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An Empirical Analysis of the Impact of Human Capital as an Intangible Asset on Environmental Performance

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ABSTRACT

This study empirically examines the impact of human capital as an intangible asset on environmental performance. Human capital is defined in a broad sense as employees' ability to perform their jobs and labor force, which are indispensable to organizations, and environmental performance is defined as the outcome of a company's efforts to meet or exceed society's expectations on environmental issues. In this study, we propose the hypothesis that human capital as an intangible asset enhances environmental performance and conduct an empirical analysis using three years (2020-2022) of published data from the Ministry of Environment's Environmental Management Practices Survey, following the validation model of Usman, Wirawan, and Zulkifli. Specifically, a regression analysis was conducted using a proxy variable for environmental performance using the Environmental Management Practices Survey data as the explained variable, and three proxy variables for human capital, which were defined from the firm's sales, total assets, and total number of employees, as the explanatory variables. In addition to the main validation on the total number of employees, the analysis included a quartile-split validation based on the total number of employees and an additional validation to account for the effect of outliers. The results of these tests support the hypothesis that human capital as an intangible asset has a positive impact on environmental performance.

1. INTRODUCTION

The purpose of this study is to empirically examine the impact of human capital as an intangible asset on environmental performance. Specifically, the hypothesis that human capital has a positive impact on environmental performance is empirically examined using published data. The background of this research is that the need for corporate environmental management initiatives has been increasing in recent years, and that research on intangible assets has increased in the fields of economics and business administration. First, as for the growing interest in environmental management, countries that agreed to the Kyoto Protocol, which came into effect in 2005, are striving to achieve their greenhouse gas emission reduction targets, and the United States and China, which did not agree to the Kyoto Protocol, announced specific reduction targets in November 2014, indicating a significant movement on a global scale. In the midst of these trends, companies are required to act in an environmentally conscious manner, as their environmentally conscious efforts and results are evaluated by various stakeholders outside the company, and management within the company must also respond to these evaluations. Especially in the manufacturing industry, the development, manufacture, and sale of environmentally conscious products are considered to be important as a way to actively develop measures to deal with environmental problems and to make these measures visible to external stakeholders. Focusing on Indian companies, it is clear that they are actively engaged in environmental management, as approximately 70% of Indian companies are making some sort of effort to address global warming and approximately 60% of them have already started or indicated their intention to start environmentally friendly activities. As explained in studies [1, 2], environmental management is being more actively addressed in the manufacturing industry. Specifically, companies as a whole are aware of environmental risks and are developing environmentally friendly products with the aim of reducing environmental impacts through their products. In addition, external reporting such as environmental reports and environmental labels are actively implemented to increase consumer awareness of environmentally conscious activities

and to encourage green purchasing. Especially in the manufacturing industry, it is easy to calculate the amount of carbon dioxide emissions based on the product life cycle from the process of development, manufacturing, and sales of environmentally friendly products, so there is a tendency to disclose quantitative environmental information to the outside world and to provide more reliable environmental reports.

Regarding the relationship between the intangible asset human capital and environmental performance, researchers [3, 4] revealed that the contribution of employees is significantly involved in the process of enhancing environmental performance. Specifically, Priede [3] explained that when a company introduced the ISO 9001 environmental management standard, the participation of highly qualified employees who were educated and trained in environmental management in the manufacturing process had a significant effect on reducing waste and pollutants in the manufacturing stage. In addition, He et al. [4] mention that new technologies and systems in environmentally friendly products are nothing but the convergence of good ideas obtained from talented employees. Here, it was revealed that the development and manufacturing of environmentally friendly products are realized by including them in the company-wide decision-making process.

From the above, it can be said that the ability of employees, i.e., their knowledge of the product, their understanding of the manufacturing process, their ability to formulate and implement specific plans, and their ability to pass on their knowledge and skills to future generations, greatly contributes to the development, manufacture, and sale of environmentally friendly products, and thus as a result, it can be said to enhance environmental performance. Therefore, based on the above discussion, this study focuses on the manufacturing industry and empirically examines the relationship between the intangible asset human capital and environmental performance.

The environmental performance discussed in this study refers to the awareness of firms regarding environmental issues and their efforts and achievements in developing, manufacturing, and selling environmentally friendly products. In this study, we refer to Fuzi et al. [5] and define it as the results of the firm's efforts to meet or exceed society's expectations on environmental issues. As proxy variables for environmental performance, three types of variables are created utilizing data from the survey "Environmental Management Practices Survey" conducted by the Ministry of Environment.

On the other hand, regarding human capital as intangible assets, which is the main focus of this study, we define human capital in a broad sense as employees' job performance and labor force, which are indispensable to organizations. As background to the growing research on intangible assets, in the economics and management fields [6, 7], human capital is defined as the ability to acquire and develop, replicate and accumulate, and it is considered as one of the intangible assets defined as the source of a firm's competitive advantage that is difficult for competitors to imitate, and it is explained to have a role in influencing firm performance and maintaining competitive advantage. Therefore, in this study, we focus on human capital as an intangible asset as a factor affecting firm performance. As proxy variables for human capital, we use three variables defined from the firm's sales, total assets, and total number of employees.

As described above, regression analysis was conducted using the least squares method with a proxy variable for environmental performance using data from the Environmental Management Practices Survey as the explained variable and three proxy variables for human capital, the explanatory variable, defined from the sales, total assets, and total number of employees of the firm. In addition to the main validation on the total number of employees, additional validation was conducted by dividing the results into quartiles based on the total number of employees and by taking into account the effect of outliers. The results of these tests support the hypothesis that human capital as an intangible asset has a positive impact on environmental performance. The results of the empirical analysis of the relationship between human capital and environmental performance support the hypothesis that human capital has a positive impact on environmental performance.

This paper is organized as follows. Section two presents the hypotheses and research design. Section three describes the data and sample used, and section four presents descriptive statistics and correlation coefficients. Section five presents the results of testing the hypothesis that human capital has a positive impact on environmental performance using the environmental performance data from the Environmental Management Practices Survey and three proxy variables for human capital defined using firm sales, total assets, and total number of employees. Finally, section six provides a summary of this study and future research questions.

2. HYPOTHESIS AND RESEARCH DESIGN

2.1 Existing studies and hypotheses

In this section, we present a hypothesis based on an example of existing research on the relationship between human capital and environmental performance. While there are a relatively large number of studies on the impact of human capital on financial performance, research on the impact of human capital on social responsibility performance, including environmental performance, is still in its developmental stage. For example, researchers [4, 8-10] found that human capital is a factor that affects not only financial performance but also social responsibility performance including environmental performance. In particular, with regard to environmental performance, Usman et al. [10] found that among a firm's management resources, employees are important in the development stage of environmentally friendly products. Consistent with this theoretical relationship, the following is an example of a study.

First, Ling and Jaw [8] revealed that human capital influences corporate social responsibility performance because employees' sharing of environmentally conscious management strategies increases their awareness of environmental considerations, which leads to the development of environmentally conscious products. Next, Priede [3] found in a case study that firms that introduced environmental management standards were able to achieve reductions in waste and pollutants in the manufacturing stage through the contributions of their employees. Kunz [11] also found that high employee motivation and social responsibility performance, including environmental performance, of the firm have a positive mutual impact.

As the importance of addressing environmental protection issues grows, companies are actively addressing these issues, and the process of developing, manufacturing, and marketing environmentally friendly products in addition to traditional products is becoming more important as a way of making these efforts visible to external stakeholders. This requires the use of materials and changes in manufacturing processes that reduce environmental impact and requires employees assigned to these processes to deepen their knowledge of environmentally friendly products and their understanding of the manufacturing process. Companies will therefore make an effort to educate their employees and share their awareness of environmental issues. Priede [3] also notes the importance of compensation systems for human capital that affect environmental performance and cites the example of a profit-sharing program that provides bonuses to employees who have made significant contributions, especially in terms of environmental measures.

