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論　文

An Empirical Study on the Relationship between the Application of MFCA, SBSC, Eco-efficiency and Financial Performance: Verification of Financial Data of Listed Manufacturing Companies in China

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Abstract

In previous studies, the possibility and effectiveness of the integration of MFCA, SBSC and eco-efficiency have been theoretically examined to play their respective roles more effectively. However, few of these previous researches have verified the economic improvement effects of MFCA, SBSC and eco-efficiency as environmental management tools using specific financial indicators. Furthermore, there is no research that verifies the relationship between the use of these three tools and financial performance by objective indicators rather than subjective judgment. In this study, we used objective indicators such as ROA, ROE, ROS and Tobin's q of the Chinese manufacturing companies to examine the relationship between the use of MFCA, SBSC and eco-efficiency and financial performance through multiple regression analysis. The results verified that only the use of MFCA has a positive effect on ROE. From the result, we can infer that the use of MFCA is likely to improve financial performance.

Keywords

MFCA, SBSC, eco-efficiency, financial performance, relationship

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1. Introduction

In recent years, global environmental problems have become more and more prominent, and companies have been working on sustainability activities to reduce the environmental load caused by production activities. It is becoming a trend that companies implement environmental management for simultaneously improving economic and environmental benefits. For this reason, companies have developed and used various environment-conscious management tools to maximize economic profits and minimize industrial pollution simultaneously.

MFCA, SBSC and eco-efficiency are such environment-conscious management tools. MFCA (Material Flow Cost Accounting) is an environment-conscious cost analysis and calculation tool, SBSC (Sustainability Balanced Scorecard) is a long-term and comprehensive performance evaluation and strategy formulation system with an environmental perspective, and eco-efficiency is an indicator measuring resource-use and the impact of economic activities on the environment. These three tools play a role in each area to support corporate environmental management (Meng, 2020: 202).

The theory and case studies of these three environmentally conscious management tools have been progressing mainly in Europe for about 20 years (The periods when these three tools were developed and applied are as follows: MFCA was in the late 1990s, SBSC was around 2000, eco-efficiency was in the first half of the 1990s). In previous studies, although the role of these three tools for achieving both environmental sustainability and economic growth has been acknowledged (we will introduce these three tools in detail in Section 2), the following problems have also been pointed out.

Regarding MFCA, two problems that MFCA has communication barriers between management and on-site works (Doorasamy, 2015: 43) and companies tend to underestimate the environmental conservation effect because of positioning MFCA as a cost-reduction method so that the promotion of MFCA will be hindered (Ito, 2009: 36; Kokubu, 2018: 95) have been pointed out. Regarding SBSC, it is difficult to link new perspectives and indicators of environment and society to the four traditional perspectives and their indicators when constructing the SBSC framework, and even the construction of the causal relationship between them is also complicated (Oka, 2010: 97). Regarding eco-efficiency, it has a problem that even if the environmental performance index deteriorates, the eco-efficiency index will improve in the eco-efficiency formula if the economic performance index improves (Oka, 2010: 97). These problems are considered to be factors that hinder the promotion of environmental management by companies.

In previous studies, MFCA, SBSC and eco-efficiency are all considered as tools for simultaneously seeking economic growth and environmental sustainability, and theoretically demonstrated the feasibility and effectiveness of their integration. However, there are few empirical studies to examine specific financial indicators as economic performance indicators about the application of the three tools, and no study examines the relationship between financial performance and the simultaneous use of two or three tools. This study will verify the financial effects of MFCA, SBSC and eco-efficiency as environmentally-friendly management tools when used alone and simultaneously using hypothesis-testing. In this study, we will select ROA, ROE, ROS and Tobin's q that are often used in empirical research on the relationship between environmental management and corporate performance as financial indicators for testing.

This study is divided into two stages. The first stage is to introduce previous studies. We will introduce

the previous studies that discussed the economic effects of MFCA, SBSC, eco-efficiency and examined the relationship between environmental management and corporate financial performance. Besides, based on these previous studies, we will submit a hypothesis that the use of MFCA, SBSC and eco-efficiency (including the simultaneous use) will lead to improving financial performance. The second stage is to verify the proposed hypothesis. We will use multiple regression analysis to test whether the use of MFCA, SBSC and eco-efficiency alone or simultaneously will have an impact on financial performance.

This study could help us to clarify whether the use of MFCA, SBSC and eco-efficiency, which are used as environmental management tools, has an impact on the companies' financial performance. We are looking forward to this study as a reference for promoting environmental management.

