater than their cost and that firms should address environmental concerns preemptively.

Firms are more operationally efficient since a primary managerial objective is to achieve excellent operational efficiency (Van Reenen, 2011). Nevertheless, McWilliams and Siegel (2001) have suggested that evaluating the outcomes of environmental and societal actions should contemplate firms' efficiency in using resources because these actions are part of firms' overall investment portfolio. Waddock and Graves (1997) have also suggested that better managers engage with key stakeholders more meaningfully; improve their relationships with all stakeholders, including neighboring communities and the environment; and result in better environmental and social performance. In addition, firms with good management are likely to achieve excellent operational performance (Van Reenen, 2011); they should also simultaneously improve environmental and societal performance. Nevertheless, the empirical examination of the implications of the interaction between operational efficiency and sustainable development is limited. Specifically, Jacobs, Kraude, and Narayanan (2016) show that operational efficiency and CSR performance are complementary when they both are sufficiently high, and Sartal, Rodríguez, & Vázquez, (2020) highlight that GHG emissions reductions have greater benefit for more operationally efficient firms.

Guided by these prior studies, we posit that a firm managing its environmental efficiency closer to its operational efficiency indicates better management and should enjoy a better financial outcome. As such, we propose the following hypothesis:

H1a. The difference between a firm's operational efficiency and its environmental efficiency is negatively associated with its financial performance.

2.2 | The efficiency difference within environmental aspects

The nature-resource-based rationale also indicates that spillovers from sustainable development, such as reducing material waste, enhancing resource utilization, and improving market perception, improve firms' baseline. Nevertheless, the rationale does not help address the challenge of managing multiple environmental and societal concerns. For example, the understanding of whether the consequences of actions vary by environmental aspects or whether trade-offs among environmental actions exist is limited.

To fill the gap, we first extend the good management theory, suggesting that good managers should effectively address various environmental concerns and achieve excellent performance among environmental issues. Additionally, we seek additional support from the product innovation literature. In essence, allocating resources in environmental activities is similar to investing in R&D activities because the effectiveness of an R&D program (i.e., the success of developing a marketable technology) is uncertain, and the magnitude of its impact (i.e., market demand for an innovative product) is difficult to assess. Therefore, we refer to product innovation studies that examine the implications of resource allocation strategies. Suggesting that a broader range of R&D projects expands the knowledge base of a firm and improves the likelihood of success in new product introduction, Klingebiel and Rammer (2014) empirically show that the number of new product development projects is positively associated with the revenue generated from new products. Also, Neuhäusler et al. (2016) use patent data with panel data analysis to show that broadening an investment portfolio increases the hedge against uncertainties, resulting in better financial performance. Furthermore, we suggest that managing various environmental concerns is similar to maintaining an investment portfolio. Based on the preceding discussion, we posit that a firm managing its environmental performance in various environmental concerns closer *should* enjoy a better financial outcome and have less business risk and propose the following hypothesis:

H1b. A firm's efficiency difference within environmental aspects is negatively associated with its financial performance.

2.3 | Efficiency differences and business risk

Expanded arguments about trade-offs between cost and potential benefit in the resource-based view, the stakeholder theory suggests that managers should carefully oversee explicit costs, including dividends and interest payments, and should control implicit costs, such as product quality, employee safety, and environment protection. Firms that do not manage these implicit costs will eventually suffer higher explicit costs (Jones, 1995). A few environmental studies have leveraged the theory and suggested that companies should spend efforts on environmental issues as part of their business risk management strategies (Kleindorfer & Saad, 2005; Reinhardt, 1999; Weinhofer & Busch, 2013). Specifically, in addition to focusing on their financial performance, companies take preemptive actions addressing environmental and societal concerns, such as water scarcity and climate change, after assessing their potential impact. From the empirical standpoint, Orlitzky and Benjamin (2001) adopt the meta-analytic approach and find that CSR activities generally lower firm risk. Weber, Fenchel, and Scholz (2008) observe that European banks incorporate environmental risks into their credit management system. Sharfman and Fernando (2008) and Dhaliwal, Li, Tsang, and Yang (2011) further show that companies with better environmental or CSR performance enjoy a lower risk, measured by their cost of capital. Recently, Zeng, Zhang, Zhou, Zhao, and Chen (2019) show that Chinese firms' water disclosure links to lower systematic market risk, measured by their stock beta coefficient. However, water disclosure does not have a significant effect on idiosyncratic market risk, measured by the standard deviation of residuals from daily stock price and CAPM based return. Similarly, Xue, Zhang, and Li (2019) show an inconclusive relationship between firms' environmental performance and idiosyncratic market risk.

Whereas existing studies have examined the relationship between sustainable development and market risk, the risk management argument implies that sustainable management should affect firms' internal business risk. Interestingly, the view also re-enforces the portfolio management argument in hypothesis H1b. That is, if risk management is a driving motivation in sustainable development, risk hedging by maintaining a balanced portfolio in sustainable development should help firms manage their business risk more effectively. Based on the preceding discussion, we extend our hypotheses H1a and H1b and posit that a firm managing its environmental efficiency closer to its operational efficiency and maintaining a balanced efficiency in various environmental aspects should enjoy *less* business risk. Therefore, we propose the following hypotheses:

H2a. The difference between a firm's operational efficiency and its environmental efficiency is positively associated with its business risk.

H2b. A firm's efficiency difference within environmental aspects is positively associated with its business risk.

3 | DATA AND EFFICIENCY

To examine our hypotheses, we provide a measurement of firms' total factor efficiency, including all material environmental inputs and outputs. To measure firms' efficiency in a specific aspect, we then focus on the subset of relevant input and output measures. This section first describes our data source and firms in our sample. It then details the approach of measuring firms' efficiency and discusses findings with interesting examples.

3.1 | Data

We collect environmental-related performance metrics from Bloomberg's environmental, social, and corporate governance (ESG) data. Bloomberg provides a broad range of metrics, including calculated indicators like firm-level sustainability disclosure scores and raw data metrics like firms' total water usage in tons. It obtains raw data by reviewing multiple data sources, such as firms' annual reports, 10-Ks, press releases, Corporate Social Responsibility or Sustainability reports, GRI indexes, and proxy statements such as DEF 14A. Besides, a majority of measures have hyperlinks linking to source documents, providing excellent traceability. Bloomberg also incorporates data from the Carbon Disclosure Project (CDP), a leading non-profit organization providing self-disclosed environmental data in empirical research.