Thus, productivity can be increased by educating employees involved in the development and manufacture of environmentally friendly products in addition to conventional products, by using a devised compensation system that evaluates each employee's job performance and his or her productivity, and by stimulating employee awareness of environmental considerations. The resulting development of more advanced environmental technologies will satisfy the demands of customers who are active in green purchasing and can be considered to enhance environmental performance as a result of the company's efforts to meet or exceed society's expectations regarding environmental issues. Based on the above discussion, the following hypotheses are formulated for this study.

Hypothesis: Human capital positively affects environmental performance.

2.2 Research design

In this study, we follow Usman et al. [10] to test the hypothesis that human capital enhances environmental performance in the Indian manufacturing industry. Although there are existing studies that have demonstrated the impact of intangible assets on social responsibility performance including environmental performance and the impact of intangible assets on financial performance, they have examined in detail the impact of intangible assets on both environmental and financial performance in recent studies, so this study adopts the verification model of the study [10].

Specifically, the following Eq. (1) is estimated by the least squares method with environmental performance (ECON) as the explained variable and human resources as the explanatory variable. As control variables, we use financial leverage, the ratio of fixed assets to total assets (physical resources), the ratio of cash flow to sales (financial resources), and firm size (size). In Eq. (1), α is the constant term, and β_1, β_2, β_3, β_4, and β_5 are the coefficients of each variable. ε_i is the error term. Subscripts indicating time points are omitted.

$$ECON_i = \alpha + \beta_1 Human\ resources_i + \beta_2 Leverage_i + \beta_3 Physical\ resources_i + \beta_4 Financial\ resources_i + \beta_5 Size_i + \varepsilon_i \quad (1)$$

Next, we explain the explanatory variable in Eq. (1), human resources. In this study, we consider marginal labor productivity as a measure of human capital and create three proxy variables based on existing studies. First, we use human resources1 expressed in Eq. (2).

$$Human\ resources1i = b_i \frac{Net\ sales\ of\ company\ i}{Total\ number\ of\ employees\ in\ firm\ i} \quad (2)$$

This human resources1 is based on the study of Yilmaz and Acar [12], and b_i is estimated based on the Cobb-Douglas type production function shown in Eq. (3) below.

$$Net\ sales\ of\ firm\ i = c(Total\ assets\ of\ firm\ i)^a (Total\ number\ of\ employees\ in\ firm\ i)^b \quad (3)$$

In other words, estimates are made for each industry to control for differences by the industry to which each firm belongs, and human resources1 defined by Eq. (2) are calculated from these values. The specific calculation process is as follows. First, the logarithm of both sides of Eq. (3) is taken to form Eq. (4). Then, by estimating Eq. (4) using the least squares method, the coefficient b_i of the total number of employees of firm i is estimated for each industry. In estimating the coefficient b_i for each industry, the industry classification is based on the Bombay Stock Exchange Industrial Classification.

$$\log(Net\ sales\ of\ firm\ i) = \log(c) + a \log(Net\ sales\ of\ firm\ i) + b \log(Total\ number\ of\ employees\ in\ firm\ i) \quad (4)$$

The second proxy variable for human capital is defined as in Eq. (5) below, which is log-transformed by dividing each firm's sales by the total number of employees [13, 14]. The reason for the log transformation is that this ratio of labor productivity is highly skewed. The log-transformed value of sales per employee defined in this way is used as the second proxy variable for human capital and is denoted as human resources2.

$$Human\ resources2i = log\left(\frac{Net\ sales\ of\ company\ i}{Total\ number\ of\ employees\ in\ firm\ i}\right) \quad (5)$$

The third human capital proxy variable is Human resources3 as sales per employee as in Eq. (6) [13, 15, 16].

$$Human\ resources3i = \frac{Net\ sales\ of\ firm\ i}{Total\ number\ of\ employees\ in\ firm\ i} \quad (6)$$

Finally, the control variables in Eq. (1), i.e., leverage, physical resources, financial resources, and size [10], a study that demonstrated the impact of intangible assets on both financial performance and social responsibility performance. Financial resources is based on the study of Sameer [17], but since cash flow is regarded as the liquidity of a company, cash flow is the sum of operating cash flow, investment cash flow, and financial cash flow. Specifically, we define the respective control variables as Eqs. (7)-(10) below.

$$Leverage_i = \frac{Total\ liabilities\ of\ firm\ i}{Firm\ i's\ equity + Firm\ i's\ total\ liabilities} \quad (7)$$

$$Physical\ resources_i = \frac{Total\ fixed\ assets\ of\ firm\ i}{Total\ assets\ of\ firm\ i} \quad (8)$$

$$Financial\ resources_i = \frac{Total\ cash\ flows\ of\ firm\ i}{Net\ sales\ of\ firm\ i} \quad (9)$$

$$Size_i = log(Total\ number\ of\ employees\ in\ firm\ i) \quad (10)$$

In this estimation of Eq. (1), when β_1 is positive and statistically significant, it means that the higher the job performance and productivity of the firm's human capital, the higher the environmental performance, which supports the hypothesis of this study.

The control variable follows the validation model [10], where leverage is the debt ratio, which measures the debt utilization ratio of a company. Conversely, a smaller value indicates a higher degree of safety, which means that the company can invest in new projects that are directly related to environmentally friendly corporate activities. Based on the above discussion, we expect β_2 to be negative because environmental performance is considered to increase when the value of leverage is small. The physical resources indicates the ratio of fixed assets to total assets, and β_3 is expected to be positive because a high ratio of fixed assets such as buildings, equipment, and land is expected to enhance environmental performance through the development and manufacturing of new products by having sufficient assets that are held for the long term and not for trading purposes. The financial resource is a proxy for total cash flow as a percentage of sales, which measures the liquidity of the firm. The higher this value is, the more resources the company has to invest in environmentally friendly corporate activities and new products, and therefore, the higher the environmental performance of the company as a result of its efforts. Based on these results, we expect β_4 to be positive. Finally, we include Size as a control variable and predict that β_5 will be positive because the larger the size of a firm, the more multifaceted and multifaceted environmental efforts by various sectors can be expected. Based on the above, we expect β_2 to be negative, β_3 to be positive, β_4 to be positive, and β_5 to be positive for the control variables. Although not shown in Eq. (1), industry dummies are also included in the estimation because environmental performance is expected to be affected by the characteristics of the industry to which the firms under analysis belong.

3. DATA AND SAMPLE SELECTION TO BE USED

3.1 Data

In Eq. (1) presented in Section 2, the explained variable ECON is a proxy variable for the environmental performance of each company to be analyzed. In this study, the proxy variable for environmental performance is created based on three years of data (2020-2022) obtained from the Environmental Management Practices Survey conducted by the Ministry of Environment.

The Environmental Management Practices Survey used in this study is a questionnaire survey aimed at evaluating how well companies are balancing environmental measures such as the reduction of greenhouse gas emissions and waste with the improvement of management efficiency. The survey mainly targets consolidated groups but also includes the results of individual responses due to the high profile of environmental management initiatives. In this study, we used the data from the manufacturing industry section of the 14th Environmental Management Survey, 15th Environmental Management Survey, and 16th Environmental Management Survey, which were released in February 2018, February 2019, and February 2020, respectively, by conducting questionnaire surveys between early September and early November 2017, early September and early November 2018, and early September and early November 2019. For example, in the 15th Environmental Management Practices Survey conducted in 2019, 765 out of 4,183 companies responded (response rate: 18.3%), of which 438 out of 1,730 companies (response rate: 25.3%) were in the manufacturing industry and 327 out of 2,543 companies (response rate: 13.3%) were in the non-manufacturing industry. As indicated by these response rates, the data from the Environmental Management Practices Survey is more reliable for the manufacturing industry than for the non-manufacturing industry, and therefore, only the Manufacturing Industry Version is included in this study.

