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The Impact of Sustainability Accounting on Environmental Performance and Productivity: A Panel Data Analysis

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ABSTRACT

Environmental accounting is a crucial tool for sustainable development as it enables the analysis, study, and measurement of natural resources' control, valuation, and management from an accounting perspective. This study aims to explore the potential of sustainable accounting as a tool for promoting the Sustainable Development Goals (SDGs). The hypotheses propose that the adoption of environmental accounting enhances a company's environmental performance, directly increases firm productivity, and indirectly increases productivity through improved environmental performance. To test these hypotheses, panel data from 2011 to 2020 is used, and the relationship among environmental accounting adoption, environmental performance, and productivity is estimated using Ordinary Least Squares (OLS), Fixed Effects (FE), and Random Effects (RE) models. The results show that the environmental accounting adoption dummy is significantly positive in all models (OLS, FE, and RE), indicating that firms that have adopted environmental accounting demonstrate higher environmental performance. The FE model is found to be the most reliable based on the results of the F-test, Breusch-Pagan test, and Durbin-Wu-Hausman test. The coefficient estimates in the FE model suggest that the effect of environmental accounting adoption is about one-third and one-half of that estimated in the OLS and RE models, respectively. Additionally, the findings suggest that firms with higher environmental performance, larger size, higher consumer relevance, and lower debt ratios demonstrate higher productivity. These results indicate that sustainability accounting has the potential to significantly contribute to the achievement of the SDGs.

1. INTRODUCTION

1.1 Background

In 2015, the United Nations adopted the Sustainable Development Goals (SDGs), a set of 17 goals (poverty, hunger, health, education, gender, water, energy, employment, infrastructure, inequality, cities, sustainable Consumption and production, climate change, marine resources, terrestrial ecosystems, peace and justice, and partnerships to achieve them) and 169 targets associated with them [1]. While corporations are seen as key players in achieving the SDGs, they also represent a great opportunity for companies to promote corporate social responsibility (CSR) more than ever before [2]. At the same time, the world's largest institutional investor, BlackRock, has incorporated SDG initiatives into its investment decisions, and companies are increasingly interested in the SDGs from a normal business perspective as well. This trend can be easily imagined from the fact that SDG logos and icons can be found in many sustainability reports and integrated reports.

1.2 Problem statement

However, if companies, as for-profit organizations, engage in the SDGs, it is crucial for them to bring about economic benefits. From an economic perspective, companies are motivated to engage in the SDGs because they can anticipate economic advantages. In fact, the SDG Compass guidelines emphasize the alignment of the SDGs with management strategies, indicating that companies consider economic considerations when working towards the SDGs. Sustainable development cannot be achieved at the expense of the environment, society, or the economy. Therefore, efforts to balance environmental and social concerns with economic considerations are necessary.

In this context, the role of accounting in contributing to the SDGs is being explored [3]. Sustainability accounting is

expected to play a significant role in supporting sustainable management. This paper aims to examine how sustainability accounting can be utilized to promote sustainable development goals. Sustainability accounting encompasses a range of accounting methods, including environmental accounting, and involves reporting on a company's economic activities related to society and the environment. Although various definitions exist, such as "the measurement, management, and reporting of corporate activities to sustain or develop an entity's ability to create value over time" by the U.S. Sustainability Accounting Standards Board [4], sustainability accounting is often used interchangeably with environmental accounting and sustainability reporting in practice. This may be because sustainability accounting is seen as a developmental form of environmental accounting and reporting [5].

Therefore, the focus here is on environmental accounting, which is a significant component of sustainability accounting. Environmental accounting is defined as "the act of recognizing, measuring, evaluating, and communicating environmental events" [6]. However, there are variations in environmental accounting based on the subject, object, purpose, and other factors. For instance, the Environmental Accounting Guidelines 2020, issued by the Ministry of Environment [7], defines environmental accounting as a method for companies to promote environmental conservation efforts efficiently and effectively while maintaining a good relationship with society, in order to achieve sustainable development. The guidelines describe environmental accounting as a system to recognize the costs of environmental conservation in business activities, the effects obtained from such activities (both environmental and economic effects), and to measure and communicate them quantitatively (in monetary or physical units) as much as possible. While not all environmental accounting practices conform strictly to these guidelines, this paper will discuss environmental accounting in a broader sense.

The primary objective of environmental accounting is to link environmental conservation activities with economic activities. If environmental accounting functions effectively, it should be possible to strike a balance between the environment and the economy. While case studies have shed light on these effects to some extent, generalizations cannot be made based solely on these individual cases. However, if these effects can be generalized, they can serve as incentives for companies to adopt sustainability accounting, including environmental accounting, and thus contribute to the promotion of the SDGs. This is evident from the fact that many of the SDG goals and targets are related to environmental issues, which are a major focus of the SDGs [8]. Notably, direct contributions are expected in achieving Goal 7 "Affordable and Clean Energy," Goal 12 "Responsible Consumption and Production," and Goal 13 "Climate Action."

1.3 Research objectives

Based on the above, this paper statistically investigates the relationships between the adoption of environmental accounting, environmental performance, and productivity using data from companies listed on the National Stock Exchange from 2011 to 2020 to show how the economy and the environment are balanced in corporate management. However, since these relationships are considered to differ greatly depending on firm-specific characteristics and the circumstances in which they are placed, the effects of the introduction of environmental accounting on environmental performance and productivity may be overestimated if these differences are not taken into account. Therefore, in our analysis, we use not only the Ordinary Least Squares (OLS) method, which is used in many accounting studies but also the Fixed Effects (FE) model and the Random Effects (RE) model to estimate how much of the perceived effects of the introduction of environmental accounting are firm-specific effects.

