International Journal of Economics and Financial Issues

ISSN: 2146-4138

available at http: www.econjournals.com

International Journal of Economics and Financial Issues, 2024, 14(5), 148-155.

Analyzing Corporate Value with Clustered Models: Identifying Financial and Non-Financial Factors Over Time

Ryota Hasegawa, Kaoru Kuramoto, Satoshi Kumagai*

Department of Industrial and Systems Engineering, Aoyama Gakuin University, Japan. *Email: kumagai@ise.aoyama.ac.jp

Received: 03 March 2024 **Accepted:** 09 July 2024 **DOI:** https://doi.org/10.32479/ijefi.16354

ABSTRACT

The importance of non-financial capital in firm valuation has been increasing. Non-financial capital comprises intellectual, human, social, relational, natural, and manufactured capital. This study proposes a clustered corporate value model to identify financial and non-financial factors influencing firm value. We cluster a group of companies and build a principal component regression model for each cluster, using the Bayesian Information Criterion for evaluation, with financial and non-financial factors as explanatory variables. We also considered the time lag in the impact of financial and non-financial factors on corporate value. In other words, we consider the impact of financial and non-financial factors on corporate value over multiple years, not just a single year. We propose an algorithm that identifies clusters and constructs a regression model for each, optimizing the combination of cluster divisions and explanatory variables using adjusted R-squared as the evaluation criterion. The cluster-specific corporate value model shows higher explanatory power than the industry-specific cluster-based corporate value model for the electrical, chemical, food, construction, and service industries.

Keywords: Corporate Value, Cluster, Time Lag
JEL Classifications: G32, G34, M14

1. INTRODUCTION

The importance of financial capital—the resources a firm uses to finance its operations and investments—in firm valuation is well-established (Quilligan, 2006; Green, 2007; Frey and Oehler, 2014; Ocak and Fındık, 2019). These resources include debt, equity, and retained earnings. Non-financial capital is a broader concept encompassing a firm's resources and capabilities, excluding financial capital. This includes intellectual, human, social, relational, natural, and manufactured capital. Intellectual capital encompasses a firm's employee knowledge and skills, along with patents, trademarks, and other intangible assets. Human capital focuses on the skills and knowledge of the workforce. Social and relational capital refers to a firm's relationships with customers, suppliers, and other stakeholders. Natural capital covers the natural resources a firm uses in its operations, while manufactured capital involves physical assets like buildings, equipment, and inventory. Environmental, social, and governance (ESG) information is classified as non-financial capital; this information can help assess a firm's non-financial capital and its impact on company value.

Friede et al. (2015) summarized the results of over 2,000 studies on the relationship between non-financial capital and firm value. They found that approximately 48% of studies analyzed found a positive correlation between non-financial capital and firm value, whereas approximately 10% found a negative relationship.

Despite the growing recognition of non-financial capital, traditional industry-based corporate valuation models often fail to consider the broader range of factors that impact corporate value over time. This study aims to determine whether a cluster-based corporate value model provides better explanatory power than traditional industry-based models by incorporating both financial and non-financial factors over multiple years.

The present study proposes a clustered firm-valuation model-a multiple regression model with firm value as the dependent variable and financial and non-financial factors as explanatory variables. The target firms are divided into clusters that yield a model with high explanatory power for firm value using both financial and non-financial capital. When dividing the clusters, financial and non-financial factors with high contributions to firm value were selected as explanatory variables. The time lag between the impact of financial and non-financial factors on corporate value was also considered. In other words, we consider the impact of financial and non-financial factors on firm value over multiple years and not just a single year.

The number of possible combinations of clusters and variable selections is vast. To construct a cluster-specific firm valuation model, we propose an algorithm that simultaneously performs cluster division and variable selection to identify the financial and non-financial factors with high explanatory power. The algorithm uses the two-split method to cluster firms, then employs local search to assess the explanatory power of the models and identify the optimal cluster divisions and regression models for each. We construct a two-cluster firm valuation model for a sample of 100 listed companies and compare it with the firm valuation models created for each industry (electrical equipment, chemical, food, construction, and service).

2. RELATED WORKS

An increasing number of studies have explored the link between corporate value and financial and non-financial capital. Hongo (2008) performed a multiple regression analysis with corporate value—defined as (market capitalization + interest-bearing debt) divided by total assets—as the dependent variable and the environmental management score from an environmental management survey as the explanatory variable. The findings suggest that environmental management efforts positively impact corporate value. Yanagi and Ito (2019) suggested that companies with high greenhouse gas emissions tend to have lower price-to-book ratios, even after adjusting for return on equity (ROE) and governance, negatively affecting firm value. Aydoğmuş et al. (2022) examined the impact of ESG scores on firm value and profitability using a sample of 1,720 listed firms. They employed regression models with ROA and Tobin's Q(TQ) as the dependent variables and ESG scores as the explanatory variables. The findings revealed that social and governance scores are positively correlated with both ROA and TQ.

Qureshi et al. (2019) examined the impact of ESG disclosure and female representation on boards on firm value using a large panel data set comprising 812 listed European firms. The findings revealed that sustainability disclosure and board gender diversity are positively correlated with corporate value. Yanagi and Yoshino (2017) showed a positive correlation between human capital, intellectual capital, and corporate value, using human capital and R&D expenditures as explanatory variables. Yamamoto (2014) explored how the employment of female staff impacts the performance of publicly listed Japanese companies. The results showed that profit margin was positively affected when the proportion of female employees ranged from 30% to 40%. Moreover, a higher ratio of female directors correlated with increased ROA and TQ. Safiullah et al. (2022) analyzed the impact of board diversity on corporate value using a regression model for Spanish companies. Diversity positively correlated with accounting measures of corporate value, such as ROA and ROE, but there was no significant correlation with TQ. Sakurada (2023) conducted a study investigating the relationship between the proportion of female directors and corporate performance. The results showed that an increase in the proportion of female directors positively affected ROA and TQ.