We focus on Bloomberg's global consumer product industry (i.e., code 11210 in Bloomberg Industry Categorization). The industry is global and vast and includes subindustries such as beverages, packaged foods, and household products. PwC estimated that the industry in the U.S. provided 2.3 M jobs and contributed $361B to GDP in 2017 (Consumer Brands Association, 2019). Environmental performance is also vital in this industry as it is a large emitter of GHGs and a large water user. Besides, firms' in this industry are sensitive to market perception because it interacts with customers directly and reputation and brand power play significant roles in their business (Patterson, 2019).

We choose to focus on this industry because environmental concerns are vastly different across industries; productivity and efficiency are difficult to compare due to fundamental differences in production processes and capital intensity (Baily, Gersbach, Scherer, & Lichtenberg, 1995). Guided by SASB's Materiality Map (SASB, 2018), we obtain firm-level material environmental performance metrics from 2010 to 2016. These metrics include water used, waste generated, energy consumed, and GHG emitted (i.e., the sum of Scopes 1 and 2 emissions). We focus on firms that report non-zero data in these material performance metrics. We also retrieve the volume of water recycled and the amount of waste recycled. In addition, we exclude companies that mainly operate in the tobacco business because of their distinctive corporate environmental and societal behavior. As a result, our sample data contain 113 unique global firms, and we summarize the characteristics of our sample firms in Table 1.

3.2 | Firm efficiency

To account for the multi-dimensionality of measuring firms' performance (McWilliams et al., 2016) and handle environmentally undesirable outputs (Fujii, Managi, & Kawahara, 2011; Ishinabe, Fujii, & Managi, 2013), we measure firms' total factor efficiency by employing the Directional Distance Function (DDF), a method widely used in environmental studies (Zhang & Choi, 2014).

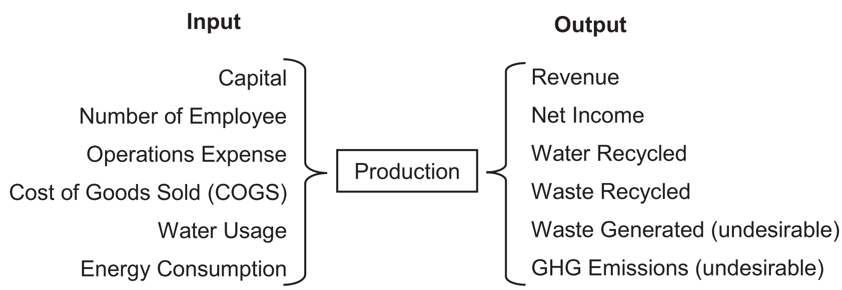
DFF allows for the inclusion of environmental input and output measures without their prices. It also does not require specific weights for measures, allowing firms to improve their performance by increasing desirable outputs and reducing inputs and undesirable outputs. To determine firms' total factor efficiency, we take a process view illustrated in Figure 1. Operationally, we include capital, the number of employees, and the sum of operations expense and cost of goods sold (COGS) as inputs measures, and we have revenue and net income as output measures, as firms could be scale or profit oriented. Environmentally, we have the volume of water used and the amount of energy used as inputs, water recycled and waste recycled as desirable outputs, and the amount of waste generated and GHG emitted as undesirable outputs.

TABLE 1 Descriptive statistic of sample firms

	Mean	S.D.	Min	Max
ROA	5.09	3.91	.012	29.02088
Altman *Z*	4.09	2.14	−.01	14.3055
Revenue (in millions)	9,832.74	16,491.19	66.10	100,467.8
Total asset (in millions)	13,241.16	26,325.71	97.44	144,266
Total capital (in millions)	9,198.96	18,366.60	79.27	105,393
Number of employees	30,341.23	57,732.25	319	339,000
Water usage (in thousands of cubic meters)	32,720.91	97,885.10	2.74	953,000
Waste amount (in thousands of tons)	1,471.51	17,802.13	.05	347,802
GHG emissions (in thousands of tons)	967.47	2,213.03	.49	18,556
Energy consumption (in MWh)	4,920.11	17,222.22	1.23	199,203

Note. 563 observations and 113 unique firms.

FIGURE 1 Process view of firm efficiency



To operationalize DFF, we denote *x*, *y*, and *b* as the vectors of inputs, desirable output, and undesirable output, respectively. We then have the production function as the following:

$$P(x) = \{x, y, b\} : x \text{ can produce } (y, b). \quad (1)$$

The inefficiency $D(x,y,b \mid g_x,g_y,g_b)$ of the production units in $P(x)$ for each of the sample firms is defined with the distance from the production frontier consisting of the efficient production units as the following:

$$\vec{D}_0(x,y,b : g_x,g_y,g_b) = Sup\{\beta : (y+\beta g_y, b-\beta g_b)\} \in P(x-\beta g_x) \quad (2)$$

where g_x, g_y, and g_b denote the non-negative directional vectors of the input, the desirable output, and the undesirable output. We assume desirable and undesirable outputs under a null-joint hypothesis. That is, a company cannot produce a desirable output without producing undesirable outputs. Specifically,

$$(y,b) \in P(x); b = 0 \Rightarrow y = 0 \quad (3)$$

Additionally, we assume weak disposability for undesirable outputs. Therefore,

$$0 \le \beta \le 1 \Rightarrow (\beta y, \beta x) \in P(x). \quad (4)$$

Under the directional vector setting $(g_x, g_y, g_b) = (0,y,b)$, we can estimate the inefficiency score of firm *k* in our sample data by the following optimization objective function:

$$\max \beta_k, \quad (5)$$

$$s.t. \sum_{i=1}^{N} \lambda_i x_i^l \le x_k^l \quad l = \text{capital, operatonal expense + COGS, labor, water usage, energy usage,} \quad (6)$$

$$\sum_{i=i}^{N} \lambda_i y_i^m \le (1+\beta_k) y_k^m \quad m = \text{revenue, net income, water recycled, waste recycled,} \quad (7)$$

$$\sum_{i=i}^{N} \lambda_i b_i^r \le (1+\beta_k) b_k^r \quad r = \text{waste generated, GHG emissions,} \quad (8)$$

$$\lambda_i \ge 0 \quad i = 1, \cdots, k, \cdots, N. \quad (9)$$

The model estimates the efficiency of a firm by considering its extent to reduce undesirable outputs (i.e., waste generated and GHG emissions) and increase desirable outputs (e.g., revenue and water

TABLE 2 Measures in the efficiency calculation

Efficiency	Type	Measures
Total efficiency	Input	Capital Number of employees Operations expense + COGS Water usage Energy usage
	Output	Revenue Net income Water recycled Waste recycled Waste generated (undesirable) GHG emissions (undesirable)
Operational efficiency	Input	Capital Number of employees Operations expense + COGS
	Output	Revenue Net income
Resourced-related environmental efficiency	Input	Water usage
	Output	Revenue Net income Water recycled Waste recycled Waste generated (undesirable)
Climate-related environmental efficiency	Input	Energy usage
	Output	Revenue Net income GHG emission (undesirable)

recycled) without increasing inputs (e.g., capital and water usage). β_k represents the distance from production unit k to the production frontier line curve and indicates its inefficiency. Besides, the model is based on the common decreasing return-to-scales assumption (DRS) to avoid potential infeasible calculation situations. To ease the interpretation, we have $1 - \beta_k$ as the efficiency score of firm k. The total efficiency score, which includes all operational and environmental measures in Figure 1, is denoted as $\Phi^T_{k,t}$ for firm k at year t.