This paper is organized as follows. Section 1 derives the hypotheses, section 2 describes the analytical methods, data, and variables used in the analysis, section 3 describes the results of the analysis, and section 4 summarizes the discussion.

2. HYPOTHESIS

When a company engages in environmental conservation, quantitative management of its status through environmental accounting is not only effective in maintaining sound environmental conservation activities, but also provides a means of fulfilling accountability to stakeholders [7]. Therefore, environmental accounting is not only a business management tool within a company, but also an information disclosure tool that influences the decision-making of stakeholders, and its functions can be divided into internal functions (internal environmental accounting) and external functions (external environmental accounting). The internal function is to enable the management of environmental costs1 and analysis of their cost-effectiveness and to promote efficient and effective environmental conservation efforts through appropriate management decisions. The external function is the function to influence stakeholders' decision-making by disclosing the results of quantitatively measured environmental conservation efforts [7]. Of these, the Ministry of the Environment's environmental accounting guidelines mainly focuses on external functions, while internal functions are often considered specifically as environmental management accounting such as material flow cost accounting (MFCA) 2. In addition to MFCA, other methods such as climate change accounting, carbon accounting, water accounting, and biodiversity accounting, which go beyond conventional environmental management accounting, have been proposed mainly in Europe [9].

Although they are the same type of environmental accounting, the scope of environmental costs in external environmental accounting is based on environmental conservation costs 3, whereas in internal environmental accounting, the scope is not necessarily limited to those costs, but can be expanded according to the purpose. For this reason, the information in external environmental accounting for information disclosure can be used for decision-making, but its effect as an internal function is indirect. In external environmental accounting, the methods should be standardized for the purpose, but the calculation methods and boundaries have not been unified [7]. Thus, environmental accounting in general does not mean that its main purpose and scope of application are unified. In any case, if the internal function works properly, even if indirectly, it is possible to manage environmental costs and analyze their cost-effectiveness by visualizing information in monetary units or physical quantity units. Environmental accounting guidelines are also designed to be useful for internal use [7]. As a result, efficient and effective environmental conservation efforts

should be promoted through appropriate management decisions. Thus, for environmental accounting to function properly, it is essential to enhance internal functions.

Then, how much has the role of such internal functions been clarified in the studies so far? However, as far as the authors are aware, studies on external functions [6, 10, 11], are the main studies under the name of environmental accounting, while there are many studies on internal functions (environmental management accounting) that systematize and utilize them, but the number of studies that clarify how well they work is limited, especially in India. In addition, overseas, although some studies such as [12-16] can be cited, the role of internal functions has not yet been fully clarified.

Among the various studies, there is a relatively substantial body of research on Material Flow Cost Accounting (MFCA), which is a prominent environmental management accounting method [17]. For example, studies have reported that the implementation of MFCA leads to reductions in environmental impacts and costs [18, 19]. Other studies have examined how the introduction of MFCA transforms organizational activity processes and contributes to success [20, 21]. In addition, research has not only focused on the short-term effects of MFCA implementation but also investigated long-term changes [22]. It has also been clarified that MFCA has been successful in Asian contexts [23, 24]. Furthermore, studies on MFCA have been conducted in various countries and industries. For instance, research has been conducted in the food industry [25], meat industry [26], industrial wastewater treatment [27], and metal processing industry [28]. These studies have analyzed the effects of MFCA implementation in diverse industries, demonstrating its applicability across different sectors.

At least these previous studies prove that the internal functions of environmental accounting are working properly (even if only partially), i.e., that the introduction of environmental accounting makes the environment and the economy compatible. However, these are case studies, and they only show that this is the case in advanced companies, and cannot be generalized. This is where the research gap in environmental accounting research exists. Therefore, to generalize, it is necessary to demonstrate and clarify the effect by quantitative analysis using corporate data. To this end, based on the above discussion, we simplify and consider the relationship between the introduction of environmental accounting, environmental performance, and economic performance. Sahu et al. [29] quantitatively analyzed the relationship among environmental management systems, environmental performance, and productivity for Indian firms from the perspective of balancing the environment and the economy, and found a positive relationship among them. However, she points out that the environmental management system is only a framework for environmental conservation efforts and that it is necessary to consider individual efforts in practice. Therefore, we will proceed with the discussion by using the analytical framework of study by Sahu et al. [29]. Productivity improvement is an economic performance focusing on the efficiency of production and is one of the desirable indicators considering that the internal function of environmental accounting is to promote efficient and effective environmental conservation efforts through appropriate management decisions.

First, although the main purpose and scope of application of environmental accounting are not standardized among companies, we assume environmental accounting in a broad sense and focus on the introduction itself, since it is believed that each company is taking measures that suit its current situation based on information from environmental accounting. Since environmental accounting is a tool for sustainability (environmental) management, it is expected to enhance environmental performance (additionally) through new initiatives using the information, even if the company has already taken such initiatives in the past. In addition, since the information enables management of environmental costs and cost-benefit analysis, it is expected to lead to productivity improvement through (at least partial) review of environmental costs that have been required up to now. However, if environmental accounting information is effective in directly reducing environmental costs, the effect is expected to directly affect productivity, but if it is effective in terms of cost-effectiveness, the effect is expected to be indirect through improved environmental performance. Thus, the following testable hypotheses are derived.