The survey data from the Environmental Management Degree Survey consist of scores for five items (environmental management promotion system, measures against pollution and biodiversity, resource recycling, product measures, and global warming countermeasures) on a 100-point scale, and their total scores. In this study, scores representing the results of company-wide efforts were selected in order to focus on the environmental protection efforts of the entire company in the manufacturing industry. For this purpose, three types of environmental performance were selected: environmental management promotion system, product measures, and a total score of five items as an overall evaluation. The proxy variable using the total score on a 500-point scale is ECON1, the proxy variable using the score of the first item, environmental management promotion system, is ECON2, and the proxy variable using the score of the fourth item, product measures, is ECON3. These items were chosen because ECON1, which is a total score, has the advantage of comprehensively measuring a company's performance from the five aspects of environmental management. Second, the proxy variable ECON2 is a score that measures a company's environmental management promotion system based on questions on the status of target management of environmental activities and the establishment of a system of initiatives in the company and its group companies, and therefore, it was selected as the result of scoring a company's understanding, consideration, and attitude toward specific initiatives regarding its interest in environmental issues. The ECON3 score was selected based on the assumption that it is the result of scoring a company's interest in environmental issues, its understanding, consideration, and attitude toward specific initiatives. Finally, the proxy variable ECON3 was selected based on whether the company has defined environmentally friendly products and services, whether it has introduced life cycle assessment methods, whether it uses environmentally friendly containers and packaging, whether used products can be recycled, and whether it can procure goods and services in a green manner. The results were selected as appropriate as a proxy variable because they can measure corporate awareness of the development, manufacturing, and sales of environmentally friendly products.

On the other hand, the other three items, i.e., Pollution and Biodiversity Control, Resource Recycling, and Global Warming Prevention, consist of detailed questions on individual aspects and represent the extent of efforts to reduce emissions of specific substances and their reduction measures. As mentioned above, in order to focus on the environmental protection efforts of the entire company, we have selected scores that represent the results of company-wide efforts. Although these three items provide detailed information on

specific substances and their reduction status, they do not show the results of company-wide environmental protection efforts[1]. As a result, the scores for the environmental management promotion system and product measures, which are considered to be questions about company-wide efforts as a manufacturer and not questions about specific substances, and the total score of the five items as the overall score are used in this analysis.

Existing research on Indian companies using survey aggregate data from Environmental Management Practices Survey as proxy variables for environmental performance include [18-20]. For example, Sudha [18] examined the impact on financial performance by using the total score of 5 items in the Environmental Management Degree Survey as a proxy variable for environmental performance, and by using the return on equity, return on total assets, return on investment, and return on sales as proxy variables.

3.2 Sample selection

In this study, as described in Section 3.1, the environmental performance of the explained variable is based on the survey results of the Environmental Management Survey. To create explanatory variables, we collected data from Bloomberg. The period covered by this study was the period during which the Environmental Management Practices Survey was conducted, i.e., the 14th Environmental Management Survey, 15th Environmental Management Survey, and 16th Environmental Management Practices Survey were conducted from early September to early November in 2017, 2018, and 2019, respectively, which is the period when the environmental performance data were collected. Therefore, the financial data were limited to one year prior to the implementation period of each survey, i.e., from September 2016 to August 2019, and data for all manufacturing industries included in the survey were collected. As mentioned in Section 3.1, the Environmental Management Degree Survey includes some results of individual responses, but since the main target of the survey is consolidated groups, the financial data is also based on consolidated financial statements, which are appropriate. As a result, 1,044 observations were obtained. Table 1 below shows the breakdown by industry of the observed values for which both financial data and environmental performance were obtained, which were collected during the implementation period of the 14th Environmental Management Survey, 15th Environmental Management Survey, and 16th Environmental Management Survey. The industry classification is based on the Bombay Stock Exchange Industrial Classification. In order to remove the influence of outliers, values in the upper and lower 1% of the data were removed for all variables used in the analysis except for environmental performance, as is done in many empirical analyses.

4. DESCRIPTIVE STATISTICS AND CORRELATION COEFFICIENTS

4.1 Descriptive statistics

Table 2 shows descriptive statistics for all proxy variables used in this study. Three proxy variables for environmental performance, the explained variable, were created from the data of the 14th Environmental Management Survey, the 15th Environmental Management Survey, and the 16th Environmental Management Survey. The explanatory variables consisted of proxy variables created from financial data for the period of the Environmental Management Survey. Table 2 was prepared after processing outliers.

4.2 Correlation coefficient

Table 3 shows the correlation coefficients among all the proxy variables listed in Table 2. Regarding the correlation between environmental performance and human capital proxy variables, the correlation coefficients between ECON1 and the three human capital proxy variables are -0.064, 0.018, and 0.003, respectively, but only the correlation coefficient between ECON1 and Human resources1 is statistically significant at the 5% significance level. Next, the correlation coefficients with ECON2 are similarly -0.039, 0.033, and 0.011, and none of the results are statistically significant. Finally, the correlation coefficients between ECON3 and the three types of human capital are -0.125, -0.033, and -0.040, respectively, and only the correlation coefficient between ECON3 and Human resources1 is statistically significant at the 5% level.

These results indicate that the correlations between environmental performance and the proxy variables for human capital, human resources1, human resources2, and human resources3, which are represented by ECON1, ECON2, and ECON3, respectively, are relatively weak. The correlation between the size of the firm and the three types of environmental performance, which is used as a control variable, suggests that the larger the size of the firm, the higher its environmental performance. Weak negative correlations were found between the size of the firm and the three types of human capital.

In summary, we obtained these results for the correlation coefficients between environmental performance and human capital for the univariate. Although multiple regression analysis is used in this study to test the hypothesis, it is clear from the correlation coefficients between ECON1 and Human resources1 and between ECON3 and Human resources1 that a positive correlation between environmental performance and human capital is not always observed in a simple regression analysis.

In this study, the Variance-Inflation Factor (VIF) was calculated to examine the degree of collinearity among the explanatory variables; a VIF greater than 10 is considered problematic for multicollinearity, but the results of the regression analysis in this study are much smaller than this criterion. Therefore, we can conclude that multicollinearity in this study is not a problem in the estimation of the model.

5. EMPIRICAL RESULTS AND CONSIDERATIONS

5.1 Empirical results and discussion for total employees

This section presents the results of testing the hypothesis that human capital enhances environmental performance. Table 4 shows the results of regressing the environmental performance proxy variables ECON1, ECON2, and ECON3 on the human capital proxy variables Human resources1.

Table 1. Breakdown of the sample by industry

	Before Outlier Processing		After Outlier Processing	
Industry	**Frequency**	**%**	**Frequency**	**%**
1 Food products	79	7.57	74	7.76
2 Textiles	34	3.26	32	3.36
3 Pulp & Paper	16	1.53	15	1.57
4 Chemicals	172	16.48	170	17.84
5 Pharmaceuticals	47	4.5	35	3.67
6 Petroleum	8	0.77	0	0
7 Rubber	22	2.11	22	2.31
8 Ceramics	11	1.05	11	1.15
9 Iron and Steel	30	2.87	29	3.04
10 Nonferrous Metal Products	49	4.69	46	4.83
11 Machinery	144	13.79	133	13.96
12 Electrical Equipment	244	23.37	209	21.93
13 Shipbuilding	6	0.57	5	0.52
14 Automobiles	83	7.95	83	8.71
15 Transportation Equipment	5	0.48	5	0.52
16 Precision Equipment	36	3.45	32	3.36
17 Other Manufacturing	58	5.56	52	5.46
Total	1044	100	953	100