Adopting from the approach of Xie et al. (2019), we determine firms' operational efficiency by including the capital, the number of employees, and the sum of operations expense and cost of goods sold as inputs measures and having revenue and net income as output measures. We denote the operational efficiency score as $\Phi^O_{k,t}$. To obtain parsimonious managerial insights, we then dichotomize environmental aspects and categorize water and waste management as the resource-related environmental aspect since they are tangible and play crucial roles in production processes. We obtain the resource-related environmental efficiency score, denoted as $\Phi^R_{k,t}$, by having the volume of water used as an input measure, the amount of waste generated as an undesirable output measure. We have revenue, net income, the volume of water recycled, and the amount of waste recycled as desirable output measures. We categorize energy consumption and GHG emissions as the climate-related environmental aspect because they are less tangible and related (Thompson Reuters, 2018). We calculate the climate-related environmental efficiency score, denoted as $\Phi^C_{k,t}$ by having energy used as an input measure, GHG emissions as an undesirable output measure. We still have revenue and net income as output measures. Table 2 summarizes each efficiency score's input and output measures, and Table 3 reports the descriptive statistics and the correlations of resulting efficiency scores.

The correlations between the total efficiency score and other scores show that operational efficiency and resource-related environmental efficiency play significant roles in determining total efficiency (0.388 with $p < 0.01$ between $\Phi^T_{k,t}$ and $\Phi^O_{k,t}$, 0.609 with $p < 0.01$ between $\Phi^T_{k,t}$ and $\Phi^R_{k,t}$, and 0.300 with $p < 0.01$ between $\Phi^T_{k,t}$ and $\Phi^C_{k,t}$). More importantly, the mean of the operational efficiency score ($\mu_{\Phi^O_{k,t}} = 0.814$) is greater than both the resource-related environmental efficiency score ($\mu_{\Phi^R_{k,t}} = 0.800$) and the climate-related environmental efficiency score ($\mu_{\Phi^C_{k,t}} = 0.359$), indicating that operational efficiency is generally greater than environmental efficiency and that resource-related environmental efficiency is greater than climate-related environmental efficiency in the consumer products industry.

We find some interesting examples and illustrate them in Figure 2. Figure 2i is Hormel Food, an American company that produces packaged and refrigerated foods. We observe that the company focused on its operational efficiency more than its environmental efficiency. It also weighted resource-related environmental efficiency more than its climate-related environmental efficiency. Figure 2ii is the Molson Coors brewing company, which mainly produces beers. The company balanced on its operational efficiency and its resource-related environmental efficiency. Nevertheless, the company does not focus on its climate-related environmental efficiency as its scores are consistently lower. We have Danone in Figure 2iii. Danone, a French food company, improved its environmental efficiency recently. It also managed to have its resource-related environmental efficiency better

TABLE 3 Descriptive statistics and correlations of DFF outcomes

		Mean	S.D.	Min	Max	1	2	3
1	Total efficiency score ($\Phi^{Ovr}_{k,t}$)	0.970	0.061	0.670	1.000			
2	Operational efficiency score ($\Phi^{Opr}_{k,t}$)	0.814	0.129	0.268	1.000	0.388***		
3	Resource-related environmental efficiency score ($\Phi^{Res}_{k,t}$)	0.799	0.318	0.001	1.000	0.609***	0.118***	
4	Climate-related environmental efficiency score ($\Phi^{Cli}_{k,t}$)	0.359	0.320	0.006	1.000	0.300***	0.361***	0.342***

*$p < 0.1$. **$p < 0.05$. ***$p < 0.01$.

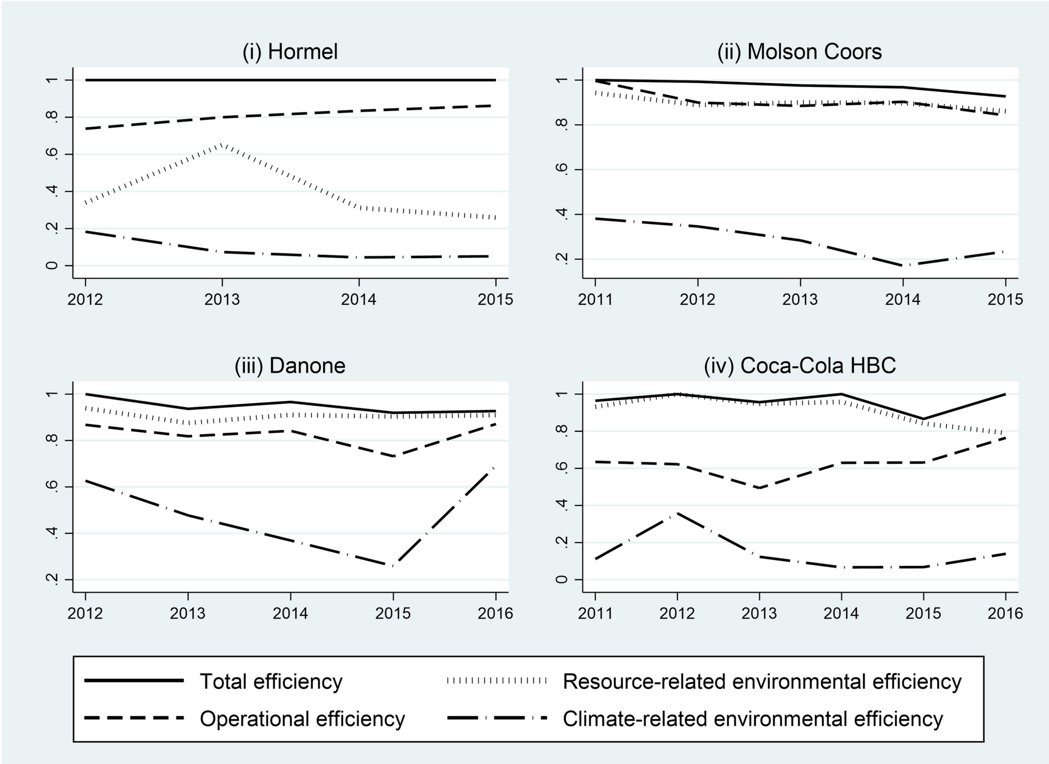


FIGURE 2 Examples of efficiency scores [Colour figure can be viewed at wileyonlinelibrary.com]

than its operational efficiency slightly and consistently. Lastly, Figure 2iv is Coke-Cola HBC, one of East Europe's major bottlers. The company improved its operational efficiency over time. The upward trend of its operational efficiency and the downward trend of resource-related environmental efficiency may also indicate managerial prioritization changes.