Duan et al. (2023) constructed a model for the manufacturing industry that includes the ESG score ranked using a 9-step method as an explanatory variable. They showed that improving ESG performance can significantly increase corporate value. Wu et al. (2003) created a regression model using firm size, board size, R&D expenditure, debt level, CSR score, and internationalization as explanatory variables. They found that corporate value decreased in the initial stage as CSR activities increased. However, corporate value increased after involvement in CSR activities exceeded a critical point. Temiz (2021) developed a model incorporating firm size, debt level, and information disclosure scores. They showed that a firm's information disclosure practices positively and significantly impacted corporate value.

Al-Issa et al. (2022) created a panel regression model that considered ESG/CSR engagement, marketing expenses, board size, and board diversity as factors affecting corporate value. ESG/CSR engagement was evaluated using the CSR, environmental pillar, and social pillar scores. The results showed that companies with high CSR participation have lower marketing costs and higher market value. They also showed that the size, diversity, and social engagement of a company's board of directors can significantly improve its market value. Kenny et al. (2024) focused on agricultural and mining companies in Southeast Asia. They constructed a corporate value model using the green accounting disclosure rate, ROA, sales growth rate, debt ratio, and firm size as explanatory variables. No correlation was found between green accounting disclosures and corporate value. Some studies considered the time lag between financial and non-financial factors and corporate value.

Rahman and Howlader (2022) constructed a model for the pharmaceutical industry that considered the impact of R&D expenditures on market capitalization for up to three periods. Nojiri et al. (2019) developed a research and development performance analysis model that accounted for a multiple-year time lag. They used the alternating least squares algorithm to calculate the partial regression coefficients for each year's explanatory variables and to determine the weights reflecting R&D investment's impact on these variables. The results showed that R&D investment in year "t" affected ROA in years "t," "t+1," "t+2," "t+3," and "t+4".

Oshika (2023) created a linear regression model with net asset value, current net profit, expected value of current profit, and "other information" as explanatory variables for corporate value.

"Other information" was non-financial information not considered in residual earnings up to the previous period ("t-1" period) but affecting residual earnings thereafter. ESG scores were analyzed as non-financial information. Results showed that ESG scores are highly correlated with corporate value.

Some studies assumed clusters and constructed highly explanatory models. Tomizuka (2017) focused on the pharmaceutical industry and revealed a positive correlation between five types of non-financial capital (intellectual, human, social and relational, environmental, and manufacturing capital) and corporate value. Zhou et al. (2022) argued that improving the ESG performance of listed companies improves their corporate value. Yamabayashi (2016) examined the correlation between corporate value creation, financial indicators, and corporate governance factors. Companies were divided into those with integrated reporting and those without, allowing for a clear analysis of corporate value and its contributing factors. Classification improved the explanatory power of corporate value.

Constantinescu et al. (2021) constructed a firm-value model for the energy industry using ESG scores as explanatory variables, clustering the industry into different groups. They decomposed ESG scores into individual environmental, social, and governance components and compared the sub-models using each component as an explanatory variable. They also compared regression models using regional sample data for North America, Europe, and Asia. They concluded that there is a relationship between ESG factor disclosure and firm value in the energy industry.

Previous studies on firm value models have analyzed company groups (clusters) in various settings, including industry, sector, time period, and region. The financial and non-financial explanatory variables differed based on the cluster setting, often leading to the selection of variables with inadequate explanatory power.

3. CLUSTERED CORPORATE VALUE MODEL WITH TIME LAG

Each cluster's corporate value model is a principal component regression with corporate value as the dependent variable and financial and non-financial factors as explanatory variables (Equation [1]).

$$y^{n,t} = \beta_0^n + \sum_{k=1}^{K} \beta_k^n PC_k^n + \varepsilon^n \tag{1}$$

$y^{n,t}$: Corporate value in cluster n in period t

β_0^n : Intercept for cluster n

k: Principal component selected using the stepwise method.

K: Number of principal components selected using the stepwise method.

β_k^n : Partial regression coefficient of principal component k in cluster n

PC_k^n : Principal component k was selected using the stepwise method in cluster n.

ε^n: Residual term for cluster n.

This method selects variables using the BIC value and a stepwise method. Principal components contributing to a cumulative contribution ratio of 80% or more were used as candidate explanatory variables. The principal component scores are given by the following Equation (2).

$$PC_{i,q}^n = \sum_{k=1}^{K} \left(\sum_{j=1}^{J} a_{qj,t-k}^n x_{ij,t-k}^n \right) \tag{2}$$

PC_i^n : Principal component score for the i-th component in cluster n.

$a_{qj,t-k}^n$: Raw data for item j of company q in cluster n at time $t-k$.