2. Literature Review and Hypothesis Development

When companies implement environmental management, it is important to consider the environmental aspects and improve economic efficiency at the same time in order to achieve a balance between economy and environmental sustainability. The effectiveness of MFCA, SBSC and eco-efficiency has been discussed theoretically as tools for environmental management, but empirical research on economic effects has been scarce.

MFCA is an environmental management accounting method developed in Germany where environmental accounting is thriving. It tracks the flow and stock of raw materials and energy input to the product manufacturing process to calculate and analyze costs not only of non-defective products but also of losses (Nakajima and Kokubu, 2002: 52–71). Companies seek to simultaneously achieve the economic improvement effect of cost reduction and the environmental conservation effects of waste reduction by implementing MFCA (Kokubu, 2018: 10). MFCA, which was internationally standardized as ISO14051 (MFCA) in 2011 led by Japan, has been attracting attention around the world, and many case studies were introduced in the "MFCA case examples" (METI, 2011). In the "MFCA case examples", the economic benefits after the introduction of MFCA, such as loss costs reduction, improvement and reform of the manufacturing processes, effective use of resources, improvement of production efficiency, and improvement of quality are highly evaluated by enterprises (METI, 2011: 1–54). For example, Tanabe Seiyaku at that time (currently, Mitsubishi Tanabe Pharma Corporation) introduced MFCA into the Onoda Plant's pharmaceutical production line (synthesis → purification → drug substance → weighing → formulation → packaging) and then revealed that the costs of waste in the synthesis process and the material loss in the pharmaceutical process were very high. Since then, Tanabe Seiyaku has achieved an economic effect of about 54 million yen per year (of which energy saving effect of about 33 million yen per year) through capital investment, changes in manufacturing methods, and improvements in waste disposal methods (METI, 2011: 21).

As is well known, the SBSC is a system that adds environmental and social elements to the financial, customer, internal business processes, learning and growth perspectives of the traditional BSC (Balanced Scorecard) in order to comprehensively evaluate corporate sustainability activities focused on sustainable development (Oka, 2010: 93). By using the strategy map simultaneously, it also functions as a manage-

ment system that ensures the vision and strategy for sustainability are formulated and executed effectively and efficiently (Oka, 2010: 93). The BSC (SBSC) build a causal chain by linking the perspectives and indicators through a strategy map and then make it easier for all employees to act in order to achieve corporate economic and environmental goals (Kaplan and Norton, translated by Yoshikawa, 2011: 67). In other words, the SBSC framework connects the financial perspective (profit) at the top with the non-financial perspective (cost) at the subordinate level, and the cost of investing in the non-financial perspective is a sacrifice to improve the financial perspective (profit) from a medium to long-term perspective (Oka, 2011: 87). The application of SBSC can link non-financial goals with financial gains. Oka and Nishitani (2015: 1–15) built a carbon SBSC framework aimed at improving ROC (Return On Carbon) with accounting profit as the numerator and CO_2 emissions as the denominator, and clarified the effectiveness of the carbon SBSC framework and the possibility that SBSC achieves economic growth and environmental sustainability simultaneously.

Eco-efficiency is an indicator of the idea of minimizing harmful environmental impacts while maximizing the value of products and services (Oka, 2010: 95). The WBCSD (2000: 3) defines the formula as "eco-efficiency = product or service value divided by environmental influence". In other words, the purpose of eco-efficiency is to improve the value of products or services while reducing its impact on the environment. DeSimone, Popoff, with the WBCSD (2000: 24–25) argue that the financial benefits of eco-efficiency are "benefits from reducing the current costs of poor environmental performance, benefits from reducing potential future costs of poor environmental performance, reduced costs of capital, benefits from increased market share and improved or protected market opportunities, benefits from enhanced image". Eco-efficiency can express the situation of corporate environmental management as an indicator comparing economic performance and environmental performance. Chen (2014: 39–44) considers the situation of the environmental management of Baoshan Iron & Steel Co., Ltd. (Baoshan Steel) using eco-efficiency. Specifically, Chen used the three eco-efficiency indicators of resource efficiency = material input/sales, energy efficiency = energy input/sales, and environmental efficiency = environmental impact/sales to determine the status and the changes of Baoshan Steel's eco-efficiency. Here, it was found that the smaller the value of each indicator of eco-efficiency, the higher the sales and the less environmental impact. As a result, each indicator showing Baoshan Steel's eco-efficiency tends to gradually decrease every year, indicating that sales per unit have less and less impact on the environment. The numerical values using the calculations of these three indicators could also be used to find and improve inefficiencies on material, energy, and environmental aspects (Chen, 2014: 39–44).