4 | VARIABLES AND EMPIRICAL APPROACH

We deploy a panel data approach to examine the implications of the efficiency differences empirically. In the following sections, we describe the construction of our key variables and discuss our empirical approach.

4.1 | Variables

4.1.1 | Independent variables

Difference between operational efficiency and environmental efficiency

We measure the difference between a firm's operational efficiency and its environmental efficiency by subtracting its resourced-related efficiency score from its operational efficiency score. A positive number indicates that a firm is more efficient operationally than environmentally. We further normalize the measure by its total efficiency score and denote the measure as $\Delta(Opr)_{k,t}$. Specifically, $\Delta(Opr)_{k,t} = \frac{\Phi^O_{k,t} - \Phi^R_{k,t}}{\Phi^T_{k,t}}$. The rationale of the normalization is to control for the heterogeneity of firms' total efficiency level because efficiency differences could be greater for firms having higher total efficiency scores.

Efficiency difference within environmental aspects

We measure the difference within environmental aspects by subtracting the climate-related environmental efficiency score from the resource-related environmental efficiency score. A positive number indicates that a firm is more efficient in the resource-related environmental aspect than the climate-related environmental aspect. We also normalize the measure by the total efficiency score and denote the measure as $\Delta(Env)_{k,t}$. Specifically, $\Delta(Env)_{k,t} = \frac{\Phi^R_{k,t} - \Phi^C_{k,t}}{\Phi^T_{k,t}}$.

4.1.2 | Dependent variables

Return of asset ($ROA_{k,t}$)

The literature has commonly used the return of asset (ROA) to indicate a firm's profitability and economic performance (Fujii, Iwata, Kaneko, & Managi, 2013; Jacobs et al., 2016; Lee & Lee, Cin, 2016; Minutolo, Kristjanpoller, & Stakeley, 2019). Guided by these prior studies, we measure it as the ratio of a firm's operating income before depreciation to its asset and use it to indicate firms' financial performance.

Altman Z ($AZ_{k,t}$)

Altman (1973) develops a *Z* score to quantify a company's internal financial health, using empirically estimated weights for multiple financial measures from the income statement and balance sheet. The score is popular in predicting the likelihood of a firm to go bankrupt (MacKie-Mason, 1990). Following the scholarly work of Gormley and Matsa (2011) and Jacobs et al. (2016), we calculate it as $AZ_{k,t} = 1.2\ x_1{+}1.4x_2{+}3.3x_3{+}0.6x_4{+}1.0x_5$, where x_1 is the ratio of working capital to assets, x_2 is the ratio of retained earnings to asset, x_3 is the ratio of interest and tax earnings to assets, x_4 is the ratio of market value to current liability, and x_5 is the ratio of sales to assets, and use this accounting-based score as a proxy for firms' business risk. Besides, a greater score indicates less risk in bankruptcy.

4.1.3 | Control variables

Operational efficiency score $\left(\Phi^{O}_{k,t}\right)$

A firm that operates efficiently should achieve better financial returns than a firm that operates inefficiently (İmrohoroğlu & Tüzel, 2014; Krasnikov & Jayachandran, 2008; Mouzas, 2006). To control for this effect, we include operational efficiency scores as a control in our models.

Firm size

Economies of scale may significantly influence firms' financial performance and environmental actions (e.g., King & Lenox, 2002; Russo & Fouts, 1997). To control for this effect, we use the natural logarithm of total assets reported as a proxy for the firms' size and incorporate it into our models.

Financial leverage

The extent of using financial leverage of a firm could affect its financial performance in multiple ways (Delmas, Etzion, & Nairn-Birch, 2013; Sharfman & Fernando, 2008). Therefore, we calculate the measure as the natural logarithm of the ratio of total assets to total common equity and include it in our models.

Growth rate

Following the suggestions of Russo and Fouts (1997), King and Lenox (2002), and Delmas et al. (2013), we control for the potential effect of changes in firms' businesses. We measure the yearly growth rate as the natural logarithm of the ratio of revenue of the year to the revenue the year before.

Capital intensity

Russo and Fouts (1997) and Delmas et al. (2013) find that capital intensity influences the relationship between environmental investment and financial performance. To control for this effect, we define the capital intensity as the natural logarithm of the ratio of assets to revenue and incorporate the measure into our models.

R&D intensity and advertising intensity

McWilliams and Siegel (2001) and Konar and Cohen (2001) suggest that firm-level R&D expenditures may affect the relationship between environmental and financial performance, whereas Russo and Fouts (1997) show that advertising expenditures influence the relationship. To control for these effects, we include R&D intensity (defined as the ratio of R&D expenditures to revenue) and advertising intensity (defined as the ratio of marketing and advertising expenditures to revenue) into our models.

Revenue percentage

Although firms in our sample primarily operate in the consumer products segment, many operate in multiple market segments. To control for the potential effect caused by the heterogeneity of market concentration, we incorporate the percentage of revenue a firm generated from the consumer products segment into our models.

Table 4 shows the descriptive statistics and the correlations of the key variables in our panel data models.

4.2 | Empirical approach

We pursue a panel data approach to examine the implications of efficiency differences on firms' financial performance and business risk. VIF test results suggest that multicollinearity is not a concern (Mean VIF is 1.74, and max VIF is 2.52 when ROA is the dependent variable, and the VIFs for our key independent variables are 2.04 and 2.18). Therefore, we incorporate the two independent variables into our models at the same time. One nature of our data is the low within-unit variances over time. The average within-firm variance of our independent variables is approximately 18% of their total variances, which could inflate estimators' variance and cause significant inefficiency in a firm-level fixed-effects model (Chen, 2017; Plümper & Troeger, 2007). Therefore, we employ the generalized least squares (GLS), random-effects estimator. The estimator also allows us to cluster standard errors by firm and control for panel-specific autocorrelation (Wooldridge, 2010). Further, we include year fixed effects to control for the effects of potential temporal events. We also incorporate sub-industry fixed effects to address unobserved heterogeneity across sub-industries. Last, we incorporate additional quadratic terms of our key independent variables to capture possible non-linear relationships because efficiency scores (and differences among them) are not linear measures. As a result, we specify the following models to test H1a and H1b simultaneously:

$$ROA_{k,t} = \beta_1\,\Delta(Opr)_{k,t} + \beta_2\,\Delta(Env)_{k,t} + \lambda_z Z_{k,t} + \mu_t + \gamma_j + \eta_k + \epsilon_{k,t}\ \text{and} \quad (10)$$

$$ROA_{k,t} = \beta_{11}\,\Delta(Opr)_{k,t} + \beta_{12}\,\Delta(Opr)^2_{k,t} + \beta_{21}\,\Delta(Env)_{k,t} + \beta_{22}\,\Delta(Env)^2_{k,t} + \lambda_z Z_{k,t} + \mu_t + \gamma_j + \eta_k + \epsilon_{k,t}. \quad (11)$$