Hypothesis 1: The introduction of environmental accounting will enhance a company's environmental performance.

Hypothesis 2a: The introduction of environmental accounting will directly increase firm productivity.

Hypothesis 2b: The introduction of environmental accounting will indirectly increase firm productivity through improved environmental performance.

3. RESEARCH DESIGN

3.1 Analysis method

In this paper, we estimate the relationship among environmental accounting adoption, environmental performance, and productivity by OLS, FE, and RE using panel data for the 10 years from 2011 to 2020. If firm-specific effects that are not visible affect environmental accounting adoption, environmental performance, and productivity, then OLS estimation may capture a sham correlation. The model for testing the hypotheses is expressed in Eq. (1) and Eq. (2).

$$Envp = \varphi_0 + \varphi_1 \, Envacc + \varphi_2 \, Cont + u \tag{1}$$

$$Product = \tau_0 + \tau_1 \, Envp + \tau_2 \, Envacc + \tau_3 \, Cont + \varepsilon \tag{2}$$

where, *Envp* is environmental performance, *Envacc* is environmental accounting introduction, *Cont* is the control variable, *Product* is productivity, u and ε are error terms, and φ and τ are estimated parameters. In the case of FE and RE, the error terms are expressed as in Eq. (3) and Eq. (4).

$$u = \gamma + \theta \tag{3}$$

$$\varepsilon = \delta + \omega \tag{4}$$

Note that γ and δ are invisible firm-specific effects, and θ and ω are actual error terms. Invisible firm-specific effects are considered constants in FE and random variables in RE.

However, even if we take into account invisible firm-specific effects in our estimation, if there is an endogeneity problem in the variables that capture the introduction of environmental accounting or environmental performance, estimation without considering the endogeneity problem may capture the opposite causal relationship: the more productive

a firm is, the more environmental accounting is introduced or the higher its environmental performance is, in which case it is preferable to use a manipulated variable method. For this purpose, we also tested for endogeneity by estimating a UN Global Compact signature dummy that takes the value of 1 when a firm has signed the UN Global Compact and a fixed-effects operating variable method that uses the number of years since signing as the operating variable [29, 30]. The endogeneity problem was not found for the variables capturing the introduction of environmental accounting and environmental performance 4. The results of the discrimination tests also showed that the reliability of the results of the fixed-effects operating variable method was not very high.

3.2 Analysis target

The analysis in this paper is based on 446 firms listed on the National Stock Exchange as of April 2022 that belong to industries excluding finance-related industries, for which data are available for the period 2011-2020. However, due to the unbalanced panel data, the total number of firms observed is 1,895 firm years.

3.3 Trends in the distribution of environmental accounting introduction

Before describing the variables and databases used in the analysis, we will examine trends in the distribution of environmental accounting adoption in the industries analyzed in this paper. Table 1 summarizes the percentage of each industry's introduction of environmental accounting among all industries by year. It should be noted, however, that according to the descriptive statistics discussed below, the number of samples for which data are available has decreased since 2015, and this may have had some effect on the trend in the distribution of environmental accounting adoption.

First, looking at all industries, the percentage of firms that have adopted environmental accounting is as high as 0.688 on average during 2011-2020, but the percentage has declined over the years from 0.741 in 2011 to 0.568 in 20205. Then, looking at the 2011-2020 average by industry, we see that construction, chemicals, machinery, electrical machinery, electrical equipment, and transportation equipment have a relatively high ratio of environmental accounting adoption to all industries, at 0.103, 0.078, 0.060, 0.111, and 0.066, respectively. On the other hand, the ratio is 0.000 in the fisheries/agriculture and forestry industry and the retail industry, and these two industries have not introduced environmental accounting at all. As reflected in all industries, the percentage of each industry that has introduced environmental accounting has generally declined year by year. In particular, in the textile, electrical equipment, precision equipment, and wholesale industries, the ratio has been 0.000 since a certain year, and environmental accounting has not been introduced at all in these industries. On the other hand, however, the ratio has exceptionally increased in the construction industry, from 0.060 in 2011 to 0.250 in 2020.

3.4 Variables

This section describes the variables used in the analysis. The descriptive statistics of the variables are summarized in Table 2. Since the highest VIF value among the variables is 2.88, multicollinearity is unlikely to occur.