Thus, they were clarified that MFCA has the economic effect of reducing losses and improving the production process associated with the discovery of losses, SBSC has the effectiveness of establishing a framework to improve accounting benefits while reducing environmental impact, and eco-efficiency could reveal the situation of corporate environmental management by calculating the ratio of economic indicators to environmental indicators.

However, recently, there was a tone that the respective problems of MFCA, SBSC and eco-efficiency hinder the environmental management of companies (introduced in Section 1). In order to improve these issues and more effectively improve their environmental and economic performance, the previous researches on the integration of these three are discussed as follows:

Möller and Schaltegger (2005) regard eco-efficiency analysis as a link between the SBSC and corporate environmental accounting system, such as an adapter with two interfaces, and discuss the relationship between the SBSC, environmental information system and eco-efficiency analysis. Oka (2010) argues that the integration of the SBSC and eco-efficiency could improve the issues of the SBSC and eco-efficiency and ultimately achieve a balance between the environment and the economy. Oka (2011) considers the possibility of evaluating and managing corporate performance by providing MFCA information to the SBSC and linking financial and non-financial perspectives. Zhang and Li (2014) propose the issues of establishing a new MFCA calculation model and regard the integration of the MFCA and eco-efficiency will solve the issues in the construction of the new calculation model. Seki and Anjo (2016) discuss ways to link MFCA activities and information to each SBSC perspective for promoting the continued introduction of MFCA. Meng (2020) argues that if MFCA is integrated with SBSC, the two problems of MFCA, the problem of communication barriers between production management and on-site works and the problem that companies tend to underestimate the environmental conservation effect and pay too much attention to cost reduction effects, can be improved. Also, based on the above-mentioned previous studies, Meng (2020) conducted a questionnaire survey of Chinese manufacturing companies to verify whether there is a financial effect when using MFCA, SBSC, eco-efficiency. The result showed that the companies using MFCA, SBSC and eco-efficiency alone or those using all three of them considered that their financial performance had been improved due to using the tools.

Thus, in recent years, it has been argued that there are the feasibility and financial effect of the integration of the three environmental management tools of MFCA, SBSC and eco-efficiency. However, few of these previous researches have verified the economic improvement effects of MFCA, SBSC and eco-efficiency as environmental management tools using specific financial indicators. Furthermore, there is no research that verifies the relationship between the use of these three tools (including the simultaneous use) and financial performance by objective indicators rather than subjective judgment.

Therefore, in this study, in order to verify whether the use of MFCA, SBSC and eco-efficiency as environmental management tools have an impact on financial performance, we refer to the following studies to select objective financial performance indicators.

Jaggi and Freedman (1992) provide weak evidence that firms with good pollution performance are not being viewed positively by the market because of the negative association between pollution and economic performance in the short period by analyzing the relationship between water pollution index and financial performance indicators of ROA, ROE, Price-Earnings ratio. Hart and Ahuja (1996) perform a multiple regression analysis using data of 127 US firms and find that there is a positive correlation between emissions reduction and financial performance indicators of ROA, ROE and ROS (Return On Sales) within one to two years after initiation. The authors also reveal that those firms with the highest emission levels stand the most to gain. Russo and Fouts (1997) find that there is a significant correlation between environmental performance (based on compliance records, abatement expenditures, support for environmental NGOs, and other factors) and economic performance based on an analysis of 243 US firms using ROA as a financial performance indicator. Ohzono (2011) demonstrates that sales and ROE have no significant effect on CSR activities, and operating profit has a negative impact on the environmental protection measures scores in CSR activities by conducting empirical analysis using the cross-sectional data from 378 firms in

Japan. Iwata and Okada (2011) establish that waste emissions do not generally have significant effects on financial performance, and greenhouse gas reduction leads to an increase in financial performance in the whole sample and clean industries by analyzing the data of Japanese manufacturing firms from 2004 to 2008. They use waste and greenhouse gas emissions as the environmental performance, and ROE, ROA, ROI, ROIC, ROS, Tobin's q-1, and the natural logarithm of Tobin's q as the financial performance. Guenster, Bauer, Derwall, and Koedijk (2011) examine the relationship between a corporate eco-efficiency and the two financial performance indicators of ROA and Tobin's q using the eco-efficiency data from 1997 to 2004, and obtain the conclusion of positive correlation. Hatakeda, Kokubu, Kajiwara, and Nishitani (2012) analyze the relationship between a firm's greenhouse gas (GHG) emissions and its profitability in Japanese manufacturing by conducting a switching regression analysis using data from 1,089 firms and find that there is a positive correlation between corporate GHG emissions and ROA. Lioui and Sharma (2012) show that both environmental strengths and concerns (environmental corporate social responsibility) have a negative impact on the firm's ROA as well as Tobin's q (Corporate Financial Performance) through using 17,000 firm-year observations for the period 1993–2007. Oura (2017) analyzes the empirical linkages between CSR and financial performance of ROA and ROE using panel data from more than 1,000 Japanese firms, and corporate governance and the environmental contribution categories of CSR are found not to be associated with financial performance. Oura (2017) states that there were various types using ROA, ROE in previous studies, and there was no unified opinion as to which was more appropriate for financial performance.