μ_t is the year fixed effects, and γ_j is the sub-industry fixed effects. The error term consists of two components: (i) η_k, which captures the

TABLE 4 Descriptive statistics and correlations of key variables

		Mean	S.D.	Min	Max	1	2	3	4	5	6	7	8	9
1	Δ(*Opr*)	0.024	0.357	−0.668	0.975									
2	Δ(*Res*)	0.447	0.376	−0.829	0.979	−0.646***								
3	Operational efficiency score	0.814	0.129	0.268	1.000	0.239***	−0.233***							
4	Firm size	8.286	1.523	4.579	11.879	0.022	−0.319***	0.352***						
5	Revenue %	78.186	30.897	0.129	100.000	0.081*	−0.064	0.216***	0.071*					
6	Leverage	0.824	0.448	0.146	3.059	0.089**	−0.147***	0.135***	0.271***	0.041				
7	Growth rate	0.002	0.101	−0.292	0.701	−0.073*	−0.061	−0.013	0.031	−0.009	0.030			
8	Capital intensity	0.004	0.503	−1.538	2.106	0.063	−0.164***	0.101**	0.468***	−0.109***	−0.028	0.032		
9	R&D intensity	−6.838	5.055	−19.183	−1.820	−0.001	−0.001	0.168***	−0.030	−0.066	−0.077*	−0.060	−0.107**	
10	Advertising intensity	−6.814	7.069	−20.525	−0.831	−0.001	−0.110***	0.046	0.198***	0.173***	−0.113***	0.007	0.207***	−0.024

*$p < 0.1$. **$p < 0.05$. ***$p < 0.01$.

firm-specific random effects, and (ii) $\epsilon_{k,t}$, which shows the idiosyncratic errors. A negative coefficient for the independent variables (β_1 or β_2) or for their quadratic terms (β_{12} or β_{22}) will support H1a or H1b. Similarly, we specify the following models to test H2a and H2b:

$$AZ_{k,t} = \beta_3\,\Delta(Opr)_{k,t} + \beta_4\,\Delta(Env)_{k,t} + \lambda_z Z_{k,t} + \mu_t + \gamma_j + \eta_k + \epsilon_{k,t} \text{ and} \quad (12)$$

$$AZ_{k,t} = \beta_{31}\,\Delta(Opr)_{k,t} + \beta_{32}\,\Delta(Opr)^2{}_{k,t} + \beta_{41}\,\Delta(Env)_{k,t} + \beta_{42}\,\Delta(Env)^2_{k,t} + \lambda_z Z_{k,t} + \mu_t + \gamma_j + \eta_k + \epsilon_{k,t}. \quad (13)$$

As a greater Altman *Z* score indicates lower bankrupt risk, a negative coefficient for the independent variables (β_3 or β_4) or for their quadratic terms (β_{32} or β_{32}) will support H2a or H2b.

5 | RESULTS

We present the results of these models in Table 5. Models 1–1 and 2–1 represent the results of Equations 10 and 11 with the control variables only. Notably, we find that greater market concentration in the consumer products industry links to better financial performance and lower business risk. Besides, we note that firms' size and growth rate are positively associated with their financial performance. They are also negatively associated with firms' business risk.

Model 1–2 represents the results of Equation 10. The difference between operational efficiency and environmental efficiency, $\Delta(Opr)_{k,t}$, is positively associated with ROA ($\beta_1 = 0.444$), but the relationship is not statistically significant ($p = 0.170$). The difference between resource-related environmental efficiency and climate-related environmental efficiency, $\Delta(Env)_{k,t}$, is negatively associated with ROA ($\beta_1 = -0.843$), and the relationship is statistically significant ($p = 0.012$). The results support H1b but not H1a.

Model 1–3 represents the results of Equation 11, which incorporates the quadratic efficiency differences to capture the potential non-linear relationship. The results highlight that the relationship between $\Delta(Opr)_{k,t}$ and ROA is in an inverted-U shape ($\beta_{11} = 2.279$ with $p < 0.001$ and $\beta_{12} = -3.689$ with $p < 0.001$) with a critical point at $-\frac{\beta_{11}}{2\beta_{12}} = 0.336$. The finding suggests that the effect of the difference on ROA is negative when $\Delta(Opr)_{k,t}$ is away from 0.336 (instead of 0). Hence, we find partial support for H1a and illustrate the relationship in Figure 3. Besides, the results do not support a non-linear relationship between $\Delta(Env)_{k,t}$ and ROA.

Model 2–2 represents the results of Equation 12, and $\Delta(Opr)_{k,t}$ is negatively associated with Altman Z ($\beta_3 = -0.451$ with $p = 0.002$). As a greater Altman *Z* score indicates lower bankrupt risk, the result indicating that a firm with a greater difference between its operational efficiency, and its environmental efficiency is associated with greater business risk and support H2a. $\Delta(Env)_{k,t}$ is also negatively associated with Altman *Z* ($\beta_4 = -0.969$ with $p < 0.001$), supporting H2b as well. Model 2–3 represents the results of Equation 13. They offer continuous support for H2a and H2b ($\beta_{31} = 0.341$ with $p = 0.205$, $\beta_{32} = -1.523$ with $p < 0.001$, $\beta_{41} = -0.923$ with $p = 0.001$, $\beta_{42} = -0.216$ with