Table 1. Percentage of industries adopting environmental accounting

Industry	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2011-2020
Fisheries & Agriculture	0.000	-	0.000	0.000	-	-	-	-	-	-	0.000
Mining	-	0.000	0.003	0.003	0.006	-	-	-	-	-	0.002
Construction	0.060	0.050	0.048	0.053	0.130	0.204	0.242	0.239	0.244	0.250	0.103
Foodstuff	0.057	0.043	0.052	0.043	0.017	0.019	0.011	0.011	0.012	0.011	0.037
Textile	0.014	0.017	0.013	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.009
Pulp & Paper	0.011	0.010	0.010	0.008	-	-	-	-	-	-	0.006
Chemical	0.099	0.114	0.119	0.101	0.034	0.010	0.011	0.011	0.012	0.011	0.078
Medical supplies	0.028	0.030	0.032	0.029	0.040	0.029	0.022	0.023	0.024	0.023	0.030
Rubber goods	0.011	0.013	0.019	0.016	0.023	-	-	-	-	-	0.012
Glass & Clay Products	0.018	0.017	0.016	0.016	0.011	0.000	0.000	0.011	0.024	0.011	0.014
Iron & steel	0.018	0.010	0.010	0.013	-	-	-	-	-	0.000	0.008
Non-ferrous metals	0.014	0.017	0.013	0.013	0.011	0.010	0.011	0.011	0.012	0.011	0.013
Metal Products	0.011	0.010	0.010	0.008	0.000	0.010	0.011	0.011	0.012	0.011	0.009
Machinery	0.060	0.074	0.071	0.059	0.068	0.049	0.033	0.034	0.037	0.045	0.060
Electronic goods	0.167	0.157	0.161	0.136	0.068	0.029	0.000	0.000	0.000	0.000	0.111
Transportation equipment	0.064	0.070	0.077	0.069	0.073	0.058	0.066	0.057	0.049	0.023	0.066
Sensitive equipment	0.011	0.017	0.010	0.011	0.011	0.000	0.000	0.000	0.000	0.000	0.009
Other products	0.025	0.023	0.026	0.021	0.023	0.019	0.022	0.023	0.024	0.023	0.023
Electricity & Gas	0.039	0.040	0.039	0.029	0.062	0.068	0.055	0.057	0.049	0.045	0.043
Land transportation	0.007	0.007	0.006	0.005	0.011	0.010	0.011	0.023	0.012	0.023	0.009
Shipping	0.007	0.010	0.010	0.008	0.017	0.019	0.022	0.023	0.012	0.011	0.012
Information & Communications	0.007	0.010	0.010	0.011	0.023	0.049	0.044	0.034	0.037	0.034	0.018
Wholesale trade	0.011	0.010	0.010	0.008	0.006	0.000	0.000	0.000	0.000	0.000	0.007
Retail trade	0.000	-	0.000	0.000	0.000	-	-	-	-	-	0.000
Service industry	0.004	0.000	0.003	0.003	0.006	0.010	0.011	0.023	0.037	0.034	0.007
All industries	0.741	0.749	0.771	0.677	0.638	0.592	0.571	0.591	0.598	0.568	0.688

Table 2. Descriptive statistics

	No. of Observations	Average	Standard Error	Minimum	Maximum
Total Factor Productivity	1895	1.228	1.666	0.306	37.068
Environmental Performance Score	1895	67.833	18.281	9.800	100.000
Environmental Accounting Introduction Dummy	1895	0.688	0.464	0	1
Environmental Management Introduction Dummy	1895	0.948	0.222	0	1
Logarithm of Total Assets	1895	12.162	1.506	8.229	16.460
Ratio of R&D expenses to sales	1895	0.041	0.055	0.000	0.438
Debt ratio	1895	1.455	1.773	0.036	32.559
Ratio of advertising expenses to sales	1895	0.011	0.016	0.000	0.154
Corporate age	1895	66.599	20.473	2	131
Industry Dummy					
Fisheries and Agriculture	1895	0.002	0.040	0	1
Mining	1895	0.002	0.046	0	1
Construction	1895	0.136	0.342	0	1
Foodstuff	1895	0.056	0.230	0	1
Textile	1895	0.023	0.151	0	1
Pulp & Paper	1895	0.007	0.083	0	1
Chemical	1895	0.102	0.303	0	1
Medical supplies	1895	0.040	0.195	0	1
Rubber goods	1895	0.016	0.125	0	1
Glass & Clay Products	1895	0.019	0.137	0	1
Iron & steel	1895	0.012	0.110	0	1
Non-ferrous metals	1895	0.016	0.125	0	1
Metal Products	1895	0.018	0.135	0	1
Machinery	1895	0.089	0.284	0	1
Electronic goods	1895	0.149	0.357	0	1
Transportation equipment	1895	0.087	0.282	0	1
Sensitive equipment	1895	0.026	0.159	0	1
Other products	1895	0.030	0.169	0	1
Electricity & Gas	1895	0.044	0.205	0	1
Land transportation	1895	0.009	0.094	0	1
Shipping	1895	0.012	0.107	0	1
Information & Communications	1895	0.063	0.244	0	1
Wholesale trade	1895	0.021	0.144	0	1
Retail trade	1895	0.003	0.051	0	1
Service industry	1895	0.020	0.138	0	1
Annual Dummy					
2011	1895	0.149	0.356	0	1
2012	1895	0.158	0.365	0	1
2013	1895	0.164	0.370	0	1
2014	1895	0.198	0.399	0	1
2015	1895	0.093	0.291	0	1
2016	1895	0.054	0.227	0	1
2017	1895	0.048	0.214	0	1
2018	1895	0.046	0.210	0	1
2019	1895	0.043	0.204	0	1
2020	1895	0.046	0.210	0	1

3.4.1 Variables capturing productivity

Total factor productivity, which is productivity that takes all factors of production into account, is used as the variable that captures productivity. In this paper, a Cobb-Douglas type production function consisting of labor (the number of employees), capital (amount of tangible fixed assets), and raw materials (manufacturing cost) are estimated and its value expressed as a residual is obtained. The specific procedure is as follows.