Table 2. Descriptive statistics of the sample

	Frequency	Average	S.D.	Minimum Value	1st Quartile	Median	3rd Quartile	Maximum Value
Explained Variables								
ECON1	953	353.619	82.516	73	304	367	413	496
ECON2	953	68.719	18.041	10	57	71	83	100
ECON3	953	65.478	21.417	10	51	68	83	100
Explanatory Variables Human resources1	953	8.337	5.493	0.675	4.426	6.902	11.149	28.260
Human resources2	953	3.425	0.566	1.675	3.064	3.417	3.839	4.840
Human resources3	953	35.850	20.608	5.340	21.421	30.463	46.497	126.414
Leverage	953	0.509	0.183	0.121	0.376	0.502	0.657	0.911
Physical resources	953	0.457	0.105	0.176	0.386	0.463	0.527	0.710
Financial resources	953	0.010	0.042	-0.155	-0.013	0.007	0.032	0.138
Size	953	8.700	1.411	5.394	7.692	8.614	9.738	11.595

Table 3. Sample correlation coefficients

	1	2	3	4	5	6	7	8	9	10
1. ECON1	1									
2. ECON2	0.860*	1								
3. ECON3	0.898*	0.724*	1							
4. Human resources1	-0.064*	-0.039	-0.125*	1						
5. Human resources2	0.018	0.033	-0.033	0.815*	1					
6. Human resources3	0.003	0.011	-0.040	0.841*	0.933*	1				
7. Leverage	0.170*	0.167*	0.192*	-0.027	0.090*	0.081*	1			
8. Physical resources	0.098*	0.128*	0.069*	0.157*	0.237*	0.280*	0.215*	1		
9. Financial resources	-0.039	0.008	-0.078*	-0.012	0.006	-0.025	-0.117*	-0.125*	1	
10. Size	0.660*	0.610*	0.622*	-0.180*	-0.129*	-0.120*	0.311*	0.152*	-0.067*	1

* indicates statistically significant at the 5% significance level.

Table 4. Verification results for the total employees

	ECON1			ECON2			ECON3		
Human resources1	2.728 [4.19]***			0.498 [3.14]***			0.637 [3.59]***		
Human resources2		27.274 [5.60]***			5.472 [4.59]***			6.223 [4.81]***	
Human resources3			0.572 [4.09]***			0.105 [3.03]***			0.137 [3.60]***
Leverage	-26.458 [-2.16]**	-33.265 [-2.70]***	-27.227 [-2.22]**	-4.571 [-1.57]	-6.118 [-2.07]**	-4.726 [-1.61]	-4.617 [-1.38]	-6.115 [-1.80]*	-4.862 [-1.44]
Physical resources	21.862 [0.94]	27.710 [1.19]	21.454 [0.92]	11.649 [2.17]**	12.788 [2.38]**	11.572 [2.15]**	1.581 [0.24]	2.926 [0.44]	1.471 [0.22]

Financial resources	-1.576	-11.545	-2.680	23.885	21.872	23.681	-20.546	-22.816	-20.815
	[-0.03]	[-0.26]	[-0.06]	[2.16]**	[1.99]**	[2.13]**	[-1.55]	[-1.73]*	[-1.58]
Size	38.751	38.740	38.664	7.878	7.886	7.863	9.002	8.997	8.985
	[24.02]***	[24.30]***	[23.96]***	[22.13]***	[22.33]***	[22.08]***	[22.32]***	[22.34]***	[22.20]***
Intercept	-0.557	-71.551	3.345	-5.496	-20.090	-4.806	-15.338	-31.432	-14.519
	[-0.03]	[-3.17]***	[0.19]	[-1.33]	[-3.79]***	[-1.18]	[-3.45]***	[-5.32]***	[-3.30]***
Industry dummy	Yes	yes	yes	yes	yes	yes	yes	yes	yes
Adjusted determination coefficient	0.473	0.480	0.472	0.393	0.401	0.393	0.430	0.436	0.430
Sample size	953	953	953	953	953	953	953	953	953

The upper panel indicates the coefficients in the estimating equation, and the numbers in [ ] in the lower panel indicate the t-values.
* indicates statistically significant at the 10% significance level, ** indicates statistically significant at the 5% significance level, and *** indicates statistically significant at the 1% significance level.

Table 5. Empirical results divided into quartiles based on the total number of employees

Panel A. Validation results for the first quartile based on the total number of employees

	ECON1			**ECON2**			**ECON3**		
Human resources1	2.342			0.096			0.565		
	[1.85]*			[0.30]			[1.57]		
Human resources2		19.808			-0.758			5.685	
		[1.39]			[-0.25]			[1.60]	
Human resources3			0.475			0.001			0.134
			[1.66]*			[0.02]			[1.68]*
Leverage	-50.035	-50.189	-49.365	-0.656	-0.258	-0.466	-14.115	-14.386	-14.130
	[-1.96]*	[-1.97]*	[-1.93]*	[-0.11]	[-0.04]	[-0.08]	[-2.17]**	[-2.19]**	[-2.17]**
Physical resources	172.186	172.977	170.721	33.495	33.096	33.313	36.391	36.831	36.169
	[3.29]***	[3.31]***	[3.26]***	[2.82]***	[2.80]***	[2.81]***	[2.25]**	[2.28]**	[2.23]**
Financial resources	-11.084	-14.865	-13.572	17.024	16.046	16.477	-30.562	-30.998	-30.680
	[-0.14]	[-0.18]	[-0.17]	[0.87]	[0.82]	[0.84]	[-1.31]	[-1.32]	[-1.32]
Size	45.865	44.611	45.534	8.873	8.988	8.909	9.080	8.676	8.946
	[5.45]***	[5.28]***	[5.38]***	[4.17]***	[4.20]***	[4.17]***	[3.76]***	[3.54]***	[3.66]***
Intercept	-140.164	-181.195	-135.101	-18.971	-16.737	-18.637	-31.340	-43.498	-30.255
	[-2.37]**	[-2.64]***	[-2.28]**	[-1.24]	[-1.01]	[-1.21]	[-1.70]*	[-2.17]**	[-1.62]
Industry dummy	Yes	yes	yes	yes	yes	yes	yes	yes	yes
Adjusted determination coefficient	0.366	0.363	0.364	0.278	0.278	0.277	0.271	0.271	0.272
Sample size	238	238	238	238	238	238	238	238	238

The upper panel indicates the coefficients in the estimating equation, and the numbers in [ ] in the lower panel indicate the t-values.
* indicates statistically significant at the 10% significance level, ** indicates statistically significant at the 5% significance level, and *** indicates statistically significant at the 1% significance level.

Panel B. Validation results for the second quartile based on the total number of employees

	ECON1			**ECON2**			**ECON3**		
Human resources1	4.986			1.277			1.010		
	[4.11]***			[4.10]***			[3.52]***		
Human resources2		46.953			12.001			8.548	
		[4.58]***			[4.52]***			[3.48]***	
Human resources3			1.180			0.291			0.254
			[4.39]***			[4.19]***			[4.07]***
Leverage	-32.042	-44.210	-35.993	-12.746	-15.845	-13.530	-10.000	-11.794	-11.115
	[-1.08]	[-1.49]	[-1.22]	[-1.81]*	[-2.28]**	[-1.93]*	[-1.29]	[-1.50]	[-1.43]
Physical resources	44.729	51.548	44.882	25.777	27.515	25.731	14.185	15.242	14.333
	[0.93]	[1.08]	[0.95]	[2.48]**	[2.68]***	[2.50]**	[1.19]	[1.27]	[1.21]
Financial resources	78.601	64.954	81.485	51.702	48.215	52.428	12.049	9.593	12.652
	[0.76]	[0.62]	[0.78]	[1.96]*	[1.86]*	[1.97]**	[0.38]	[0.30]	[0.40]
Size	32.342	33.143	32.285	7.855	8.066	7.945	8.929	9.303	8.775
	[1.73]*	[1.79]*	[1.74]*	[1.93]*	[2.00]**	[1.96]*	[1.73]*	[1.81]*	[1.71]*
Intercept	40.380	-85.355	43.414	-12.884	-45.055	-12.660	-17.971	-42.015	-16.595
	[0.25]	[-0.54]	[0.27]	[-0.37]	[-1.30]	[-0.36]	[-0.42]	[-0.98]	[-0.39]
Industry dummy	Yes	yes	yes	yes	yes	yes	yes	yes	yes
Adjusted determination coefficient	0.127	0.150	0.137	0.133	0.158	0.138	0.165	0.167	0.176
Sample size	238	238	238	238	238	238	238	238	238

The upper panel indicates the coefficients in the estimating equation, and the numbers in [ ] in the lower panel indicate the t-values.
* indicates statistically significant at the 10% significance level, ** indicates statistically significant at the 5% significance level, and *** indicates statistically significant at the 1% significance level.