TABLE 5 Main results

Variables	Model 1–1 ROA	Model 1–2 ROA	Model 1–3 ROA	Model 2–1 Altman Z	Model 2–2 Altman Z	Model 2–3 Altman Z
Δ(*Opr*)		0.444 (0.323)	2.279*** (0.476)		−0.451*** (0.147)	0.341 (0.269)
Δ(*Opr*)^2			−3.689*** (0.750)			−1.523*** (0.388)
Δ(*Env*)		−0.843** (0.335)	−0.730 (0.607)		−0.969*** (0.143)	−0.923*** (0.285)
Δ(*Env*)^2			−0.287 (0.639)			−0.216 (0.311)
Operational efficiency score	5.508*** (0.629)	4.842*** (0.699)	2.202** (0.882)	2.628*** (0.299)	2.379*** (0.320)	0.941** (0.460)
Firm size	0.448*** (0.062)	0.427*** (0.071)	0.448*** (0.073)	0.209*** (0.027)	0.142*** (0.029)	0.168*** (0.033)
Revenue %	0.013*** (0.004)	0.011*** (0.004)	0.014*** (0.004)	0.011*** (0.002)	0.011*** (0.002)	0.010*** (0.002)
Financial leverage	−0.078 (0.175)	−0.326 (0.210)	−0.228 (0.191)	−1.615*** (0.084)	−1.811*** (0.085)	−1.755*** (0.087)
Growth rate	3.302*** (0.708)	2.534*** (0.710)	2.571*** (0.776)	1.589*** (0.333)	1.458*** (0.316)	1.466*** (0.328)
Capital intensity	−0.306 (0.195)	−0.665*** (0.171)	−0.542*** (0.191)	−0.227** (0.088)	−0.213** (0.083)	−0.184* (0.096)
R&D intensity	−0.064*** (0.022)	−0.038 (0.023)	−0.060*** (0.021)	−0.024*** (0.009)	−0.025*** (0.008)	−0.028*** (0.008)
Advertising intensity	−0.004 (0.013)	−0.021 (0.013)	−0.017 (0.014)	0.000 (0.006)	−0.004 (0.006)	−0.012* (0.006)
Observations	563	563	563	561	561	561
χ^2	3,137	3,864	3,122	7,841	5,985	7,250

Note. Standard errors in parentheses. Year dummies are omitted for brevity. *$p < 0.1$. **$p < 0.05$. ***$p < 0.01$.

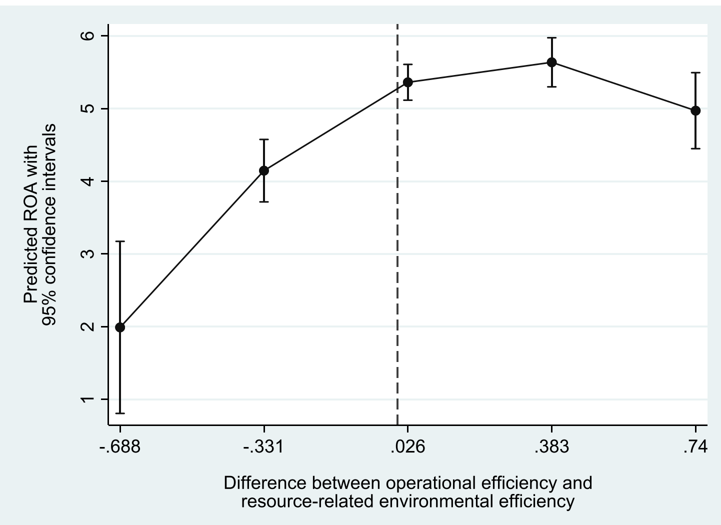


FIGURE 3 Predicted ROA in the difference between operational efficiency and environmental efficiency.
Note: to illustrate the relationships, we use the results from Models 1–3 and set the difference between operational efficiency and resource-related environmental efficiency at its mean (i.e., $\mu_{\Delta(Opr)}$ = 0.026), at one standard deviation above and below its mean (i.e., $\mu_{P(Opr)} \pm \sigma_{P(Opr)}$, where $\sigma_{P(Opr)}$ = 0.357), and at two standard deviations above and below its means (i.e., $\mu_{P(Opr)} \pm 2\sigma_{P(Opr)}$). All other parameters are at their mean. Additionally, the dashed line is where the difference is zero; that is, the operational efficiency equals the resource-related environmental efficiency [Colour figure can be viewed at wileyonlinelibrary.com]

p = 486). Subtly, the results also suggest that the relationship between $\Delta(Opr)_{k,t}$ and Altman *Z* score is non-linear, and the relationship between $\Delta(Env)_{k,t}$ and Altman Z is linear.

In sum, we find partial support for H1a as the effect of the operational and environmental efficiency difference is negative when the difference deviates away from a critical point. Also, we find empirical evidence supporting H1b, H2a, and H2b.

5.1 | Robustness checks

We examine the robustness of the main results by using market-based measures as alternative dependent variables (i.e., Tobin's *q* and the cost of equity), incorporating additional explanatory variables, and employing alternate independent variables. Our findings are robust to these checks. For brevity, we describe them in detail in the appendix.

6 | DISCUSSION

Our DDF analysis outcomes show firms are more efficient operationally as expected. Also, firms are more efficient in the resource-related environmental aspect than in the climate-related environmental aspect. Our panel data analysis results offer support for our hypotheses, suggesting that the efficiency difference harms firms' financial performance and business risk in general. Although we obtain the coefficients of these efficiency differences, we retrain from interpreting their magnitude on financial performance and business risk because the efficiency scores and their differences are not linear measures.

Our results offer less direct support for H1a, and Figure 3 highlights that the relationship between the operational and environmental efficiency difference and financial performance has a positive critical point. That is, managers should manage their operational efficiency slightly greater than environmental efficiency to obtain the optimal effect of sustainable development. We also refrain from predicting the critical point's exact value as the efficiency difference is not a linear measure.

Our study contributes to the environmental strategy and sustainability development literature in several aspects. First, the adverse effect of efficiency difference on firms' financial performance offers empirical evidence for the extended good management theory and stakeholder theory. A well-managed company should achieve operational excellence and address environmental concerns broadly and evenly. The finding also offers support for the portfolio management argument. Because of knowledge accumulation and risk hedging, maintaining a balanced portfolio addressing multiple environmental concerns enhances firms' overall performance. Second, our results show that the effects of efficiency differences on firms' business risk are material, supporting the notion that risk management motivates sustainable development. The finding also suggests that risk hedging is the underlying mechanism and lends additional support for the portfolio management argument, providing a more complete picture to the literature.

Although not hypothesized upon, we find that the relationship between the operational and environmental efficiency difference and financial performance is in an inverted-U shape. We offer two possible explanations for the non-linear relationship. First, the finding supports a stream of literature interested in a phenomenon called "low hanging fruit." This literature stream suggests that profitable environmental efforts exist initially, expects that the increasing costs and diminishing returns of environmental efforts will make additional environment efforts less favorable as environmental performance advances, and has predicted that the relationship between environmental performance and financial performance is non-linear (Schaltegger & Synnestvedt, 2002; Walley & Whitehead, 1994). From an empirical standpoint, Wagner (2005) finds support for an inverted U-shaped relationship in the European paper industry, and Fujii et al. (2013) finds support in the Japanese manufacturing firms. Our study offers additional empirical evidence from the global consumer product industry for this stream.