The Cobb-Douglas type production function consisting of labor, capital, and raw materials is expressed as in Eq. (5).

$$X = AL^{\alpha}K^{\beta}M^{1-\alpha-\beta} \tag{5}$$

where, X is output, A is total factor productivity (i.e., $A = \frac{X}{L^{\alpha}K^{\beta}M^{1-\alpha-\beta}}$), L is labor, K is capital, and M is raw materials. In addition, α, β, and 1-α-β are the distribution rates of labor, capital, and raw materials, respectively, with $0<\alpha<1$, $0<\beta<1$, and $0<\alpha+\beta<1$.

Taking the logarithm of both sides of Eq. (5) to make it linear, it is expressed as in Eq. (6).

$$\begin{aligned} lnX &= lnA + \alpha lnL + \beta lnK + (1-\alpha-\beta)\, lnM \\ &= lnA^{*} + \alpha lnL + \beta lnK + (1-\alpha-\beta)\, lnM + \mu \end{aligned} \tag{6}$$

lnA^{*} is the constant portion that captures the average value of total factor productivity, and μ is the residual. Since this residual can be viewed as a relative deviation from lnA^{*}, it can be assumed that the residual includes factors such as technological innovation and business efficiency that cannot be explained by labor, capital, and raw materials alone in total factor productivity, as can be seen from Eq. (7).

$$\mu = lnX - lnA^* - \alpha lnL - \beta lnK - (1 - \alpha - \beta) lnM \quad (7)$$

Therefore, Eq. (6) was estimated using the operating variable method with the number of employees, amount of tangible fixed assets, and manufacturing cost one period earlier as operating variables to obtain the value of μ among total factor productivity. Note that since μ is a logarithmic value, the original value was used as the variable.

3.4.2 Variables capturing the introduction of environmental accounting

As a variable to capture the introduction of environmental accounting, we use an environmental accounting introduction dummy, which is a dummy variable that takes 1 if environmental accounting has been introduced and 0 if it has not. Due to the characteristics of the data used (National CSR Database (Environment), described below), this variable is not limited to specific types of environmental accounting, such as environmental accounting based on the Ministry of Environment guidelines, but rather captures the introduction of environmental accounting in a more general and broad sense, including such accounting 6.

It may be more desirable to focus on the details of the introduction of environmental accounting rather than the introduction itself, but as mentioned earlier, the main purpose and scope of application are not standardized among companies, and data based on different standards (units) cannot be treated in the same way. Furthermore, even if they could be treated identically, it would be difficult to use them in the analysis because the number of samples from which data related to the contents of "environmental accounting, understanding of the amount of costs and effects" and "total environmental conservation costs" could be obtained would be limited.

3.4.3 Variables capturing environmental performance

As a variable for capturing environmental performance, we use the environmental performance score, which is a score related to environmental conservation efforts and performance, included in the National CSR Database (Environmental Section). Based on the results of the National CSR Database, companies' environmental conservation efforts and performance are comprehensively evaluated on a scale of 0 to 100, and the database contains scores for the top 500 to 800 companies each year (500 companies until 2013, 700 companies from 2014 to 2019, and 800 companies from 2020 onward) 7. Note that since these scores are evaluated after taking into account the introduction of environmental accounting and environmental management, it is not desirable to use data obtained from the same year's database for these in the analysis. For this reason, data from one year earlier are used for the environmental accounting introduction and environmental management introduction variables (and other control variables).

3.4.4 Control variables

The control variables are as follows. First, we use an environmental management introduction dummy, a dummy variable that takes 1 if the firm has introduced environmental management such as ISO 14001 and 0 if it has not, to control for the effect of various environmental conservation efforts. Second, to control for the effect of firm size, we use the log value of total assets. Third, we use the debt ratio, which is total debt divided by equity, to control for the effect of corporate financial safety. Fourth, to control for the impact of R&D, we use the ratio of R&D expenditures to sales, which is R&D expenditures divided by sales. Fifth, to control for the impact of the firm's position in the supply chain, we use the ratio of advertising expenditures divided by sales. We assume that the ratio of advertising expenditures to sales is higher for firms with higher consumer relevance. Sixth, we use firm age to control for firm maturity. Seventh, to control for the effect of each industry, we control for the 25 industries to which the sample firms belong (fisheries, agriculture, forestry, mining, construction, food products, textile products, pulp and paper, chemicals, pharmaceuticals, rubber products, glass and stone products, steel, nonferrous metals, metal products, machinery, electric equipment, transportation equipment, confidential machinery, and electrical equipment) out of 29 industries excluding finance-related industries classified by the National Stock Exchange. We use industry dummies, which are dummy variables that take the value of 1 for each of the firms belonging to the following industries: oil and coal products, air cargo, oil and coal products, food products, textile products, pulp and paper, chemicals, pharmaceuticals, rubber products, glass and soil products, iron and steel, nonferrous metals, metal products, machinery, electrical equipment, transportation equipment, confidential machinery, other products, electricity and gas, land transportation, shipping, information and communication, wholesale, retail, and services. Note that these industry dummies are not included because firms belonging to the petroleum and coal products, air transportation, warehousing, transportation-related industries, and real estate industries are not in the sample. Eighth, we use annual dummies, which are dummy variables that take 1 for each of the years 2011-2020 to control for various macro shocks in each year.