Panel C. Validation results for the third quartile based on the total number of employees

	ECON1			ECON2			ECON3		
Human resources1	0.988 [0.90]			0.070 [0.26]			0.255 [0.75]		
Human resources2		21.817 [2.49]**			3.653 [1.75]*			6.539 [2.34]**	
Human resources3			0.212 [0.86]			0.017 [0.29]			0.061 [0.79]
Leverage	-49.218 [-2.49]**	-54.826 [-2.76]***	-49.504 [-2.49]**	-11.461 [-2.32]**	-12.649 [-2.53]**	-11.512 [-2.31]**	-5.051 [-0.79]	-6.839 [-1.06]	-5.212 [-0.80]
Physical resources	-98.495 [-2.36]**	-96.147 [-2.30]**	-98.587 [-2.37]**	-17.911 [-1.60]	-18.039 [-1.63]	-17.975 [-1.60]	-35.150 [-2.87]***	-34.672 [-2.83]***	-35.341 [-2.89]***
Financial resources	-74.173 [-0.98]	-96.102 [-1.27]	-73.892 [-0.97]	1.044 [0.06]	-3.519 [-0.20]	0.970 [0.05]	-50.999 [-1.83]*	-57.957 [-2.06]**	-51.198 [-1.83]*
Size	45.583 [4.22]***	43.825 [4.20]***	45.622 [4.23]***	8.085 [2.93]***	7.751 [2.86]***	8.084 [2.93]***	10.476 [3.28]***	9.932 [3.24]***	10.475 [3.29]***
Intercept	-5.329 [-0.05]	-54.368 [-0.52]	-4.790 [0.05]	6.928 [0.26]	-1.274 [-0.05]	6.973 [0.26]	-15.908 [-0.52]	-30.603 [-0.99]	-15.750 [-0.52]
Industry dummy	Yes	yes	yes	yes	yes	yes	yes	yes	yes
Adjusted determination coefficient	0.172	0.198	0.172	0.077	0.092	0.078	0.150	0.176	0.150
Sample size	238	238	238	238	238	238	238	238	238

The upper panel indicates the coefficients in the estimating equation, and the numbers in [ ] in the lower panel indicate the t-values.
* indicates statistically significant at the 10% significance level, ** indicates statistically significant at the 5% significance level, and *** indicates statistically significant at the 1% significance level.

Panel D. Validation results for the fourth quartile based on the total number of employees

	ECON1			ECON2			ECON3		
Human resources1	0.929 [0.56]			0.596 [2.02]**			0.670 [2.19]**		
Human resources2		22.744 [2.86]***			7.173 [3.47]			6.487 [3.74]***	
Human resources3			0.220 [0.73]			0.138 [2.17]**			0.127 [2.15]**
Leverage	-17.752 [-0.73]	-42.239 [-1.83]*	-19.399 [-0.80]	-9.390 [-1.92]*	-15.089 [-2.81]***	-10.346 [-2.04]**	-12.079 [-2.56]**	-16.360 [-3.25]***	-12.130 [-2.44]**
Physical resources	99.760 [2.35]**	97.186 [2.25]**	98.904 [2.33]**	27.708 [2.53]**	27.349 [2.45]**	27.188 [2.48]**	16.827 [1.48]	16.697 [1.45]	16.534 [1.48]
Financial resources	68.998 [0.90]	50.466 [0.68]	68.890 [0.90]	55.624 [2.69]***	50.779 [2.51]**	55.595 [2.68]***	12.458 [0.64]	8.509 [0.44]	12.840 [0.65]
Size	23.652 [5.00]***	21.218 [4.45]***	23.484 [4.96]***	7.066 [5.18]***	6.539 [4.73]***	6.970 [5.10]***	6.998 [6.22]***	6.626 [6.08]***	7.009 [6.25]***
Intercept	125.235 [2.32]**	96.003 [1.60]	128.286 [2.39]**	-7.845 [-0.58]	-18.761 [-1.45]	-5.992 [-0.44]	-0.366 [-0.03]	-10.969 [-0.83]	0.640 [0.05]
Industry dummy	Yes	yes	yes	yes	yes	yes	yes	yes	yes
Adjusted determination coefficient	0.330	0.355	0.330	0.282	0.313	0.285	0.411	0.429	0.407
Sample size	239	239	239	239	239	239	239	239	239

The upper panel indicates the coefficients in the estimating equation, and the numbers in [ ] in the lower panel indicate the t-values.
* indicates statistically significant at the 10% significance level, ** indicates statistically significant at the 5% significance level, and *** indicates statistically significant at the 1% significance level.

Table 6. Verification results for the total employees

	ECON1			ECON2			ECON3		
Human resources1	3.390 [3.79]***			0.673 [3.20]***			0.977 [4.18]***		
Human resources2		27.054 [4.34]***			5.447 [3.74]***			8.134 [5.01]***	
Human resources3			0.676 [3.68]***			0.138 [3.08]***			0.200 [4.11]***
Leverage	-18.750 [-1.25]	-23.979 [-1.58]	-19.105 [-1.27]	-3.085 [-0.88]	-4.175 [-1.17]	-3.223 [-0.91]	-2.577 [-0.62]	-4.315 [-1.02]	-2.787 [-0.66]
Physical resources	12.118 [0.42]	14.903 [0.51]	10.412 [0.36]	15.138 [2.29]**	15.701 [2.38]**	14.794 [2.24]**	-3.505 [-0.45]	-2.658 [-0.34]	-4.004 [-0.52]
Financial resources	-68.572 [-1.09]	-76.297 [-1.22]	-71.042 [-1.13]	17.072 [1.13]	15.518 [1.03]	16.572 [1.09]	-32.764 [-1.86]*	-35.080 [-1.99]**	-33.491 [-1.89]*
Size	36.906	37.041	36.826	7.750	7.779	7.737	8.922	8.971	8.904

	[19.96]***	[20.07]***	[19.85]***	[20.12]***	[20.20]***	[20.01]***	[20.32]***	[20.28]***	[20.09]***
Intercept	14.984	-51.255	21.153	-8.569	-21.981	-7.446	-15.622	-35.872	-14.008
	[0.64]	[-1.73]*	[0.93]	[-1.69]*	[-3.32]***	[-1.50]	[-2.87]***	[-4.97]***	[-2.61]***
Industry dummy	Yes	yes	yes	yes	yes	yes	yes	yes	yes
Adjusted determination coefficient	0.444	0.446	0.443	0.391	0.393	0.390	0.425	0.429	0.424
Sample size	792	792	792	792	792	792	792	792	792

The upper panel indicates the coefficients in the estimating equation, and the numbers in [ ] in the lower panel indicate the t-values.
* indicates statistically significant at the 10% significance level, ** indicates statistically significant at the 5% significance level, and *** indicates statistically significant at the 1% significance level.