Based on the above studies, we selected ROA, ROE, ROS and Tobin's q values, which are often used in previous researches and easily collected, as objective financial performance indicators of enterprises to verify the impact of the use of MFCA, SBSC and eco-efficiency on financial performance.

Moreover, according to the above studies, we also found that the impact of environmental management activities on financial performance is not always positive, but also may be negative. Besides, as mentioned in Section 1, MFCA, SBSC and eco-efficiency all have their problems, and these problems are likely to affect the company's environmental management. Therefore, we are very interested in how the use of MFCA, SBSC and eco-efficiency affects financial performance.

In this study, we introduced the economic effects and the integration effectiveness of MFCA, SBSC and eco-efficiency. Combined with the survey results of Meng (2020), we can assume that MFCA, SBSC and eco-efficiency may improve financial performance. Therefore, we refer to the indicator selection and hypothesis development in the above studies on the relationship between environmental management and financial performance to select ROA, ROE, ROS and Tobin's q values as financial performance indicators of enterprises and consider the following hypothesis:

Hypothesis: The use of MFCA, SBSC and eco-efficiency (including the simultaneous use) has a positive impact on corporate financial performance (ROA, ROE, ROS, Tobin's q).

3. Data Analysis and Results

As a preliminary investigation, we conducted a questionnaire survey on the manufacturing companies in China to investigate the use status of MFCA, SBSC and eco-efficiency. In order to increase the response rate and prevent non-response bias as much as possible, we conducted this questionnaire survey using payment items of a Chinese questionnaire survey company (the largest survey site in China https://www.wjx.cn/). As the conditions of samples for this survey, we required the survey respondents to meet the following requirements: firstly, Zhejiang, Jiangsu and Shandong provinces were selected as the regions for this survey. The reason is that the industrial and economic development of these three provinces is very good in China. Secondly, the survey was only for manufacturing companies. The reason is that the three environmental management tools, especially MFCA, were developed under the assumption of manufacturing use. Thirdly, the objects of this survey were above medium-sized companies. The reason is that environmental management is still in the initial stage in China, and few companies use MFCA, SBSC and eco-efficiency. Thus, when conducting the questionnaire survey, we targeted medium-sized, large, extra-large manufacturing enterprises[1] located in Zhejiang, Jiangsu and Shandong provinces. Finally, the respondents were asked to be environmental management-related positions, as we should try our best to avoid the respondents' misunderstanding of the questionnaire questions.

This questionnaire survey was conducted through targeting at 1,334 manufacturing companies in Zhejiang, Jiangsu and Shandong provinces with very good industrial and economic development in China and finally collected responses from 489 companies with a response rate of 36.66%. The implementation time is from April 23 (pm 2:00) to July 10 (pm 5:00), 2019. Among all the responding companies, there were 85 listed companies. Since this study uses financial data, we will analyze these 85 listed companies.

In order to ensure reliability and accuracy of the questionnaire survey, we require that all question items including relevant respondents' job title and company name must be filled, and ensure the consistency of answers must be guaranteed by setting trap questions (to prevent non-sampling error). Besides, since the development and application of environmentally friendly tools such as MFCA, SBSC, and eco-efficiency are still in the initial stage in China, we explained the concepts and functions of these three tools in detail in the introduction part before entering the question part to prevent the understanding errors of respondents. The main questions included the basic situation of the company, environmental awareness, awareness of environmentally friendly tools, the use status of MFCA, SBSC and eco-efficiency, the reasons for non-use or use, and the application effect. Depending on the research purpose, this research focuses only on the option of usage status of MFCA, SBSC and eco-efficiency (whether or not it is used).