3.5 Databases

Data on environmental accounting, environmental performance, and environmental management were obtained from the National CSR Database (environment section), while data used to derive total factor productivity and control variables were obtained from Fundoodata.

4. ESTIMATION RESULTS

Estimated results on the effect of the introduction of environmental accounting on environmental performance are presented in Table 3. Models OLS and RE include industry and year dummies, and model FE includes year dummies, but their coefficients and standard errors are not shown due to space limitations (industry dummies are not included in FE because industry dummies and fixed effects cause perfect multicollinearity). (In FE, the industry dummy is not included because it is a variable that increases by 1 each year, causing full multicollinearity with the annual dummies). These also apply to Table 4.

In all of the models OLS, FE, and RE, the environmental accounting adoption dummy is significantly positive. These results suggest that firms that have adopted environmental accounting have higher environmental performance, supporting hypothesis 1. However, based on the results of the F-test, Breusch-Pagan test, and Durbin-Wu-Hausman test, the reliability of the results of the model estimated by FE is the highest among these models. Comparing the coefficients

among the models, the coefficient of model OLS is 19.322, that of model FE is 6.434, and that of model RE is 12.831, indicating that the effect estimated by FE is about one-third and one-half of that estimated by OLS and RE, respectively. In other words, although the results of models OLS and RE also support the hypothesis, a large portion of the effects of the introduction of environmental accounting in those models are firm-specific effects that are not visible (in model OLS, there is still room to control for firm-specific effects that are not visible), and the effects of the introduction of environmental accounting estimated by OLS and RE are overestimated.

In the model with the highest reliability FE, in addition to the dummy for the introduction of environmental accounting, the dummy for the introduction of environmental management and the logarithm of total assets are also significantly positive. The results suggest that environmental performance is higher for firms that have introduced environmental management and for firms that are larger in size. In particular, the fact that the environmental management introduction dummy is significantly positive (although the significance level is rather weak at 10%) indicates that there are (various) efforts to improve environmental performance other than the introduction of environmental accounting. However, its effect is also only about one-third that of the model that does not adjust for firm-specific effects.

Table 3. Effects of environmental accounting introduction on environmental performance

	Ordinary Least Squares (OLS)		**Fixed Effects (FE)**		**Random Effects (RE)**	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Environmental Accounting Introduction Dummy	19.322	0.644***	6.434	1.104***	12.831	0.844***
Environmental Management Introduction Dummy	11.933	1.099***	2.733	1.600*	7.641	1.294***
Logarithm of total assets	4.737	0.215***	4.911	1.890***	6.125	0.372***
Debt ratio	0.166	0.145	0.203	0.151	0.116	0.138
Ratio of R&D expenses to sales	5.059	5.895	15.216	11.628	17.386	8.308**
Ratio of advertising expenses to sales	34.758	16.465**	-80.384	49.461	-11.195	26.203
Corporate age	0.033	0.013**	-	-	0.052	0.025**
Constant term	-14.624	5.893**	8.269	23.505	-29.457	5.195***
Adjusted R^2/Adjusted R^2 (Overall)			0.711	0.253		0.693
Number of observations			1895	1895		1895
F-test (p-value)				0.000		
Breusch-Pagan test (p-value)				0.000		
Durbin-Wu-Hausman test (p-value)				0.000		

Note: *** means significant at the 1% level, ** means significant at the 5% level, and * means significant at the 10% level

Table 4. Effects of environmental accounting introduction and environmental performance on productivity

	Ordinary Least Squares (OLS)		**Fixed Effects (FE)**		**Random Effects (RE)**	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Environmental Performance Score	-0.004	0.003	0.003	0.002*	0.002	0.001*
Environmental Accounting Introduction Dummy	0.251	0.111**	-0.051	0.065	-0.045	0.062
Environmental Management Introduction Dummy	-0.084	0.161	0.212	0.093**	0.185	0.090**
Logarithm of total assets	0.152	0.034***	0.173	0.110	0.169	0.051***
Debt ratio	0.007	0.021	-0.015	0.009*	-0.014	0.009*
Ratio of R&D expenses to sales	-1.241	0.837	0.666	0.677	0.211	0.629
Ratio of advertising expenses to sales	7.856	2.341***	3.066	2.881	6.193	2.476**
Corporate age	-0.007	0.002***	-	-	-0.006	0.004
Constant term	0.274	0.838	-1.260	1.368	-0.165	0.743
Adjusted R^2/Adjusted R^2 (Overall)		0.297		0.010		0.303
Number of observations		1895		1895		1895
F-test (p-value)					0.000	
Breusch-Pagan test (p-value)					0.000	
Durbin-Wu-Hausman test (p-value)					0.733	

Note: *** means significant at the 1% level, ** means significant at the 5% level, and ** means significant at the 10% level

Estimation results for the effects of environmental accounting introduction and environmental performance on productivity are in Table 4. In model OLS, the environmental accounting adoption dummy is significantly positive, but the environmental performance score is not statistically significant. This result suggests that productivity is higher for firms that have adopted environmental accounting. On the other hand, in models FE and RE, the environmental performance score is significantly positive, but the environmental accounting introduction dummy is not statistically significant. This result suggests that productivity is higher for firms with higher environmental performance. Although the estimation results differ by model, according to the results of the F-test, Breusch-Pagan test, and Durbin-Wu-Hausman test, the estimation results by RE in the model are the most reliable. Therefore, hypothesis 2b is supported in practice.