$x_{ij,t-k}^n$: Principal component loading for item j of the i-th principal component in cluster n at $t-k$

i: Component number

j: Number of items in raw data

$t-k$: Time $t-k$ period

k: Number of years hence

J: Number of items in the raw data

q: Company

Selecting cluster divisions and explanatory variables that meet the following two conditions:

1. Adjusted R-squared: R^2 of the clustered model should be higher than that of the industry-specific model. This ensures that the clustered model provides a better fit for the data and has higher explanatory power (Equation [3]).
2. Long-term Explanatory Power: The clustered model should demonstrate strong explanatory power for firm value over multiple years. This implies that the model effectively captures the impacts of financial and non-financial factors on firm value over an extended period.

$$R^2 = 1 - \frac{\dfrac{\sum_{i=1}^{n} \left(y_i - \widehat{y_i} \right)^2}{n-k-1}}{\dfrac{\sum_{i=1}^{n} \left(y_i - \bar{y} \right)^2}{n-1}} \tag{3}$$

n: Sample size

k: Number of explanatory variables

$\widehat{y_i}$: Data estimated from the regression equation

$\bar{y}$: Mean value of y

y_i: i-th data point

4. RESULTS

Financial data was collected for fiscal years 2017-2022 using NEEDS-FinancialQUEST. Non-financial capital data were collected from the CSR Corporate Overview for fiscal years 2017-2022. (Toyo Keizai Shinposha 2018a, 2018b, 2019a, 2019b, 2020a, 2020b, 2021a, 2021b, 2022a, 2022b, 2023a, 2023b). Table 1 presents the dependent and explanatory variables employed in the principal component regression model.

Clustering methods, company assignments, and explanatory variable selection yield numerous combinations. Therefore, a

Table 1: Objective and explanatory variables

Types	Variable	Scale adjustment
Corporate value	$\frac{\textit{Market Capital} - \textit{Equity}}{\textit{Equity}}$	
Financial factors	ROE	
	R and D expenses	*
	Operating C/F	*
	Equity ratio	
Environmental factors	Water resource input	*
	GHG emissions	*
	Waste discharge	*
	Average salary	*
Social factors	Ratio of employees with disabilities	
	Female management ratio	
	Average monthly overtime hours	
Governance factors	External director ratio	
	Female officer ratio	

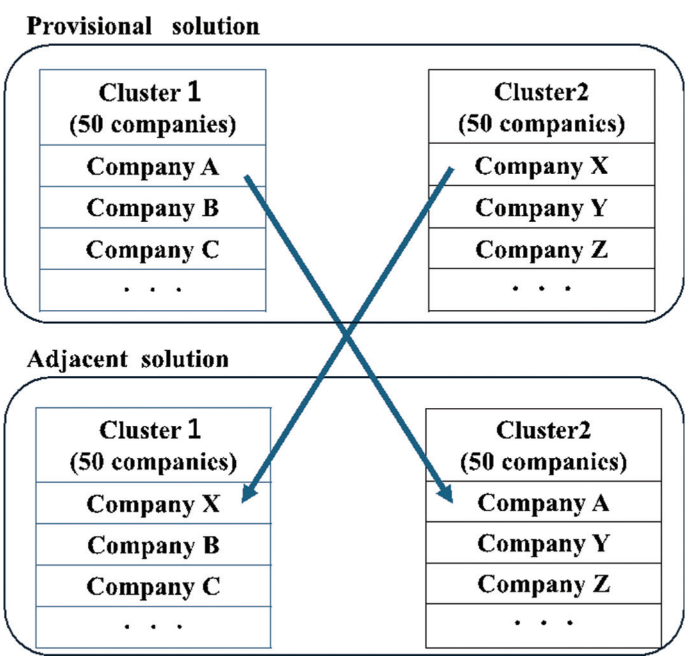
*Dividing by revenue for scale adjustment. R and D: Research and development, GHG: Greenhouse gas

Table 2: Cluster 1 - standardized partial regression coefficient

Principal components	Standardized partial regression coefficient
PC 1	0.212***
PC 2	0.174***
PC 3	−0.261***
PC 5	0.119**
PC 7	0.498***
PC 8	−0.389***
PC 9	0.331***
PC 10	−0.385***
PC 11	−0.199***
PC 12	0.224***

**The standardized partial regression coefficient is significant at the 0.05% significance level, ***The standardized partial regression coefficient is significant at the 0.01% significance level

Figure 1: Provisional and adjacent solutions



multi-start local search algorithm was used to select the clusters and explanatory variables. Target companies were divided into two clusters, and a corporate value model was created for each cluster using principal component regression. R^2 values were calculated for each cluster. The sum of the clustering R^2 value, corporate value models for each cluster, and the coefficient of determination was considered the provisional solution. A neighboring solution exchanges a pair of companies between clusters, and corporate value models are created for each cluster.

The provisional solution is replaced with an adjacent solution if the combined R^2 values from the corporate value models improves; otherwise, the solution is retained. Cluster segmentation with the highest total R^2 of the firm-value models was considered appropriate for the target year.