Table 7. Empirical results divided into quartiles based on the total number of employees

Panel A. Validation results for the first quartile based on the total number of employees

	ECON1			ECON2			ECON3		
Human resources1	6.453			0.980			1.463		
	[3.45]***			[2.26]**			[2.80]***		
Human resources2		40.467			4.575			10.555	
		[2.28]**			[1.21]			[2.43]**	
Human resources3			1.346			0.201			0.341
			[3.25]***			[2.11]**			[3.12]***
Leverage	-88.491	-89.596	-89.150	-5.302	-5.069	-5.380	-17.886	-18.488	-18.295
	[-2.86]***	[-2.86]***	[-2.87]***	[-0.74]	[-0.71]	[-0.75]	[-2.22]**	[-2.26]**	[-2.26]**
Physical resources	245.056	242.954	241.222	51.800	50.151	51.143	45.225	45.917	45.212
	[3.48]***	[3.38]***	[3.41]***	[3.60]***	[3.49]***	[3.54]***	[2.15]**	[2.15]**	[2.16]**
Financial resources	-61.699	-76.640	-62.932	12.874	10.245	12.634	-38.271	-41.343	-37.946
	[-0.39]	[-0.48]	[-0.40]	[0.38]	[0.30]	[0.37]	[-0.89]	[-0.96]	[-0.88]
Size	40.989	40.907	40.601	8.039	8.067	7.983	7.912	7.859	7.789
	[3.28]***	[3.19]***	[3.19]***	[2.87]***	[2.81]***	[2.81]***	[2.28]**	[2.21]**	[2.21]**
Intercept	159.649	-247.796	-148.022	-29.157	-36.944	-27.289	-35.769	-60.674	-34.303
	[-1.83]*	[-2.21]**	[-1.70]*	[-1.44]	[-1.45]	[-1.36]	[-1.49]	[-2.12]**	[-1.43]
Industry dummy	Yes	yes	yes	yes	yes	yes	yes	yes	yes
Adjusted determination coefficient	0.322	0.307	0.316	0.237	0.223	0.233	0.223	0.216	0.223
Sample size	198	198	198	198	198	198	198	198	198

The upper panel indicates the coefficients in the estimating equation, and the numbers in [ ] in the lower panel indicate the t-values.
* indicates statistically significant at the 10% significance level, ** indicates statistically significant at the 5% significance level, and *** indicates statistically significant at the 1% significance level.

Panel B. Validation results for the second quartile based on the total number of employees

	ECON1			ECON2			ECON3		
Human resources1	5.486			1.143			1.385		
	[3.85]***			[3.16]***			[3.70]***		
Human resources2		48.405			11.018			12.733	
		[3.86]***			[3.55]***			[3.99]***	
Human resources3			1.285			0.267			0.329
			[4.17]***			[3.38]***			[4.05]***
Leverage	-11.825	-20.590	-13.080	-8.317	-10.727	-8.561	-11.424	-13.956	-11.825
	[-0.36]	[0.61]	[0.40]	[-1.05]	[-1.36]	[-1.08]	[-1.22]	[-1.48]	[-1.27]
Physical resources	70.201	69.650	70.705	24.050	23.941	24.154	14.312	14.177	14.445
	[1.22]	[1.22]	[1.24]	[1.88]*	[1.90]*	[1.90]*	[1.02]	[1.01]	[1.03]
Financial resources	-37.774	-42.616	-36.839	23.729	23.645	23.883	-20.692	-21.410	-20.258
	[-0.35]	[-0.39]	[-0.34]	[0.83]	[0.85]	[0.84]	[-0.60]	[-0.62]	[-0.60]
Size	42.921	41.979	42.909	14.955	14.603	14.958	7.424	7.101	7.394
	[1.99]**	[1.94]*	[1.99]**	[3.21]***	[3.20]***	[3.23]***	[1.26]	[1.21]	[1.26]
Intercept	-74.767	-186.108	-72.991	-71.904	-96.833	-71.552	-9.180	-38.241	-8.645
	[-0.39]	[-0.96]	[-0.38]	[-1.73]*	[-2.30]**	[-1.73]*	[-0.18]	[-0.75]	[-0.17]
Industry dummy	Yes	yes	yes	yes	yes	yes	yes	yes	yes
Adjusted determination coefficient	0.170	0.172	0.182	0.192	0.205	0.200	0.192	0.199	0.203
Sample size	198	198	198	198	198	198	198	198	198

The upper panel indicates the coefficients in the estimating equation, and the numbers in [ ] in the lower panel indicate the t-values.
* indicates statistically significant at the 10% significance level, ** indicates statistically significant at the 5% significance level, and *** indicates statistically significant at the 1% significance level.

Panel C. Validation results for the third quartile based on the total number of employees

	ECON1	ECON2	ECON3
Human resources1	1.805	0.087	0.816
	[1.04]	[0.22]	[1.52]
Human resources2	28.234	2.769	11.124

		[2.19]**			[0.92]			[2.80]***	
Human resources3			0.355 [0.97]			0.010 [0.12]			0.168 [1.46]
Leverage	-16.470 [-0.75]	-26.026 [-1.16]	-16.694 [-0.75]	-6.227 [-1.12]	-7.381 [-1.29]	-6.149 [-1.10]	5.781 [0.79]	2.270 [0.31]	5.584 [0.76]
Physical resources	-114.244 [-2.61]***	-115.986 [-2.58]**	-114.483 [-2.62]***	-5.847 [-0.42]	-6.531 [-0.46]	-5.655 [-0.40]	-38.074 [-2.74]***	-38.160 [-2.64]***	-38.401 [-2.77]***
Financial resources	-79.772 [-0.75]	-99.256 [-0.92]	-78.520 [-0.74]	19.004 [0.77]	16.020 [0.63]	19.456 [0.79]	-55.464 [-1.57]	-61.886 [-1.73]*	-55.320 [-1.55]
Size	48.103 [4.71]***	49.745 [5.03]***	48.132 [4.71]***	8.896 [3.10]***	9.116 [3.21]***	8.874 [3.08]***	13.085 [4.34]***	13.664 [4.67]***	13.123 [4.35]***
Intercept	-27.725 [-0.28]	-118.573 [-1.12]	-25.744 [-0.26]	-9.744 [-0.35]	-19.430 [-0.67]	-9.385 [-0.33]	-39.653 [-1.32]	-74.537 [-2.23]**	-39.041 [-1.30]
Industry dummy	Yes	yes	yes	yes	yes	yes	yes	yes	yes
Adjusted determination coefficient	0.192	0.220	0.191	0.117	0.123	0.117	0.183	0.226	0.183
Sample size	198	198	198	198	198	198	198	198	198

The upper panel indicates the coefficients in the estimating equation, and the numbers in [ ] in the lower panel indicate the t-values.
* indicates statistically significant at the 10% significance level, ** indicates statistically significant at the 5% significance level, and *** indicates statistically significant at the 1% significance level.

Panel D. Validation results for the fourth quartile based on the total number of employees

	ECON1			**ECON2**			**ECON3**		
Human resources1	0.960 [0.50]			0.793 [2.11]**			0.901 [2.63]***		
Human resources2		17.598 [2.21]**			6.675 [3.10]***			6.454 [3.46]***	
Human resources3			0.213 [0.67]			0.163 [2.20]**			0.155 [2.63]***
Leverage	-28.363 [-0.93]	-48.731 [-1.87]*	-29.978 [-1.04]	-13.310 [-2.29]**	-16.978 [-2.79]***	-13.987 [-2.35]**	-18.035 [-3.62]***	-20.311 [-3.70]***	-17.312 [-3.29]***
Physical resources	99.182 [2.26]**	98.377 [2.27]**	98.052 [2.28]**	37.943 [3.23]***	37.078 [3.15]***	37.002 [3.16]***	10.279 [0.93]	9.267 [0.83]	9.192 [0.82]
Financial resources	7.665 [0.10]	-11.091 [-0.15]	4.601 [0.06]	51.311 [2.25]**	45.593 [2.01]**	49.159 [2.14]**	-5.155 [-0.23]	-10.247 [-0.46]	-6.737 [-0.30]
Size	21.985 [5.12]***	20.211 [4.67]***	21.835 [5.14]***	6.750 [4.86]***	6.355 [4.59]***	6.673 [4.82]***	6.605 [5.25]***	6.310 [5.06]***	6.625 [5.31]***
Intercept	148.262 [3.28]***	126.147 [2.62]***	151.680 [3.40]***	-9.231 [-0.63]	-19.282 [-1.34]	-6.844 [-0.46]	8.453 [0.62]	-1.785 [-0.14]	10.169 [0.74]
Industry dummy	Yes	yes	yes	yes	yes	yes	yes	yes	yes
Adjusted determination coefficient	0.389	0.402	0.390	0.296	0.313	0.297	0.425	0.433	0.418
Sample size	198	198	198	198	198	198	198	198	198

The upper panel indicates the coefficients in the estimating equation, and the numbers in [ ] in the lower panel indicate the t-values.
* indicates statistically significant at the 10% significance level, ** indicates statistically significant at the 5% significance level, and *** indicates statistically significant at the 1% significance level.