In the OLS estimation of the model, the introduction of environmental accounting can be interpreted as directly increasing productivity, while in models FE and RE, the introduction of environmental accounting can be interpreted as indirectly increasing productivity through environmental performance. However, it can be seen that the effect of the introduction of environmental accounting is considerably overestimated because the correlation between the introduction of environmental accounting and the increase in productivity in the OLS estimation is a sham correlation. In other words, although the introduction of environmental accounting increases productivity, most of the direct effects are due to firm-specific effects that are not visible. However, even adjusting for this (although the significance level is rather weak at 10%), there are at least some indirect effects through environmental performance.

The dummy for the introduction of environmental management is not statistically significant in model OLS but is significantly positive in models FE and RE. In practice, it is difficult to believe that environmental accounting alone can increase productivity as in model OLS, so the results of models FE and RE are plausible from the perspective of practice since there are (various) efforts to increase productivity while improving environmental performance other than the introduction of environmental accounting. However, the FE in the model has a slightly larger effect on environmental performance and the introduction of environmental management than the RE in the model, although it cannot be said to be an overestimation.

Furthermore, in the most reliable model RE, in addition to the environmental performance score and the dummy for the introduction of environmental management, the logarithm of total assets, and the ratio of advertising expenses to sales are significantly positive, and the ratio of debt to sales is significantly negative. The results suggest that productivity is higher for firms with the larger size, higher consumer relevance, and lower debt ratios.

5. DISCUSSION AND CONCLUSION

The purpose of this paper was to explore the potential of sustainability accounting as a means to promote the SDGs. If the introduction of sustainability accounting can bring about a balance between the environment and the economy in corporate activities, it can be an incentive for many companies to introduce sustainability accounting, and as a result, the SDGs should be promoted. Therefore, in this paper, we quantitatively analyzed the relationship between the introduction of environmental accounting, environmental performance, and productivity, which is one of the sustainability accounting methods, using the data of companies listed on the National Stock Exchange from 2011 to 2020, and demonstrated the compatibility between the environment and the economy. In doing so, by estimating not only OLS but also FE and RE, we also verified how many of the effects perceived as the effects of introducing environmental accounting are actually company-specific. The main analysis results are as follows.

First, it is clear that the introduction of environmental accounting enhances environmental performance. Therefore, quantitative information on environmental costs and effects on environmental conservation obtained from environmental accounting works well to enhance environmental performance. Since environmental accounting is only visualized as quantitative information, it can be said that efforts based on the information enhance environmental performance rather than that the introduction of environmental accounting itself enhances environmental performance. In other words, it can be understood that visualization leads to improvements in areas that were previously overlooked, and as a result, environmental performance can be enhanced. The finding that the primary effect of improving environmental performance can be achieved is important because companies do not need to introduce environmental accounting if their only objective is to reduce costs.

On the other hand, as mentioned earlier, the environmental performance score obtained from the National CSR Database (environmental section), which is a variable that captures environmental performance, is evaluated after taking into account the introduction of environmental accounting in the first place. Therefore, even if data from one year ago were used as the variable for the introduction of environmental accounting, we cannot completely deny the suspicion that the introduction of environmental accounting enhances environmental performance because it is largely derived from the characteristics of the data. However, since the National CSR Database (environment section) clearly indicates the distribution of scores related to the introduction of environmental accounting, we additionally conducted an analysis adjusting the distribution of scores, but the results remained almost the same. Therefore, although the data is second best from the viewpoint of availability, it is considered that the introduction of environmental accounting enhances environmental performance to some extent. However, the robustness of the results is an issue for the future.

At the same time, it became clear that there are (various) efforts to enhance environmental performance other than the introduction of environmental accounting (and related efforts). This result is probably plausible from a practical point of view, since not all firms have introduced environmental accounting, and it cannot be said that firms that have not introduced environmental accounting cannot improve their environmental performance. In addition, the environmental management system, which is a proxy variable for various environmental conservation efforts, is a framework for promoting environmental conservation efforts through the PDCA cycle in the first place, suggesting the possibility that continuous efforts are necessary.

However, the effects of the introduction of environmental accounting and other environmental conservation efforts may not actually be very large. This is because if the invisible, company-specific effects that affect both the introduction of environmental accounting and other environmental conservation efforts and environmental performance are adjusted for, the respective effects are reduced to about one-third. Conversely, if they were not adjusted for, they would be taken as effects of environmental accounting and other environmental conservation efforts. This indicates that companies that improve their environmental performance have such capabilities and attributes by nature, and that their portion may be very large. However, even after adjusting for this, it is still a significant finding that the introduction of environmental accounting and other environmental conservation efforts enhances environmental performance. It can be said that firm-specific capabilities and attributes are not sufficient to enhance environmental performance and that the

introduction of environmental accounting and other environmental conservation efforts play a complementary role.

Second, it is clear that the introduction of environmental accounting increases productivity indirectly through improved environmental performance. Although it is not necessary to introduce environmental accounting if the only purpose is to increase productivity (or reduce costs), it is still noteworthy that it results in increased productivity. Therefore, quantitative information on environmental costs and their effects on environmental conservation obtained from environmental accounting works well to increase productivity. In other words, the quantitative information from environmental accounting suggests that cleaner production-type production systems work well. For example, in the case of MFCA, the relationship between environmental performance (associated with waste reduction) and productivity may be intuitively understandable because costs are equally allocated to waste (negative products) as well as products (positive products) in proportion to their quantity. These economic benefits provide an incentive for firms to adopt environmental accounting and other environmental conservation efforts over the long term. However, environmental accounting can be interpreted as a way to increase productivity only by increasing environmental performance, rather than by increasing environmental performance and productivity independently of each other. This is consistent with the fact that environmental accounting is a method that focuses on increasing environmental performance.