Figure 2: R^2 of Clustered corporate value model (2022)

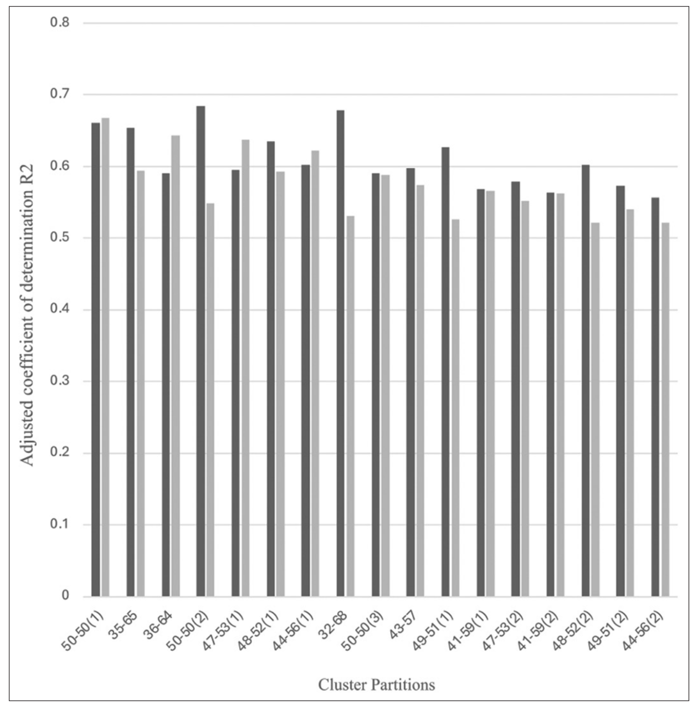
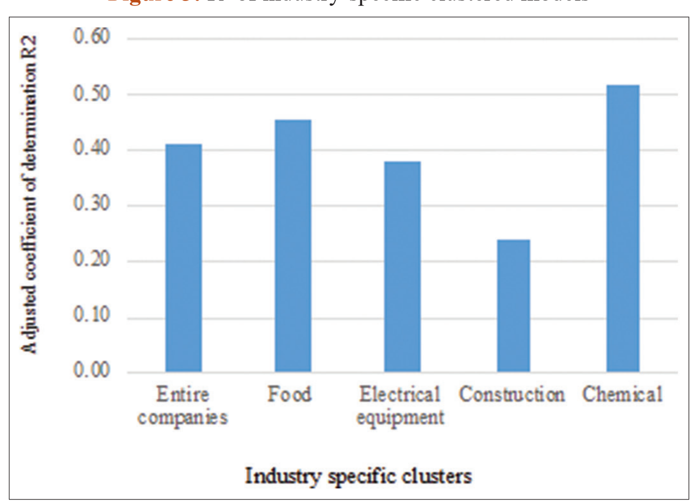


Figure 3: R^2 of industry-specific clustered models



Assuming a provisional cluster partition where Cluster 1 comprises 50 companies, including Company A, Company B, and 48 others, and Cluster 2 comprises 50 companies, including Company X, Company Y, and others (Figure 1), the following steps can be taken to determine a near-optimal solution:

1. Swap a company from Cluster 1 with a company from Cluster 2: Select one company (Company A) from Cluster 1 and one company (Company X) from Cluster 2. Swap these two companies, resulting in a new cluster segmentation.
2. Re-estimate the corporate value models for each cluster: For each cluster (Cluster 1 and Cluster 2), re-estimate the corporate value model by selecting the explanatory variables that maximize the R^2 value.
3. Evaluate the improvement in model performance: Compare the R^2 values of the new cluster partition to the original cluster segmentation. If the total R^2 values improve, the swap has resulted in a near-optimal solution.

Table 3: Cluster 2 - standardized partial regression coefficient

Principal components	Standardized partial regression coefficient
PC 1	0.380***
PC 2	0.444***
PC 3	0.529***
PC 5	−0.352***
PC 7	0.241***