In this research, since we use financial data to calculate financial performance indicators, it is necessary to collect financial data firstly. These financial data of 85 listed companies are disclosed in the company's Annual Reports, and the Annual Reports are disclosed in two Chinese Stock Markets of the Shenzhen Stock Exchange (http://www.szse.cn/) and the Shanghai Stock Exchange (http://www.sse.com.cn/). According to the Administrative Measures for the Disclosure of Information of Listed Companies in China, listed companies must disclose their Annual Reports to the public (company website, Shenzhen Stock Exchange or Shanghai Stock Exchange) by the date of April 30 and submit to Securities Regulatory Commission (statutory disclosure/compulsory disclosure). The fiscal year of the Annual Report is January 1 to

Table 1 The basic situation of the target listed companies

Location area Classification (provinces)	26 companies in Zhejiang, 36 companies in Jiangsu, 21 companies in Shandong
Respondents' job title	Finance Department 8 people, Corporate administrator 18 people, Production Department 36 people, Accounting Department 2 people, Environment-related Department 3 people, Other 16 people
Industry classification[1]	Food/beverage processing manufacturing 5 companies, Spinning/clothing processing manufacturing 2 companies, Wood/furniture products 3 companies, Printing/paper industry 1 company, Petroleum industry 1 company, Chemical industry 8 companies, Pharmaceutical industry 7 companies, Textile products 1 company, Metallurgical industry 4 companies, Metal products 4 companies, General purpose equipment manufacturing industry 6 companies, Transportation equipment 12 companies, Power equipment manufacturing industry 13 companies, General equipment/electronic equipment industry 13 companies, other products 3 companies

Note: 1. The industry classification of manufacturing enterprises was made according to "National Industries Classification (GB/T4754-2011)"

December 31. The financial accounting report must be audited by an accounting firm qualified to carry out securities and futures-related business. We collect financial data from the financial accounting report in the Annual Report disclosed by the 85 listed companies and then calculate ROA, ROE, ROS and Tobin's q values we need.

Among the 85 listed companies that responded the questionnaire, one company just went public in May 2019, and one company had been delisted during the questionnaire survey. Since the financial data of these two companies could not be collected, the number of actual survey and analysis have changed to 83. This study examined the relationship between the application of MFCA, SBSC, eco-efficiency and financial performance indicators (ROA, ROE, ROS and Tobin's q) that were collected from the financial data published by these 83 listed companies from 2018 to 2019. Therefore, the actual number of observations was 166.

Table 1 shows the basic situation of these 83 listed companies. Many of the respondents were in charge of production, management, finance, accounting, environment-related duties, and so on. Thus, it can be said that these respondents have directly or indirectly participated in the environmental management related issues involved in the questionnaire survey. Besides, since the industries of the companies that responded to the questionnaire survey cover various industries within the manufacturing industry, it can be said that there is no industry bias.

3.1 Construction of Verification Model and Explanation of Variables

Based on previous researches that verify the relationship between environmental management and financial performance, this research uses the usage status of MFCA, SBSC and eco-efficiency as explana-

tory variables (dummy variables and interactive items of dummy variables), ROA, ROE, ROS and Tobin's q, which are indicators of corporate financial performance, as explained variables (continuous variables) to test the hypothesis submitted in Section 2. Specifically, we will perform a multiple regression analysis of panel data using financial data for two years from 2018 to 2019. We constructed a linear regression model by referring to the previous studies (such as Iwata and Okada, 2011) that used regression analysis.

Data on the usage of MFCA, SBSC and eco-efficiency, which are explanatory variables, are from the results of the questionnaire survey. All financial indicators, which are explained variables and control variables, are calculated by collecting data from the Annual Report. The control variables, as same as the explained variables, were selected based on previous studies that verified the relationship between environmental management and financial performance. These control variables are to control the economics of scale and the impact of other factors on ROA, ROE, ROS and Tobin's q. For examples, at the firm level, firm size is most likely to influence ROA and Tobin's q; leverage is most likely to influence ROA and ROE; firm growth, advertisement intensity, research and development intensity are most likely to influence ROS; capital intensity is most likely to influence ROE and ROS. We included all controls in the analysis model for completeness (Hart and Ahuja, 1996; Russo and Fouts, 1997; Iwata and Okada, 2011; Lioui and Sharma, 2012).

Based on the above hypothesis, the verification model is constructed as follows:

$$\text{Financial performance (ROA, ROE, ROS, Tobin's q)}_{it} = \beta_0 + \beta_1 \text{MFCA}_{it} + \beta_2 \text{SBSC}_{it} + \beta_3 \text{E/E}_{it} + \beta_4 \text{ MFCA*SBSC}_{it} + \beta_5 \text{ MFCA*E/E}_{it} + \beta_6 \text{ SBSC*E/E}_{it} + \beta_7 \text{ MFCA*SBSC*E/E}_{it} + \beta_8 \text{ Size}_{it} + \beta_9 \text{ Growth}_{it} + \beta_{10} \text{ Advertisement}_{it} + \beta_{11} \text{ R\&D}_{it} + \beta_{12} \text{ Leverage}_{it} + \beta_{13} \text{ Capital}_{it} + \varepsilon_{it}$$