Human resources2, and Human resources3 for total employees.

Looking at the results in detail, the coefficients of the impact of human resources1, human resources2, and human resources3 on ECON1 were estimated to be 2.728 ($p < 0.01$), 27.274 ($p < 0.01$), and 0.572 ($p < 0.01$), respectively. The coefficients are all positive and statistically significant. The coefficients on ECON2 were also estimated to be 0.498 ($p<0.01$), 5.472 ($p<0.01$), and 0.105 ($p<0.01$), respectively, all positive and statistically significant. The coefficients on ECON3 were estimated to be 0.637 ($p<0.01$), 6.223 ($p<0.01$), and 0.137 ($p<0.01$), respectively, all statistically significant and confirmed to have a positive impact. The control variable, size of firm, was found to have a positive impact on environmental performance at the 1% significance level in all estimations.

The above results support our hypothesis that human capital has a positive impact on environmental performance based on the results for total employees. It is clear that higher marginal labor productivity as human capital increases environmental performance. The results also indicate that environmental performance increases as the size of the firm increases.

5.2 Empirical results and discussion of quartiles based on the total number of employees

To analyze thoroughly how human capital affects environmental performance, we refer to the results of the correlation coefficient shown in Section 4.2 and focus on the variable Size, which has the strongest correlation with environmental performance and is a proxy for firm size, indicating that environmental performance is higher as firm size increases. Therefore, in this section, we examined the relationship between the number of employees before logarithmic transformation and the size of the firms by quantifying the total number of employees[2]. Table 5 consists

of panels A, B, C, and D, which are divided into quartiles based on the total number of employees, and show the results of regressing the environmental performance proxy variables ECON1, ECON2, and ECON3 on the human capital proxy variables Human resources1, Human resources2, and Human resources3, respectively.

The results of Panels A, B, C, and D are summarized below. Panel A, which is the result of the analysis for the first quartile, confirms the hypothesis of this study only in the effects of Human resources1 and Human resources3 on ECON1 and the effect of Human resources3 on ECON3. In Panel B, similar to the results in Table 4, all validation results support the hypothesis of this study that human capital has a positive impact on environmental performance. On the other hand, in Panel C, which is the result of the analysis for the third quartile, the results partially support the hypothesis of this study, but only when the proxy variable for human capital is human resources2, there is a statistically significant positive impact on the three proxy variables of environmental performance. In addition, the results for the fourth quartile shown in Panel D confirm that human capital has a positive and statistically significant impact on the three environmental performance proxy variables, except for the impact of Human resources1 and Human resources3 on ECON1 and the impact of Human resources2 on ECON2, all of which are similar to Panel B. The control variable, firm size, has a positive impact on environmental performance in all estimations, although the significance levels differ, and it is clear that the larger the firm size, the higher the environmental performance.

Thus, to summarize the results in Table 5, in this validation focusing on firm size, the results do not support the hypothesis for the relationship between human capital and environmental performance in all validations as shown in Table 4 above. However, in Panel B and D of Table 5, many combinations of the relationship between human capital and environmental performance are found to support the hypothesis. However, it is clear that the results in Panels A and C are also limited, even though they support the hypothesis.

The descriptive statistics shown in Table 2 in section 4.1 have relatively large standard variances and large data variability, which may be the cause of the outlier affecting the empirical results. Therefore, we conducted an additional verification using an outlier treatment method that removes the upper and lower 3% of the 1,044 total observed values shown in Table 1. The results are shown in section 5.3 below.

5.3 Additional validation results and discussion

First, we explain how we decided to conduct the additional validation. Based on the results of section 5, Paragraphs 1 and 2, we drew histograms to visualize the scattering of data to confirm the status of outliers for the variables used in the empirical analysis of this study and found that the values of Human resources1, Human resources2, and Human resources3, could not be removed when the upper and lower 1% were eliminated as outliers were removed when the upper and lower 3% were removed as outliers. Specifically, regression analysis was conducted on the 792 observed values for which the values in the upper and lower 3% of the 1,044 total observed values were eliminated as anomalies.

Table 6 presents the validation results for total employees as in Table 4. Table 7 consists of panels A, B, C, and D. Divided into quartiles based on the total number of employees, it shows the results of regressing the environmental performance proxy variables ECON1, ECON2, and ECON3 on the human capital proxy variables human resources1, human resources2, and human resources3.

The results of the analysis for total employees in Table 6 clearly show that Human resources1, Human resources2, and Human resources3 have a positive impact on ECON1, which is statistically significant. resources2 and Human resources3 have a positive impact on ECON2, and similar results are obtained for the impact of Human resources1, Human resources2, and Human resources3 on ECON3. These results support the hypothesis that human capital has a positive impact on environmental performance.

The results for the first quartile of the total number of employees shown in Panel A of Table 7 indicate that the coefficients of the impact of human resources1, human resources2, and human resources3 on ECON1 are 6.453 ($p<0.01$), 40.467 ($p<0.05$), and 1.346 ($p<0.01$), respectively. The coefficients are all positive and statistically significant. Next, the effects of Human resources1, Human resources2, and Human resources3 on ECON2 are statistically significant only for the relationship between Human resources1, Human resources3, and ECON2, with coefficients of 0.980 ($p < 0.05$) and 0.201 ($p < 0.05$). The remaining positive relationship between Human resources2 and ECON2 is not statistically significant. On the other hand, the estimated coefficients for the impact of Human resources1, Human resources2, and Human resources3 on ECON3 were 1.463 ($p < 0.01$), 10.555 ($p < 0.05$), and 0.341 ($p < 0.01$), respectively. All of them were statistically significant positive results. Similarly, for the control variables, all of the estimates indicate that firm size has a positive impact on environmental performance at the 1% significance level, indicating that the larger the size of the firm, the higher its environmental performance.

Next, Panel B of Table 7 shows the results of the analysis for the second quartile of the quartiles based on the total number of employees, and the coefficients of the impact of human resources1, human resources2, and human resources3 on ECON1 are estimated to be 5.486 ($p<0.01$), 48.405 ($p<0.01$), and 1.285 ($p<0.01$), respectively, all positive and statistically significant results. The impact of human resources1, human resources2, and human resources3 on ECON2 is estimated to be 1.143 ($p<0.01$), 11.018 ($p<0.01$), and 0.267 ($p<0.01$), respectively, all positive and statistically significant. The coefficients of the effect of human resources1, human resources2, and human resources3 on ECON3 were estimated to be 1.385 ($p < 0.01$), 12.733 ($p < 0.01$), and 0.329 ($p < 0.01$), respectively, all statistically significant results. The control variables also showed a positive, albeit partial, effect of firm size on environmental performance as a statistically significant result, indicating that the larger the firm size, the higher the environmental performance.

Next, Panel C of Table 7 shows the results for the third quartile of the quartiles based on the total number of employees, and the coefficients are all positive for the impact of human resources1, human resources2, and human resources3 on ECON1. However, only the relationship between human resources2 and ECON1 was statistically significant, with an estimated coefficient of 28.234 ($p<0.05$). Next, no statistically significant results supporting the hypothesis were obtained for the effects of human resources1, human resources2, and human resources3 on ECON2. On the other hand, the coefficient of the impact of human resources1, human resources2, and human resources3 on ECON3 was statistically significant and positive only for the relationship

between human resources2 and ECON3, with an estimated coefficient of 11.124 ($p<0.01$), indicating a positive impact. Similarly, for the control variables, the coefficient of firm size has a positive impact on environmental performance at the 1% significance level in all estimations.