***The standardized partial regression coefficient is significant at the 0.01% significance level

Table 4: Cluster 1 - principal component loadings of explanatory variables

Variables	PC 1	PC 2	PC 3	PC 5	PC 7	PC 8	PC 9	PC 10	PC 11	PC 12
ROE (t−1)	−0.101	0.119	−0.099	0.300	0.129	−0.366	0.198	−0.169	0.453	−0.178
R and D expenses (t−1)	0.596	−0.485	−0.170	0.365	0.061	0.168	0.143	−0.194	−0.085	0.059
Operating C/F (t−1)	0.362	−0.315	0.068	0.205	0.070	−0.252	−0.221	−0.057	−0.203	−0.026
Equity ratio (t−1)	0.487	−0.068	0.228	−0.359	0.041	0.131	0.035	−0.069	0.131	−0.193
Water resource input (t−1)	−0.137	−0.764	0.193	−0.147	−0.143	−0.223	−0.191	0.052	0.101	−0.238
GHG emissions (t−1)	−0.230	−0.657	0.156	−0.071	−0.087	0.161	0.106	−0.048	0.023	0.112
Waste discharge (t−1)	−0.586	−0.268	0.069	0.051	−0.059	0.079	0.227	−0.183	0.095	0.011
Average salary (t−1)	−0.314	0.087	−0.342	0.482	0.029	−0.262	0.055	−0.434	0.053	−0.212
Female management ratio (t−1) disabilities (t−1)	0.174	0.246	−0.279	−0.250	−0.115	−0.025	0.261	0.044	−0.041	−0.088
Ratio of employees with disabilities (t−1)	0.280	0.283	0.661	0.355	0.045	0.061	−0.007	−0.027	0.030	−0.085
Average monthly overtime hours (t−1)	−0.576	0.126	−0.185	0.212	0.006	−0.105	0.338	−0.109	−0.003	−0.197
External director ratio (t−1)	0.295	−0.196	−0.570	0.326	0.044	−0.060	−0.120	0.398	0.129	−0.063
Female officer ratio (t−1)	0.153	0.138	−0.425	−0.289	0.233	0.091	−0.151	−0.362	−0.113	−0.132
ROE (t−2)	−0.149	0.100	0.099	0.019	0.235	0.233	−0.001	0.087	0.720	0.108
R&D expenses (t−2)	0.594	−0.473	−0.162	0.379	0.062	0.172	0.168	−0.202	−0.069	0.044
Operating C/F (t−2)	0.573	−0.221	0.148	−0.372	0.297	−0.093	0.063	0.002	0.223	0.155
Equity ratio (t−2)	0.528	−0.134	0.053	−0.199	0.031	−0.005	0.321	0.019	−0.051	−0.472
Water resource input (t−2)	−0.158	−0.795	0.193	−0.129	−0.150	−0.200	−0.160	0.036	0.082	−0.218
GHG emissions (t−2)	−0.286	−0.741	0.130	−0.072	−0.037	0.179	0.115	−0.058	0.060	0.059
Waste discharge (t−2)	−0.553	−0.295	0.050	0.041	−0.079	0.208	0.221	−0.258	0.225	0.090
Average salary (t−2)	−0.389	0.127	−0.108	0.026	0.146	−0.041	−0.222	−0.463	0.306	0.124
Female management ratio (t−2)	0.241	0.183	−0.277	−0.212	−0.096	0.045	0.301	−0.035	−0.008	0.027
Ratio of employees with disabilities (t−2)	0.283	0.256	0.689	0.352	0.057	0.030	0.003	0.001	0.051	−0.041
Average monthly overtime hours (t−2)	−0.652	0.182	−0.043	0.041	0.074	0.279	−0.059	−0.013	0.186	−0.045
External director ratio (t−2)	0.285	−0.184	−0.619	0.313	0.024	−0.070	−0.127	0.356	0.182	−0.088
Female officer ratio (t−2)	0.213	0.138	−0.465	−0.279	0.171	0.013	−0.118	−0.312	−0.113	−0.160
ROE (t−3)	−0.117	−0.061	0.168	−0.167	0.438	0.296	−0.180	0.215	0.027	−0.340
R&D expenses (t−3)	0.604	−0.467	−0.163	0.367	0.066	0.183	0.177	−0.186	−0.078	0.038
Operating C/F (t−3)	0.201	−0.212	0.299	−0.157	0.675	−0.185	0.044	0.084	0.078	0.235
Equity ratio (t−3)	0.420	−0.048	0.085	−0.323	−0.150	−0.121	0.311	−0.145	0.197	−0.278
Water resource input (t−3)	−0.087	−0.525	0.110	0.063	−0.082	−0.267	−0.218	−0.099	−0.210	0.034
GHG emissions (t−3)	−0.290	−0.742	0.135	−0.076	−0.041	0.175	0.118	−0.057	0.071	0.068
Waste discharge (t−3)	−0.513	−0.445	0.109	0.003	0.222	0.403	0.024	0.014	−0.097	0.018
Average salary (t−3)	−0.284	0.089	−0.171	0.042	0.151	0.009	−0.364	−0.202	0.005	−0.224
Female management ratio (t−3)	0.134	0.269	−0.160	−0.241	−0.232	−0.121	0.356	0.124	0.032	0.067
Ratio of employees with disabilities (t−3)	0.299	0.273	0.693	0.296	0.040	0.034	−0.050	−0.036	−0.007	−0.106
Average monthly overtime hours (t−3)	−0.459	0.082	−0.130	0.195	0.217	0.427	−0.085	0.083	−0.248	−0.311
External director ratio (t−3)	0.324	−0.164	−0.612	0.368	−0.018	0.091	−0.052	0.249	0.205	−0.050
Female officer ratio (t−3)	0.196	0.126	−0.459	−0.197	0.287	0.112	−0.087	−0.294	−0.065	−0.118
ROE (t−4)	−0.196	−0.121	−0.023	−0.060	0.489	−0.256	0.235	0.265	−0.072	−0.258
R&D expenses (t−4)	0.592	−0.461	−0.159	0.381	0.070	0.175	0.193	−0.203	−0.068	0.036
Operating C/F (t−4)	0.236	−0.154	0.204	−0.334	0.563	−0.171	0.063	−0.014	−0.076	0.130
Equity ratio (t−4)	0.402	0.005	0.141	−0.347	−0.251	0.186	−0.097	−0.101	0.202	−0.385
Water resource input (t−4)	−0.162	−0.809	0.198	−0.133	−0.154	−0.166	−0.161	0.030	0.086	−0.192
GHG emissions (t−4)	−0.280	−0.744	0.134	−0.072	−0.046	0.193	0.110	−0.066	0.070	0.058
Waste discharge (t−4)	−0.535	−0.348	0.069	0.073	0.257	0.017	0.401	0.138	−0.153	0.044