However, without adjusting for firm-specific effects, it would be perceived as directly increasing productivity instead. This is a sham correlation, and most of the direct effects of the introduction of environmental accounting are due to firm-specific effects that are not visible. If we interpret the results only in terms of this (apparent) effect, we may mislead the effects of the introduction of environmental accounting. For example, a company that prioritizes cost reduction may introduce environmental accounting expecting a direct effect on productivity from the results but may decide not to do so because such an effect is not seen in reality. This is because obtaining the more accurate data needed for environmental accounting is both time-consuming and costly, as it requires complex processes to be covered and accurate cost calculations to be made. However, the main purpose of environmental accounting is to improve environmental performance, and from this point of view, such an approach is a complete waste of time and money. However, the fact that the effects of environmental accounting exist at least as indirect effects through environmental performance, even when company-specific effects are adjusted, may provide an opportunity for companies that place importance on economic effects to introduce environmental accounting with a focus on enhancing environmental performance. This is because it can be interpreted as the discovery of previously overlooked waste in terms of the "environment," which has not been taken into consideration, and the realization of production innovation in the form of increased productivity.

These results suggest that the realization of production innovation while enhancing environmental performance through the introduction of sustainability accounting is exactly the innovation expected by the SDG Compass. The results support that the introduction of sustainability accounting will provide incentives to the companies to adopt sustainability accounting because it will bring about a balance between the environment and the economy, and will be an opportunity for the SDGs to be promoted. As companies are expected to contribute to the SDGs, they should be able to do so in a way that also benefits their core business. In this paper, we have clarified these possibilities through empirical analysis using data and proved that they can be generalized. Therefore, it can be said that this paper has brought new knowledge about the approaches of companies in the SDGs era and the way sustainability accounting should be done.

5.1 Limitations

However, this paper also has the following limitations. First, although sustainability accounting is a collection of various accounting methods, this paper focuses on environmental accounting as a major component and does not cover environmental reporting (sustainability reporting), which is another aspect of sustainability accounting, even though it is important from the perspective of balancing the environment and the economy. However, since the focus of this paper was on increasing productivity among the economic aspects, it would not be a major problem even if environmental reporting is not included in the scope of this paper. On the other hand, since the functions of environmental accounting include not only internal and external functions, but also methods and boundaries for calculating environmental costs, effects on environmental conservation, and economic effects from measures taken to achieve them are not standardized, the introduction of environmental accounting is treated uniformly and simplified in this paper, which may not adequately capture the functions for environmental performance and productivity. For further elaboration, it would be necessary to focus on MFCA and other functions specific to internal functions, or to consider boundaries including the supply chain, but even so, in light of the results of this paper, it is considered that these functions are picked up to some extent. It is expected that these limitations will be clarified in future studies.

5.2 Future research

Finally, we would like to discuss some policy recommendations on sustainability accounting. Under such circumstances, corporate action guidelines such as the SDG Compass are indispensable for companies to address the SDGs, but the role of sustainability accounting has not been considered so far. On the other hand, the results of this paper suggest that sustainability accounting has the potential to fully contribute to the SDGs. In light of the above, the inclusion of sustainability accounting in the corporate action guidelines will not only help promote the SDGs but also provide a good opportunity for sustainability accounting (environmental accounting), the role of which has been decreasing in the number of companies that have adopted it, to be reconsidered. In addition, if environmental accounting guidelines and environmental management accounting method workbooks are restructured in relation to the corporate action guidelines of the SDGs, it is expected to have a greater effect in India. We hope that this paper will serve as a starting point.

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APPENDIX

End Notes

(1) General environmental costs.

(2) An environmental management accounting method that tracks the flow (flow) of raw materials (materials) within a production process in monetary and physical units and calculates costs (costs) by considering not only the products (positive products) produced by the process but also waste as a type of product (negative products) [31].

(3) Amount of investment and cost for prevention, control or avoidance of environmental impact, elimination of impact, restoration of damage caused, or efforts contributing to these [7].

(4) The United Nations Global Compact is a voluntary initiative to participate in the creation of a global framework for sustainable development, and the companies that have signed it are implementing various initiatives under the commitment of top management to meet the ten principles on human rights, labor, the environment, and anti-corruption measures. Therefore, while the signing of the United Nations Global Compact is considered to have an impact on the introduction of environmental accounting and environmental performance, it is unlikely to have a direct impact on productivity, which is why it was used as a control variable.

(5) Since the reduction in sample size caused by the availability of data may have contributed to this trend, we relaxed this restriction by restricting the sample to firms for which environmental accounting adoption and environmental performance data were available and looked at the distribution in the same way, but the result remained the same, at least in terms of a significant decrease in the proportion of firms adopting environmental accounting compared to the 2011 and 2020 data.

(6) Others include those that follow company-specific and industry-specific standards.

(7) Due to the availability of data, many of the sampled firms are actively involved in the environment.