The other explanation relates to the classic trade-off effect, asserted in the manufacturing and operations strategy literature (Rosenzweig & Easton, 2010; Skinner, 1969). Scholars have proposed the theory of performance frontier and suggested that when firms perform close to the performance frontier, the competitive nature makes the law of trade-offs more significant than the law of cumulative capabilities (Schmenner & Swink 1998; Vastag, 2000). The trade-off effect merges in the interaction between operational efficiency and environmental efficiency as firms in the industry have achieved excellent efficiency in these aspects (e.g., Molson Coors, Danone, and Coca-Cola HBC in Figure 2).

Last, the critical point of the inverted-U shape relationship is based on the difference between environmental efficiency and operational efficiency, highlighting the crucial role of operational efficiency in the environmental strategy literature. The finding also shed light on a not-yet-addressed research question: "how good is good enough?" The finding suggests that it is optimal to have operational efficiency slightly greater than environmental efficiency and that environmental efficiency should not be too close or surpass operational efficiency. This question certainly warrants a future research avenue.

Our study offers new insights for managers managing multiple sustainable development initiatives. Leveraging the strength of DDF, we demonstrate that firms can evaluate their performance without knowing the managerial weights of key performance indicators and their shadow prices explicitly. Although one of the common critics of the approach is that results may be difficult to interpret and challenging to link to trackable managerial actions, our outcomes are intuitive and provide valuable benchmarks. Managers can evaluate their relative performance across multiple environmental and societal aspects and better understand their strategic position.

More importantly, our study helps managers facing challenges related to increasing environmental awareness and societal concerns while working with limited resources. Our findings suggest that firms benefit from minimizing the performance difference in multiple environmental and societal aspects, rather than allocating resources to a specific environmental aspect and improving its performance narrowly. That is, when managers manage multiple aspects together, they should evaluate their current performance and attentively maintain a balanced portfolio. Additionally, they should be mindful of diminishing returns in future sustainable development and potential trade-offs between operational performance and environmental and societal performance.

We recognize several limitations in our study. Because efficiency measures are difficult to compare (Baily et al., 1995) and the perception of environmental concerns vary significantly across industries, our study only focuses on the consumer products industry to ensure that assessing the impact of environmental issues is consistent among our sample firms. Although investigating differences in environmental assessments across industries is challenging, findings can benefit policymakers and non-governmental environmental planners in tailoring their policies or programs. Therefore, this limitation could be a greater undertaking and lead to a new research direction. Also, the dichotomous categorization of environmental aspects in our study aims to simplify our analyses and obtain parsimonious insights. Managers may expand the categorization for their strategic evaluation in practice. Further, several studies in the literature have examined the direction of causality between CSR performance and financial performance and suggested a "virtuous circle"; that is, the causation is supported in both directions (Orlitzky, Schmidt, & Rynes, 2003; Waddock & Graves, 1997). Although our empirical approach is limited in addressing the causality concern, we achieve our research objectives and gain managerial insights, and the results of our robustness tests with alternative dependent and independent variables should alleviate the concern of endogeneity.

Notwithstanding these limitations, our findings are robust. Our study examines the relationship between environmental performance and firm performance from a new angle. It contributes to the literature by offering theoretical support for the balanced portfolio approach in managing multiple environmental concerns with empirical evidence. The study findings also provide managerial guidelines for decision-making in sustainable development. In sum, managing multiple environmental and societal concerns is an art of balance. To gain a greater benefit, managers should aim to minimize the performance difference within multiple environmental aspects and manage a subtle balance between operational performance and environmental performance.

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APPENDIX A: ROBUSTNESS CHECKS

We examine the robustness of our findings using alternative dependent variables and incorporating additional explanatory variables. We also conduct additional tests using alternative independent variables and other model specifications. We describe the approach and report the results of these robustness tests in the following sections.

A.1 | Alternative dependent variables

Orlitzky et al. (2003) find that the connection between CSR performance and financial performance is weaker when dependent variables are marketing-based measures. Accordingly, we alternate our dependent variables with market-based measures. To represent firms' financial performance, we also use Tobin's *q*, which is regarded as a more appropriate measure to capture intangible firm value because it shows the ratio of the firm's market value to its replacement cost (Minutolo et al., 2019). Specifically, it is calculated as $\frac{x_1+x_2+x_3}{x_4}$, where x_1 is the share price multiplied by the number of common shares outstanding; x_2 is the liquidation value of outstanding preferred stock; x_3 is the sum of the book value of inventories, long-term debt, and current liability less current assets; and x_4 is the book value of total assets. We also employ the cost of equity as the alternative to Altman *Z* (Sharfman & Fernando, 2008). The cost of equity is based on the capital asset pricing model (Sharpe, 1964) and is calculated as $x_1+\beta x_2$, where $x_1$is the risk-free interest rate of a firm's country, β is the firm's stock market beta coefficient, and x_2 is the risk premium of the country. The results of the models incorporating these variables are reported in Table A1. We still find the inverted-U shape relationship between $\Delta(Opr)_{k,t}$ and Tobin's *q*, as in our main result. We also find support for H1b when assuming the relationship is nonlinear. We find support for H2b but not H2a because of statistical insignificance.

A.2 | Additional explanatory variables

Jacobs et al. (2016) show that operational performance and CSR performance complement each other in relation to financial performance and bankruptcy risk. To examine and control for this complement effect, we calculate firms' overall environmental efficiency score by including all environmental-related measures. Following the Russo and Fouts (1997) approach, we incorporate the overall environmental score efficiency score and the interaction term of the demeaning operational efficiency score and the demeaning overall environmental efficiency score into our models. The results are reported in Table A2. The coefficients of the interaction term are mostly positive, but many are statistically insignificant, failing to provide support for the positive complementary effect between operational efficiency and environmental efficiency. More importantly, the results continuously offer support for our main findings (i.e., they show the inverted-U shape relationship and support H1b, H2a, and H2b continuously).

A.3 | Alternative independent variables

We use the difference between the operational efficiency score and the overall environmental efficiency score obtained in the previous section and denote it as Δ(*aOpr*). We also use the range of environmental efficiency scores and denote it as Δ(*aEnv*). The results of the corresponding models incorporating these alternative independent variables are in Table A3. Overall, our findings largely hold.