ROE: Return on equity, R and D: Research and development, GHG: Greenhouse gas

Table 5: Cluster 2 - principal component loadings of explanatory variables

Variables	PC 1	PC 2	PC 3	PC 5	PC 7
ROE (t−1)	−0.165	0.167	−0.030	−0.169	−0.173
R and D expenses (t−1)	−0.100	−0.824	−0.193	−0.274	−0.080
Operating C/F (t−1)	0.039	−0.474	−0.062	−0.115	−0.112
Equity ratio (t−1)	−0.378	−0.524	0.047	0.019	0.133
Water resource input (t−1)	0.847	−0.217	−0.063	0.020	−0.020
GHG emissions (t−1)	0.819	−0.190	−0.009	−0.015	−0.042
Waste discharge (t−1)	0.723	0.199	0.079	−0.034	−0.088
Average salary (t−1)	−0.036	0.291	−0.113	−0.470	−0.509
Female management ratio (t−1)	−0.018	0.314	−0.647	−0.341	0.258
Ratio of employees with disabilities (t−1)	−0.065	0.064	−0.066	0.235	−0.096
Average monthly overtime hours (t−1)	0.135	0.401	0.245	−0.076	−0.013
External director ratio (t−1)	−0.021	−0.242	−0.460	0.262	0.205
Female officer ratio (t−1)	−0.053	0.305	−0.632	0.260	−0.244
ROE (t−2)	−0.078	0.041	0.144	−0.171	0.428
R and D expenses (t−2)	−0.107	−0.815	−0.176	−0.295	−0.082
Operating C/F (t−2)	−0.024	−0.451	−0.309	−0.155	0.102
Equity ratio (t−2)	−0.371	−0.571	−0.070	0.024	0.084
Water resource input (t−2)	0.882	−0.220	−0.063	0.012	−0.028
GHG emissions (t−2)	0.957	−0.156	−0.097	0.008	−0.009
Waste discharge (t−2)	0.798	0.109	0.067	0.064	−0.075
Average salary (t−2)	0.035	0.368	−0.059	−0.470	−0.425
Female management ratio (t−2)	−0.046	0.117	−0.604	−0.498	0.272
Ratio of employees with disabilities (t−2)	−0.066	0.009	−0.033	0.198	−0.087
Average monthly overtime (t−2)	0.148	0.448	0.342	−0.048	0.239
External director ratio (t−2)	0.034	−0.096	−0.563	0.259	0.177
Female officer ratio (t−2)	−0.039	0.304	−0.739	0.274	−0.183
ROE (t−3)	0.069	0.050	0.143	−0.177	0.627
R and D expenses (t−3)	−0.110	−0.827	−0.181	−0.281	−0.064
Operating C/F (t−3)	0.005	−0.383	0.104	0.001	0.084
Equity ratio (t−3)	−0.323	−0.482	−0.012	0.056	−0.106
Water resource input (t−3)	0.563	−0.167	−0.026	−0.090	−0.074
GHG emissions (t−3)	0.958	−0.156	−0.094	0.011	−0.007
Waste discharge (t−3)	0.881	−0.001	0.060	−0.036	0.103
Average salary (t−3)	0.029	0.310	−0.133	−0.532	−0.130
Female management ratio (t−3)	−0.092	0.283	−0.502	−0.418	0.266
Ratio of employees with disabilities (t−3)	−0.071	0.032	−0.075	0.223	−0.071
Average monthly overtime (t−3)	0.104	0.286	0.319	−0.123	0.386
External director ratio (t−3)	0.056	−0.127	−0.587	0.212	0.215
Female officer ratio (t−3)	0.041	0.313	−0.709	0.216	−0.174
ROE (t−4)	0.208	0.169	−0.060	−0.064	0.359
R and D expenses (t−4)	−0.108	−0.825	−0.184	−0.278	−0.073
Operating C/F (t−4)	0.027	−0.270	−0.025	−0.018	0.040
Equity ratio (t−4)	−0.329	−0.365	−0.026	0.169	0.075
Water resource input (t−4)	0.891	−0.226	−0.058	0.017	−0.025
GHG emission (t−4)	0.953	−0.169	−0.093	0.009	−0.011
Waste discharge (t−4)	0.804	0.077	0.083	0.018	0.071
Average salary (t−4)	0.081	0.265	0.052	−0.546	−0.290
Female management ratio (t−4)	0.027	0.228	−0.598	−0.468	0.236
Ratio of employees with disabilities (t−4)	−0.066	0.003	−0.021	0.150	−0.068
Average monthly overtime (t−4)	0.119	0.425	0.336	−0.090	0.260
External director ratio (t−4)	0.038	−0.024	−0.648	0.260	0.221
Female officer ratio (t−4)	−0.005	0.384	−0.643	0.214	−0.149

ROE: Return on equity, R and D: Research and development, GHG: Greenhouse gas

Repeat steps 1-3 until no further improvement is found: Continue swapping companies between clusters and re-estimating the corporate value models until no further improvement in R^2 values is observed.

One hundred types of initial cluster segmentations were prepared. For equal segmentation of the two clusters, 2500 types of cluster segmentation were evaluated. For unequal segmentation, the number of companies in each cluster varied from 20 (80 companies) to 50 (50 companies), assessing all possibilities in between.

Figure 2 presents the evaluation results of the cluster segmentation model using the two-division method. The horizontal axis shows the number of companies in clusters 1 and 2. (49-51) indicates that Cluster 1 consists of 49 companies and Cluster 2 consists of 51 companies. If the number of companies in the cluster overlaps, it is indicated as (49-51)(1), (49-51)(2), (49-51)(3), and so on. This figure shows the combinations with the highest average corporate value for the cluster companies. (50-50)(1) is the optimal cluster segmentation method.

We created industry-specific clustered corporate value models and analyzed the R^2 values (Figure 3). The results showed that the two-cluster model had higher explanatory power than the industry-specific models.

5. CLUSTERED CORPORATE VALUE MODEL

The correlation between corporate value and the explanatory variables can be described as the product of each explanatory variable's standardized partial regression coefficient and its principal component loading. Table 2 shows the standardized partial regression coefficients of the principal components of Cluster 1, while Table 3 shows the same for Cluster 2. Tables 4 and 5 detail the principal component loadings for the explanatory variables in Clusters 1 and 2, respectively.