Here, i represents the individual company, which is information in the cross-section direction, and t represents time, which is information in the time series direction. Financial performance includes four indicators: ROA, ROE, ROS and Tobin's q. MFCA*SBSC, MFCA*E/E (E/E refers to eco-efficiency), SBSC*E/E, and MFCA*SBSC*E/E refer to the simultaneous use of MFCA, SBSC and eco-efficiency. Size represents the firm size, and the value uses the natural logarithm of total assets. Growth represents the firm growth, and the value uses the growth rate in sales and operating revenue. Advertisement represents advertisement intensity, and the value uses the ratio of advertisement expenses to sales and operating revenue. R&D represents research and development intensity, and the value uses the ratio of research and development expenses to sales and operating revenue. Leverage is the financial leverage, defined as the sum of liabilities and net assets is divided by total stockholders' equity. Capital is capital intensity, defined as sales and operating revenue divided by stockholders' equity. Detailed definitions of each variable are shown in Table 2.

3.2 Verification Results

In this study, we analyzed the financial data of 83 listed companies that responded to the questionnaire survey in two consecutive years. Table 3 shows the descriptive statistics showing the characteristics of each variable. As the financial data as the dependent variables and control variables in this study are balanced data from 2018 to 2019, the missing value has not been included. During the whole period (from

Table 2 Explanation of variables

Variables	Explanation
Dependent variables	
ROA	ROA is a financial ratio that shows the percentage of profit a company earns in relation to its overall resources. It is calculated as net income divided by total assets.
ROE	ROE is a profitability ratio that measures the ability of a firm to generate profits from its shareholders investments in the company. It is calculated as net income divided by shareholders' equity.
ROS	ROS is a ratio used to evaluate a company's operational efficiency. It is calculated as income divided by sales and operating revenue.
Tobin's q	Tobin's q is an indicator to measure the company's performance, especially on the value of companies that demonstrate performance management in managing the assets of the company. Tobin's q value is measured as the sum of total debt and market value divided by total assets.
Independent variables	
MFCA	The usage of MFCA; unused (=0), used (=1)
SBSC	The usage of SBSC; unused (=0), used (=1)
E/E	The usage of eco-efficiency; unused (=0), used (=1)
MFCA*SBSC	The usage of MFCA and SBSC; non-simultaneous use (=0), simultaneous use (=1)
MFCA*E/E	The usage of MFCA and eco-efficiency; non-simultaneous use (=0), simultaneous use (=1)
SBSC*E/E	The usage of SBSC and eco-efficiency; non-simultaneous use (=0), simultaneous use (=1)
MFCA*SBSC*E/E	The usage of MFCA, SBSC and eco-efficiency; non-simultaneous use (=0), simultaneous use (=1)
Control Variables	
Size	Firm size is the natural logarithm of total assets.
Growth	Firm growth is the growth rate in sales and operating revenue. Specifically, it is the ratio of the increase in sales and operating revenue of an enterprise to the total sales and operating revenue of the previous year.
Advertisement	Advertisement intensity is defined as advertisement expenses divided by sales and operating revenue.
R&D	Research and development intensity is defined as research and development expense divided by sales and operating revenue.
Leverage	Financial leverage is defined as the sum of liabilities and net assets is divided by total stockholders' equity.
Capital	Capital intensity is defined as sales and operating revenue divided by stockholders' equity.

Note: E/E refers to eco-efficiency.

Table 3 Descriptive statistics

Variable	N	Mean	Std. Dev.	Min	Max
ROA	166	0.0456	0.0380	−0.0975	0.1970
ROE	166	0.0935	0.0791	−0.2421	0.3060
ROS	166	0.1407	0.2425	−0.5965	1.1588
Tobin's q	166	1.5541	0.8442	0.5221	5.7436
MFCA	166	0.2530	0.4361	0	1
SBSC	166	0.2048	0.4048	0	1
E/E	166	0.1928	0.3957	0	1
MFCA*SBSC	166	0.1325	0.3401	0	1
MFCA*E/E	166	0.1205	0.3265	0	1
SBSC*E/E	166	0.1205	0.3265	0	1
MFCA*SBSC*E/E	166	0.0843	0.2787	0	1
Size	166	23.5231	1.9030	18.3155	28.6365
Growth	166	0.1109	0.2905	−0.7978	2.2483
Advertisement	166	0.0101	0.0289	0	0.1866
R&D	166	0.0520	0.0960	0	0.8474
Leverage	166	2.2567	0.8036	1.1036	4.7464
Capital	166	1.6222	1.1513	0.0417	6.4178

Note: E/E refers to eco-efficiency.