TABLE A1 Alternative dependent variables

Variables	Tobin's *q*	Tobin's *q*	Tobin's *q*	Cost of equity	Cost of equity	Cost of equity
Δ(*Opr*)		0.088 (0.060)	0.431*** (0.097)		0.246 (0.263)	0.281 (0.409)
$\Delta(Opr)^2$			−0.689*** (0.151)			−0.306 (0.603)
Δ(*Env*)		−0.075 (0.063)	−0.284***(0.122)		0.685** (0.279)	−0.137 (0.506)
$\Delta\,(Env)^2$			0.160 (0.120)			0.983* (0.517)
Operational efficiency score	0.707*** (0.124)	0.563*** (0.129)	0.155 (0.177)	−1.402** (0.548)	−1.561*** (0.560)	−1.630** (0.728)
Firm size	0.069*** (0.011)	0.071*** (0.012)	0.075*** (0.012)	0.190*** (0.059)	0.227*** (0.060)	0.220*** (0.060)
Revenue %	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.005 (0.004)	0.004 (0.004)	0.003 (0.004)
Financial leverage	0.289*** (0.129)	0.340*** (0.122)	0.308*** (0.139)	0.857*** (0.640)	0.955*** (0.643)	0.973*** (0.671)
Capital intensity	0.100** (0.042)	0.094** (0.040)	0.040 (0.044)	−0.152 (0.170)	−0.081 (0.176)	−0.084 (0.173)
R&D intensity	−0.024*** (0.003)	−0.022*** (0.004)	−0.025*** (0.004)	−0.078*** (0.017)	−0.072*** (0.017)	−0.079*** (0.017)
Advertising intensity	0.002 (0.002)	0.001 (0.002)	−0.002 (0.002)	0.013 (0.009)	0.016* (0.009)	0.018* (0.009)
Observations	561	561	561	563	563	563
χ^2	2,397	2,670	2,373	1,294	1,326	1,339

Note. Standard errors in parentheses. Year dummies are omitted for brevity. *$p < 0.10$. **$p < 0.05$. ***$p < 0.01$.

TABLE A2 Overall environmental efficiency and its interaction with operational efficiency as additional explanatory variables

Variables	ROA	ROA	ROA	Altman Z	Altman Z	Altman Z
$\Delta(Opr)$		−0.834 (0.701)	1.411** (0.709)		−0.597* (0.351)	0.196 (0.475)
$\Delta(Opr)^2$			−4.960*** (0.804)			−1.551*** (0.464)
$\Delta(Env)$		−0.831** (0.359)	−1.862*** (0.677)		−0.910*** (0.149)	−0.946*** (0.320)
$\Delta(Env)^2$			0.521 (0.674)			−0.112 (0.340)
Operational efficiency score	6.396*** (0.612)	6.235*** (0.915)	2.658*** (0.966)	2.741*** (0.298)	2.752*** (0.451)	1.118* (0.607)
Overall environmental efficiency score	−1.451*** (0.276)	−1.683** (0.812)	−1.957** (0.774)	−0.185 (0.126)	−0.180 (0.422)	−0.227 (0.489)
Overall environmental efficiency score × operational efficiency score	2.509 (2.151)	0.977 (2.349)	−7.654*** (2.452)	3.316*** (0.812)	1.600** (0.772)	0.006 (1.353)
Firm size	0.458*** (0.062)	0.435*** (0.072)	0.466*** (0.072)	0.177*** (0.024)	0.123*** (0.027)	0.173*** (0.034)
Revenue %	0.011*** (0.004)	0.010*** (0.004)	0.014*** (0.004)	0.009*** (0.002)	0.010*** (0.002)	0.010*** (0.002)
Financial leverage	−0.171 (0.140)	−0.388* (0.222)	−0.252 (0.182)	−1.676*** (0.086)	−1.820*** (0.086)	−1.764*** (0.088)
Growth rate	2.687*** (0.678)	2.565*** (0.716)	2.187*** (0.783)	1.669*** (0.324)	1.538*** (0.315)	1.394*** (0.338)
Capital intensity	−0.722*** (0.146)	−0.714*** (0.168)	0.570*** (0.184)	−0.171** (0.081)	−0.164** (0.079)	−0.172* (0.099)
R&D intensity	−0.042* (0.024)	−0.036 (0.025)	−0.060*** (0.021)	−0.023*** (0.009)	−0.026*** (0.009)	−0.027*** (0.009)
Advertising intensity	−0.017 (0.013)	−0.021 (0.014)	−0.015 (0.013)	−0.003 (0.006)	−0.006 (0.006)	−0.011* (0.006)
Observations	563	563	563	561	561	561
χ^2	4,871	3,447	3,154	8,176	5,295	5,053

Note. Standard errors in parentheses. Year dummies are omitted for brevity. *p < 0.10. **p < 0.05. ***p < 0.01.

TABLE A3 Alternative independent variables

Variables	ROA	ROA	Altman Z	Altman Z
$\Delta(aOpr)$	0.717* (0.340)	1.896** (0.513)	−0.405** (0.157)	−0.036 (0.222)
$\Delta(aOpr)^2$		−2.713** (0.992)		−0.884* (0.396)
$\Delta(aEnv)$	−1.119** (0.325)	−4.954** (1.024)	−1.003** (0.142)	−2.877** (0.416)
$\Delta(aEnv)^2$		4.474** (1.006)		2.077** (0.424)
Operational efficiency score	4.645** (0.731)	2.812** (0.940)	2.271** (0.329)	1.891** (0.352)
Firm size	0.426** (0.070)	0.428** (0.072)	0.148** (0.029)	0.097** (0.026)
Revenue %	0.011** (0.004)	0.006 (0.004)	0.010** (0.002)	0.007** (0.002)
Financial leverage	−0.396* (0.197)	−0.364 (0.219)	−1.820** (0.086)	−1.729** (0.089)
Growth rate	2.574** (0.731)	2.774** (0.785)	1.444** (0.321)	1.297** (0.339)
Capital intensity	−0.709** (0.168)	−0.785** (0.171)	−0.261** (0.084)	−0.268** (0.083)
R&D intensity	−0.044 (0.024)	−0.057* (0.024)	−0.027** (0.008)	−0.033** (0.008)
Advertising intensity	−0.024 (0.013)	−0.024 (0.013)	−0.005 (0.006)	−0.000 (0.006)
Observations	563	563	561	561
χ^2	2,782	3,258	8,997	10,378

Note. Standard errors in parentheses; Year dummies are omitted for brevity. *p < 0.10. **p < 0.05. ***p < 0.01.

A.4 | Additional robustness checks

Our main results remain consistent if we incorporate country-level fixed effects by firms' primary equity trading market, if we use the number of employees instead of total assets as a measure of firm size, and if we substitute the operational efficiency score with the overall efficiency score. Moreover, our results are largely unchanged if we use leaped dependent variables, that is, $ROA_{k,t+1}$ and $AZ_{k,t+1}$. The tables summarizing the results of these additional tests are excluded for brevity.