To account for the time lag in explanatory variables, we used different symbols based on their correlation with corporate value. "+" indicates all explanatory variables from periods t-1, t-2, t-3, and t-4 are positively correlated with corporate value (Table 6). "−" signifies whether variables from periods t-1, t-2, t-3, and t-4 are negatively correlated with corporate value. "±" is used when there is a mix of positive and negative correlations among the variables. In this case, the effect of the explanatory variables on corporate value is time-dependent.

In Cluster 1 companies, financial factors such as ROE and operating cash flow positively correlate with corporate value. The standardized partial regression coefficients were large, indicating a significant impact on corporate value. ROE from the t-1 period positively correlates with corporate value, whereas the ROE from the t-1 period and t-2 period have a negative correlation. This finding suggests that the impact of ROE on corporate value is greater in the most recent period.

Environmental factors, such as water resource input and greenhouse gas (GHG) emissions, negatively correlate with corporate value. The standardized partial regression coefficients were lower than those of the other explanatory variables, indicating a smaller impact. The social factor items were positively correlated with corporate value. Governance items such as the female officer ratio positively correlate with corporate value, whereas the external director ratio negatively correlates with corporate value.

In Cluster 2 companies, research and development expenses, as well as the equity ratio, are negatively correlated with corporate value. However, ROE for the periods t-1 through t-3 period show a positive correlation, indicating that ROE is evaluated from a long-term perspective in this cluster. Additionally, environmental factors, such as GHG emissions, water resource input, and waste emissions, positively correlate with corporate value, suggesting that higher emissions are associated with higher corporate value. Governance items, such as the external director ratio and the ratio of female officers, negatively correlate with corporate value.

Table 6: Comparison of cluster 1 and 2

Category	Variables	Correlation withcorporate value	
		Cluster 1	Cluster 2
Finance	ROE	±	+
	R and D expenses	+	−
	Operating C/F	+	−
	Equity ratio	±	−
Environment	Water resource input	−	+
	GHG emissions	−	+
	Waste discharge	−	+
Society	Average salary	+	+
	Female management ratio	+	±
	Average monthly overtime hours	±	+
	Ratio of employees with disabilities	−	−
Governance	External director ratio	−	−
	Female officer ratio	+	−

ROE: Return on equity, R and D: Research and development, GHG: Greenhouse gas, +: all explanatory variables from periods t-1, t-2, t-3, and t-4 are positively correlated corporate value. -:whether variables from periods t-1, t-2, t-3, and t-4 are negatively correlated with corporate value. +/-:there is a mix of positive and negative correlations among the variables corporate value.

Table 7: Number of companies in cluster 1 and cluster 2

Industries	Cluster 1	Cluster 2
Electrical equipment	12	15
Chemical	8	18
Food	12	7
Construction	13	6
Service	5	4
Total	50	50

Table 7 shows the number of companies in each industry belonging to Clusters 1 and 2. There is a bias in the number of companies in the chemical and food industries between Clusters 1 and 2. This suggests that the explanatory variables affecting corporate value differ even within the same industry.

6. CONCLUSION

This study proposed a clustered corporate value model, employing extensive cluster division and explanatory variable selection. A principal component regression model was constructed using a multi-start method for cluster division and variable selection. It also considered the time lag of explanatory variables' impact on corporate value, clarifying the short- and long-term effects of ESG factors. The cluster-based firm value model has higher explanatory power for corporate value than the traditionally industry-based value model. By defining clusters outside traditional industry groupings and building a corporate value model for each, managers can improve corporate value and set appropriate ESG goals. This approach also helps investors assess risks that may affect corporate value.

REFERENCES

Al-Issa, N., Audil, R.K., Jreisat, A., Al-Mohamad, S., Fahl, D., Limani, E. (2022), Impact of environmental, social, governance, and corporate social responsibility factors on firm's marketing expenses and firm value: A panel study of US companies. Cogent Business and

Management, 9(1), 2135214.

Aydoğmuş, M., Gülay, G., Ergun, K. (2022), Impact of ESG performance on firm value and profitability. Borsa Istanbul Review, 22(S2), 119-127.

Constantinescu, D., Caraiania, C., Lungua, C.I., Mititeana, P. (2021), Environmental, social and governance disclosure associated with the firm value. Evidence from energy industry. Accounting and Management Information Systems, 20(1), 56-75.

Duan, Y., Yang, F., Lin, X. (2023), Environmental, social, and governance (ESG) performance and firm value: Evidence from Chinese manufacturing firms. Sustainability, 15(17), 12858.

Frey, H., Oehler, A. (2014), Intangible assets in Germany: Analysis of the German stock market index DAX and a survey among the German Certified Public Accountants. Journal of Applied Accounting Research, 15(2), 235-248.

Friede, G., Busch, T., Bassen, A. (2015), ESG and financial performance: Aggregated evidence from more than 2000 empirical studies. Journal of Sustainable Finance and Investment, 5(4), 210-233.

Green, A. (2007), Intangible assets in plain business language. VINE, 37 (3), 238-248.

Hongo, A. (2008), Does environmental management enhance firm value? An analysis of firm value using the environmental management degree survey. The Journal of Social Science, 64 (COE Special Edition), 257-268.

Kenny, F., Han, J., Frista, F., Kurniawan, B. (2024), The effect of green accounting disclosure on the firm value of listed mining and agriculture companies in Southeast Asia countries. International Journal of Energy Economics and Policy, 14(1), 377-382.