2018 to 2019), the firms in our sample have an average Tobin's q greater than one (1.55), the average value of financial leverage (Equity Multiplier) is around two (2.26), and the research and development intensity accounts for 5%. These sample enterprises seem to be constituted by well performing firms with reasonable capital structure (Lioui and Sharma, 2012; National Bureau of Statistics of China).

In this study, we took 83 listed manufacturing companies that responded to the questionnaire survey as the target companies and used multiple regression analysis to analyze whether the use of MFCA, SBSC and eco-efficiency has an impact on financial performance (ROA, ROE, ROS and Tobin's q). As an analysis method, a large number of dummy variables were used as independent variables following Shen (2008: 60–63) and Zhang (2014: 12–13). The test results of corporate financial performance are shown in Table 4.

Based on previous studies and the author's survey of Chinese manufacturing companies in another article, we have reached the hypothesis that the application of MFCA, SBSC and eco-efficiency (including simultaneous use) have a positive impact on the financial performance of the company. Table 4 presents the test results of corporate financial performance. The results imply that the use of MFCA has a statistically significant positive impact on ROE. However, contrary to expectations, the result shows that the simultaneous use of MFCA and eco-efficiency has a negative impact on ROA and ROE. Besides, the effects of the use of MFCA, SBSC and eco-efficiency are not statistically significant on ROS and Tobin's q. In other cases, the use of MFCA, SBSC and eco-efficiency such as the use of SBSC, the use of eco-efficiency, the simultaneous use of MFCA and SBSC, the simultaneous use of SBSC and eco-efficiency,

Table 4 Test results of corporate financial performance

	ROA	ROE	ROS	Tobin's q
MFCA	0.0135	0.0458*	0.0204	0.1164
	(0.0127)	(0.0268)	(0.0899)	(0.3468)
SBSC	−0.0196	−0.0303	−0.0498	−0.0825
	(0.0208)	(0.0441)	(0.1422)	(0.5439)
E/E	0.0173	0.0539	−0.0931	−0.1198
	(0.0176)	(0.0372)	(0.1277)	(0.4972)
MFCA*SBSC	0.0363	0.0320	0.0160	−0.1968
	(0.0268)	(0.0568)	(0.1901)	(0.7349)
MFCA*E/E	−0.0594**	−0.1516***	−0.0504	−0.4382
	(0.0266)	(0.0562)	(0.1922)	(0.7476)
SBSC*E/E	0.0215	0.0222	0.3368	−0.4634
	(0.0327)	(0.0692)	(0.2300)	(0.8876)
MFCA*SBSC*E/E	0.0218	0.0920	−0.0746	1.5917
	(0.0418)	(0.0885)	(0.2983)	(1.1551)
Size	0.0027	0.0058	0.0405***	−0.1141**
	(0.0019)	(0.0040)	(0.0136)	(0.0524)
Growth	0.0304****	0.0695****	0.1027***	0.1896
	(0.0080)	(0.0174)	(0.0389)	(0.1338)
Advertisement	−0.1057	−0.3159	−0.6436	2.0879
	(0.1287)	(0.2747)	(0.7807)	(2.8223)
R&D	0.0291	0.0597	0.4718**	1.4653*
	(0.0358)	(0.0765)	(0.2192)	(0.7950)
Leverage	−0.0224****	−0.0114	−0.0316	−0.0548
	(0.0044)	(0.0093)	(0.0291)	(0.1088)
Capital	0.0087***	0.0229****	−0.0501**	0.1118
	(0.0032)	(0.0069)	(0.0207)	(0.0763)
R^2	0.3879	0.3683	0.3468	0.1873
No. of firms	83	83	83	83
Observations	166	166	166	166

Notes: 1. E/E refers to eco-efficiency. 2. The numbers outside parentheses are regression coefficients, and the numbers in parentheses are standard errors. 3. The asterisks ****, ***, ** and * indicate 0.1%, 1%, 5%, and 10% of significance levels, respectively.

the simultaneous use of MFCA, SBSC and eco-efficiency are not statistically significant for ROA, ROE, ROS and Tobin's q.

According to previous studies, although relationships between these control variables and these measures of firm performance are generally as would be expected, the influence of these control variables on these firm performance indicators will also slightly change due to the difference in sample selection

and sample size. In this study, the results are as follows: Firm size is positively correlated with ROS but negatively correlated with Tobin's q. Firm growth displays a positive and significant relationship with ROA, ROE and ROS, but it does not show any significant correlation with Tobin's q. There is no statistical correlation between advertisement intensity and these four measures of companies. Research and development intensity is a positive factor for ROS and Tobin's q. Financial leverage is significant only associated with ROA. Capital intensity is a significant and positive predictor for ROA and ROE, but it shows a negative sign for ROS.