Finally, the results for the fourth quartile of the total number of employees shown in Panel D of Table 7 confirm that only Human resources2 has a statistically significant positive impact on ECON1, with an estimated coefficient of 17.598 ($p<0.05$). Next, the effects of Human resources1, Human resources2, and Human resources3 on ECON2 were estimated to have coefficients of 0.793 ($p<0.05$), 6.675 ($p<0.01$), and 0.163 ($p<0.05$), respectively, all statistically significant and positive. The coefficients for the impact of Human resources1, Human resources2, and Human resources3 on ECON3 were estimated to be 0.901 ($p<0.01$), 6.454 ($p<0.01$), and 0.155 ($p<0.01$), respectively, all statistically significant and had a positive impact. Similarly, for the control variables, all of the estimates indicate that firm size has a positive impact on environmental performance at the 1% significance level, indicating that the larger the firm size, the higher the environmental performance.

The above results show that there is little improvement in the results for Panels B, C, and D in Table 7, while a large improvement is observed for Panel A. Compared with the results in section 5, section 2, the validation after dealing with the outliers of 1% above and below the data shows no statistically significant positive effect of using Human resources2 as a proxy variable for human capital in any of the regression analysis results, as shown in Panel A of Table 5. However, additional testing in this section, i.e., treating the upper and lower 3% of the data as outliers, shows an improvement in the impact of human resources2 on ECON1 and ECON3, as shown in Panel A of Table 7, confirming a statistically significant positive impact and supporting the hypothesis.

In other words, an additional test in which the upper and lower 3% of the data in this section were treated as outliers revealed the effect of outlier treatment in the analysis for the first quartile. In other words, the statistically significant results obtained when all three human capital proxy variables were used support the hypothesis of this study that human capital enhances environmental performance.

6. CONCLUSION

This study empirically examines the impact of human capital as an intangible asset on environmental performance. Specifically, we propose the hypothesis that human capital enhances environmental performance and conduct an empirical analysis using three years of published data from the Ministry of Environment's Environmental Management Practices Survey based on the verification model by Usman et al. [10]. Regression analysis was conducted using three proxy variables for environmental performance using data from the Environmental Management Practices Survey as explained variables, and three proxy variables for human capital, which was defined from sales, total assets, and total number of employees of the firm as explanatory variables. In addition to the main validation for all employees, detailed validation was conducted by dividing the results into quartiles based on the number of employees, as well as additional validation to take into account the effects of outlier values. The results support the hypothesis that human capital as an intangible asset has a positive impact on environmental performance.

The results indicate that employees' knowledge of the product, their understanding of the manufacturing process, and their ability to formulate and implement specific plans contribute significantly to the development, manufacture, and sale of environmentally friendly products, which in turn improves environmental performance.

Although many previous studies have reported on the relationship between intangible assets and financial performance and the relationship between social responsibility performance including environmental performance and financial performance, studies on the impact of intangible assets on social responsibility performance including environmental performance have been verified in a very few studies, and are still insufficient. As an example, Usman et al. [10], who found that intangible assets play a mediating role between the effects of financial performance and social responsibility performance, also pointed out that there are not enough studies on the effects of intangible assets on social responsibility performance. Therefore, it is significant that a study such as the present study focused on human capital, one of the intangible assets, as a factor affecting environmental performance in the Indian manufacturing industry, and demonstrated the relationship between the two.

However, this study has limitations in the choice of proxy variables, the way data outliers are handled, and the period under analysis. First, there is a limitation regarding the proxy variable of environmental performance. This study was conducted using some data from the Ministry of Environment's Environmental Management Survey, but the problem is that the survey items in this data do not fully take into account whether the environmental performance of firms can be measured from multiple perspectives.

The second limitation is with regard to the proxy variable for human capital. In this study, we created a proxy variable for human capital by referring to existing studies and using sales and the total number of employees, but there is a problem that other proxy variables used in existing studies were not tested in the empirical analysis of this study. In addition, we believe that the proxy variables for human capital employed in this study need to be re-examined. In other words, there is a problem whether the proxy variable for human capital that enhances environmental performance is captured by marginal labor productivity, which is the measurement scale used in this study. Specifically, there is room for a detailed examination of the measured human capital of individual firms, which was created using the production function.

On the other hand, regarding the method of processing the outliers in the data, in addition to the method of removing the top and bottom 1%, which is used in many empirical studies, this study also tried the method of removing the top and bottom 3% and obtained results that supported the hypothesis. However, this study is limited in that it does not fully focus on the characteristics and trends of firms that were removed because they were included in the outliers. Another limitation is that the environmental performance data used in this study were limited to three years, so we were not able to examine the relationship between intangible assets and environmental performance from a long-term perspective. Accordingly, the explanatory variables that proxy for intangible assets were created on a one-year basis, and thus intangible assets were not considered as assets that accumulate over multiple years.

We would like to improve on these limitations and continue

our research in the future. There have been many studies on the relationship between financial performance and social responsibility performance, and future studies should take a broad view of corporate social responsibility, not limited to environmental protection issues, and should also consider measures for employment issues or corporate philanthropy [21, 22].

Regarding the selection of proxy variables, we would like to incorporate proxy variables that are not used in this study into the analysis and improve them so that we can present desirable proxy variables for hypothesis testing. As an example, to capture intangible assets from a long-term perspective, Kaul [23] created a proxy variable for innovation by setting the amortization rate at 15% and capitalizing R&D expenses in his empirical analysis of innovation as an intangible asset. Some existing studies have also done so. We would like to examine how to create a proxy variable for human capital using this method as well and incorporate it into future research.

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APPENDIX

End Notes

1. The second item, Pollution Control and Biodiversity Response consists of detailed questions on the status of measures for pollution control and biodiversity conservation from the perspectives of soil pollution control, chemical management status, and air pollution control, according to the Environmental Management Practices Survey report. The Environmental Management Practices Survey Report consists of detailed questions on the status of measures against pollution and biodiversity conservation from the viewpoints of soil contamination control, chemical management, and air pollution control. Specifically, the questions are limited to the status of measures for pollution control and biodiversity conservation regarding the establishment of action methods and regulations to prevent chemical substance leakage accidents, the status of NOx and SOx emissions, and the status of implementation of activities to conserve biodiversity and promote sustainable use. The third item, Resource Circulation, similarly consists of questions on waste and water resource management, beginning with the amount of waste and other emissions, followed by questions on the status of monitoring emissions and wastewater in India and overseas, the number of production sites that have achieved zero emissions, and wastewater management efforts. The fifth item, Global Warming Countermeasures, similarly consists of questions on efforts to reduce greenhouse gas emissions and save electricity, the status of greenhouse gas emissions, and government global warming countermeasures, and efforts in transportation and logistics processes and vehicle usage. Specifically, the survey clarified performance values and progress in terms of GHG emissions and self-help reductions at domestic and overseas production sites, the acquisition and use of carbon credits, whether or not GHG reduction targets have been set, and the use and understanding of renewable energy sources.
2. The first quartile is defined as those with less than 25% of the total number of employees, or less than 2,191 employees; the second quartile is defined as those with between 25% and 50% of the total number of employees, or between 2,191 and 5,506 employees; the third quartile is defined as those with between 50% of the total number of employees and 75% of the total number of employees; and the fourth quartile is defined as those with 75% of the total number of employees and more than 16,955 employees. The third quartile is between the median of the 50th percentile and the 75th percentile, i.e., between 5,506 and 16,955 employees, and the fourth quartile is above the 75th percentile, i.e., 16,955 or more employees.