Nojiri, Y., Yamashita, H., Hagiwara, M. (2019), R&D activities considering several time-rag of finance investment in fine chemical firms. Journal of Japan Association for Management Systems, 36(2), 137-143.

Ocak, M., Fındık, D. (2019), The impact of intangible assets and sub-components of intangible assets on sustainable growth and firm value: Evidence from Turkish listed firms. Sustainability, 11(19), 5359.

Oshika, T. (2023), Usefulness of Non-financial Information in Decision Making. Japan: Chuo Keizai-Sha.

Quilligan, L. (2006), Intangible assets identification and valuation under IFRS 3. Accountancy Ireland, 38(3), 10-12.

Qureshi, M.A. Kirkerud, S., Tran, K.T, Ahsan, T. (2019), The impact of sustainability (environmental, social, and governance) disclosure and board diversity on firm value: The moderating role of industry sensitivity. Business Strategy and the Environment, 29(3), 1199-1214.

Rahman, M.M., Howlader, M.S. (2022), The impact of research and development expenditure on firm performance and firm value: Evidence from a South Asian emerging economy. Journal of Applied Accounting Research, 23(4), 825-845.

Safiullah, M., Akhter, T. Saona, P., Azad, M.A.K. (2022), Gender diversity on corporate boards, firm performance, and risk-taking: New evidence from Spain. Journal of Behavioral and Experimental Finance, 35, 100721.

Sakurada, Y. (2023), Relationship between ratio of female directors and corporate performance. The Economic Studies, 73(2), 1-16.

Temiz, H. (2021), The effects of corporate disclosure on firm value and firm performance: Evidence from Turkey. International Journal of Islamic and Middle Eastern Finance and Management, 14(5), 1061-1080.

Tomizuka, Y. (2017), Does non-financial information relate to firm value? Empirical analysis based on integrated reports of pharmaceutical companies. Accounting, 69(7), 116-122.

Toyo Keizai Shinposha. (2018a), CSR Corporate Overview: ESG Edition 2018. Tokyo: Toyo KEIZAI Inc.

Toyo Keizai Shinposha. (2018b), CSR Corporate Overview: Employment and Human Resource Utilization Edition 2018. Tokyo: Toyo KEIZAI Inc.

Toyo Keizai Shinposha. (2019a), CSR Corporate Overview: ESG Edition 2019. Tokyo: Toyo KEIZAI Inc.

Toyo Keizai Shinposha. (2019b), CSR Corporate Overview: Employment and Human Resource Utilization Edition 2019. Tokyo: Toyo KEIZAI Inc.

Toyo Keizai Shinposha. (2020a), CSR Corporate Overview: ESG Edition, Weekly Toyo Keizai Special Issue DB Series 2020. Tokyo: Toyo KEIZAI Inc.

Toyo Keizai Shinposha. (2020b), CSR Corporate Overview: Employment and Human Resource Utilization Edition 2020, Weekly Toyo Keizai Special Issue DB Series 2020. Tokyo: Toyo KEIZAI Inc.

Toyo Keizai Shinposha. (2021a), CSR Corporate Overview: ESG Edition, Weekly Toyo Keizai Special Issue DB Series 2021. Tokyo: Toyo KEIZAI Inc.

Toyo Keizai Shinposha. (2021b), CSR Corporate Overview: Employment and Human Resource Utilization Edition 2020, Weekly Toyo Keizai Special Issue DB Series 2020. Tokyo: Toyo KEIZAI Inc.

Toyo Keizai Shinposha. (2022a), CSR Corporate Overview: ESG Edition, Weekly Toyo Keizai Special Issue DB Series 2022. Tokyo: Toyo KEIZAI Inc.

Toyo Keizai Shinposha. (2022b), CSR Corporate Overview: Employment and Human Resource Utilization Edition 2022, Weekly Toyo Keizai Special Issue DB Series 2022. Tokyo: Toyo KEIZAI Inc.

Toyo Keizai Shinposha. (2023a), CSR Corporate Overview: ESG Edition, Weekly Toyo Keizai Special Issue DB Series 2022. Tokyo: Toyo KEIZAI Inc.

Toyo Keizai Shinposha. (2023b), CSR Corporate Overview: Employment and Human Resource Utilization Edition 2023, Weekly Toyo Keizai Special Issue DB Series 2023. Tokyo: Toyo KEIZAI Inc.

Wu, R., Hossain, M.A., Teng, Z., Shen, X. (2023), The relationship between corporate social responsibility and firm value of Chinese firms: Exploring from degree of internationalization. Journal of Environmental and Public Health, 1-11.

Yamabayashi, T. (2016), Effects of governance factors on corporate financial performance - With special reference to companies adopting integrated reporting in Japan. Bulletin of Graduate Studies, 4, 24-43.

Yamamoto, I. (2014), Relationship between Women's Utilization and Corporate Performance in Listed Companies -Verification Using Corporate Panel Data-, DP - RIETI Discussion Paper Series, 4-J-016.

Yanagi, R., Ito, K. (2019), Evidence on the 'ROESG' Model and Natural Capital, Monthly Capital Market, No 409, p36-46.

Yanagi, R., Yoshino, T. (2017), Consideration of the Relationship between Human Capital, Intellectual Capital, and Corporate Value (PBR), Capital Market Monthly, (No.386), p4-13.

Zhou, G., Liu, L., Luo, S. (2022), Sustainable development, ESG performance and company market value: Mediating effect of financial performance. Business Strategy and the Environment, 31(7), 3371-3387.