4. Conclusion

In previous researches, there were the verification studies of the relationship between environmental management and financial performance, but no verification study of the relationship between the usage status of MFCA, SBSC, eco-efficiency and financial performance. Furthermore, there were studies about the integration of these three tools, but no study to verify the relationship between use of the three (including the simultaneous use) and financial performance.

The purpose of this study was to examine the relationship between the usage status of MFCA, SBSC, eco-efficiency as environmental management tools and the financial performance. We chose ROA, ROE, ROS and Tobin's q, which are often used in empirical researches to verify the relationship between environmental management and financial performance, as the financial performance indicators of the enterprises. In another research, we conducted a questionnaire survey of 489 companies, and concluded that companies that use MFCA, SBSC and eco-efficiency alone or simultaneously have improved their financial performance. Combining previous studies, we come up with a hypothesis that the use of MFCA, SBSC and eco-efficiency (including the simultaneous use) has a positive impact on corporate financial performance (ROA, ROE, ROS, Tobin's q). Then, in order to verify this hypothesis, we selected the data of all listed companies (83 companies) in the past two years from the answers to the past questionnaire and tested it using multiple regression analysis.

The results of this study suggest that only the use of MFCA may lead to improving corporate financial performance (ROE). However, the slightly surprising finding is that the simultaneous use of MFCA and eco-efficiency may have a negative impact on financial performance (ROA and ROE). As environmental management tools aiming at achieving economic growth and environmental protection at the same time, the function of these two tools is to improve the environmental performance of enterprises as much as possible while ensuring stable economic development. However, considering what has been mentioned before, that these three tools have their own problems and these problems are likely to affect the company's environmental management (Section 1), the result that the simultaneous use of MFCA and eco-efficiency has negative effects on ROA and ROE is not particularly surprising.

The results of a questionnaire survey we conducted on the Chinese manufacturing companies showed that corporate financial performance could be improved whether the single-use or the simultaneous use of MFCA, SBSC and eco-efficiency. However, the results of the test of the four financial performance indicators used in this research are different from expectations (this article's hypothesis). In other words,

from the regression results, we can find that, except for the use of MFCA has a positive impact on ROE, the use of SBSC and eco-efficiency and various forms of simultaneous use between these three tools have no positive impact on corporate financial performance. This may be caused by the problems of the three tools themselves (Section 1), or other reasons. In response to this result, we make the following conjectures: firstly, because the sample size of the questionnaire survey is 489 companies, and only 83 listed companies among them are the subjects in this test, there may be deviations caused by different samples. Then, questionnaire surveys generally use the subjective judgment of the respondents, so the financial performance indicators we use are likely inconsistent with judgment indicators of the questionnaire respondents. Finally, previous studies have emphasized that these three tools can be integrated to achieve the balance of economic growth and environmental protection more effectively, and the questionnaire survey we conducted can only ensure that companies use these three tools simultaneously but cannot guarantee that they have implemented the integration.

In response to the above remaining issues, we will test whether the use of MFCA, SBSC and eco-efficiency (including the simultaneous use) will lead to the improvement of corporate financial performance by expanding the sample size and conducting enterprise interviews. Enterprise interviews can also determine the specific conditions such as the stage and level of the use of these tools, thereby eliminating the problems of understanding differences among the questionnaire respondents. Moreover, future work will need to examine critically the "reverse causality" hypothesis: enterprises with good financial performance are more likely to adopt environmental management tools such as MFCA, SBSC and eco-efficiency. It cannot be denied that when adopting MFCA, SBSC and eco-efficiency, companies are bound to pay corresponding costs, and the companies must also bear the corresponding risks. Therefore, the important subject of verifying the "reverse causality" hypothesis needs to be treated with caution in future research.

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Note:

[1] The enterprise scale of Chinese manufacturing enterprises is classified according to the "Notice Concerning Print Distribution of Enterprise Scale Classification Standards" published by The National Bureau of Statistics of China. Medium-sized manufacturing enterprises are those with more than 300

employees and less than 1,000 employees, operating revenues of more than 20 million yuan and less than 400 million yuan; Large manufacturing enterprises are those with more than 1,000 employees and operating revenues of more than 400 million yuan; Extra-large manufacturing enterprises are those that specially classified from large enterprises and have a major impact on the national economy and strategic development.

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