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Managerial Overconfidence and Cost Behavior of R&D Expenditures

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Abstract: This study examines the impact of a CEO's confidence level on decisions regarding research and development (R&D) expenditures. R&D is an important part of a company's strategy for achieving long-term sustainable growth. However, due to its discretionary nature, some CEOs choose to reduce R&D costs to enhance short-term performance. In other words, R&D cost behavior may vary depending on CEO characteristics. This study examines whether, in an effort to improve their firm's future performance, CEOs who are highly overconfident tend not to actively decrease R&D expenditures even when sales decrease. We posit that CEO overconfidence affects the cost behavior of R&D spending that is not related to their personal privileges. A cost behavior model was utilized to verify the relationship between CEOs' propensity for overconfidence and R&D expenditures. Our findings show that highly overconfident CEOs tend not to take actions to reduce R&D costs even if sales decrease because CEO overconfidence tends to be positively related to R&D. Since R&D represents both costs and long-term investments, policy support for capitalizing R&D costs can be considered as enhancing the sustainability of businesses.

Keywords: overconfidence; R&D; cost behavior; cost stickiness

1. Introduction

Due to its discretionary nature, research and development (R&D) spending is often used by CEOs for earnings management, which suggests that the cost behavior of R&D expenditures is related to the CEO's inclinations and the company's characteristics [1–3]. This study examines the impact of a CEO's confidence level on decisions regarding R&D expenditures. It uses Andersen et al.'s [4] cost behavior model to verify whether CEOs with high overconfidence tend not to actively reduce R&D costs even if sales decrease.

Cost behavior has traditionally been assumed to move symmetrically with changes in sales (activity) regardless of the activity level. However, Noreen and Soderstrom [5] and Cooper and Kaplan [6] suggest that an alternative model of cost behavior may exist. That is, some costs may exhibit sticky changes, where decreases when the activity level declines are smaller than increases when the activity level goes up. Anderson et al. [4] claim that asymmetric cost behavior exists in selling, general, and administrative (SG&A) costs, while later studies have used various methodologies to prove that asymmetric cost behavior does, in fact, exist [7–13].

Anderson et al. [4] argue that one of the reasons for asymmetric cost behavior is a CEO's optimistic expectations for future sales improvement. That is because CEOs anticipate future sales will increase even when current sales have declined, they tend to maintain costs (current resources) at their existing levels to reduce the adjustment costs that will be incurred when sales increase again. In other

words, CEOs with high expectations for future sales tend not to take actions to reduce costs even if sales decrease.

Asymmetric cost behavior reflects the positive actions taken by CEOs to reduce the adjustment costs that will be incurred in the future. Moreover, it can also be explained from the negative aspect of a CEO's reluctance to reduce the cost of maintaining his/her private benefits and privileges. Anderson et al. [4] and Chen et al. [14] also point out that CEOs are reluctant to take actions to reduce costs when sales decline, in an effort to maintain their own benefits and privileges. CEOs do not actively reduce private costs incurred in order to pursue private profits. In other words, if the cost behavior related to private expenditures is asymmetric, shareholder value is impaired, resulting in higher agency costs [4].

Based on prior studies, Chen et al. [15] argue that the greater the CEO's overconfidence, the higher the expectations for future performance, which results in asymmetric cost behavior. However, companies with highly overconfident CEOs also have incentives to actively reduce inefficient SG&A to improve performance.

Thus, to support the argument that overconfident CEOs reduce costs due to their optimistic expectations for future sales, it is reasonable to examine those costs that have positive implications for future performance. That is, based on CEO overconfidence, it is necessary to examine R&D cost behavior since R&D is a positive factor that can lead to the creation of future performance, unlike expenses incurred to maintain the CEOs' own personal benefits and privileges.

As R&D expenditures are not highly responsive to sales growth and declines, when sales decrease, it is possible for CEOs to use their discretion to adjust the amount of R&D expenditures [1,16]. However, even if management performance deteriorates in the short term, it would be short-sighted for a company CEO who wants to enhance mid-to-long-term performance to reduce R&D spending. He/she would rather reduce other expenses because competitive R&D capability is vital for a company's sustainable growth [17]. Even if management performance deteriorates in the short term, a CEO who is confident that business performance will improve is especially expected not to reduce R&D spending because of its positive effect on future performance. Instead, he/she may even increase R&D spending. Hence, it is necessary to analyze how CEO characteristics affect decision-making behavior related to R&D expenditures, which contribute to long-term management performance. Therefore, this study focuses on R&D expenditures, and analyzes the relationship between CEO overconfidence and cost behavior.

2. Literature Review

2.1. Literature Review: CEO Overconfidence

CEO overconfidence is known to affect methods of financial reporting [18–21]. Ahmed and Duellman [18] find a tendency toward less conservative accounting when CEOs have stronger overconfidence. Schrand and Zechman [19] report more accounting errors in the financial statements of an entity operated by an overconfident CEO. Galasso and Simcoe [20] report that as a CEO's overconfidence increases, more innovative management activities are pursued. Hribar and Yang [21] report that CEO overconfidence leads to more frequent voluntary disclosure of forecast information. Hayward et al. [22] report that as CEOs become more overconfident in their judgment and ability to cope with their future, they are more likely to understate the risks inherent in their operations and make excessive investments, or make wrong decisions in their investment and financial policies. For example, McLean and Elkind [23] report that Jeffrey Skilling, the former CEO of Enron, thought he could manipulate financial information without being detected, but his overconfidence led to Enron's collapse.

Malmendier and Tate [24] examine whether overconfident CEOs over-invest when internal funds are abundant, and reduce investments when external funds are needed, since they tend to overestimate not only the return on their own investment plans but also external financing costs. Their analysis shows that overconfident CEOs are more sensitive to cash flow when investing, especially in capital-dependent companies. In addition, in a summary of prior study results, Malmendier and Tate [25] examine the

effect of CEO overconfidence on investments. As a result of the analysis, they present additional evidence in their follow-up study on the relationship between excessive investment decisions and media coverage of CEOs, a proxy for CEO overconfidence that was developed in prior studies [24]. The additional evidence demonstrates that CEO overconfidence depends on the perceptions of people outside the organization rather than on the CEO's own actions. This study analyzes the effect of CEO overconfidence on the cost behavior of R&D expenditures, which positively affect future performance.

Various studies have also been conducted to measure CEO overconfidence. Ahmed and Duellman [18] define a CEO as overconfident if the sum of the various tangible assets extracted from the cash flow statement is greater than the median industry level of capital expenditures. Campbell et al. [26] describe a CEO as overconfident if the company's capital expenditures are greater than those of average companies in the same industry. Schrand and Zechman [19] define overconfident CEOs as the heads of overly-invested companies that have greater asset growth than sales growth. In addition, some define companies with a tendency to demonstrate CEO overconfidence as those with a debt ratio (total liabilities divided by capital) that is higher than the industry average in terms of acquiring investment capital, or those with a zero-dividend ratio [19].

2.2. Literature Review: Research and Development Costs

It is known that CEOs adjust expenditures according to business performance to ensure that they achieve target profit levels [27–32]. Thus, R&D expenditures are perceived as large amounts that reflect considerable CEO discretion. A number of studies have been conducted regarding whether CEOs adjust R&D spending as a means of managing the earnings of the companies they oversee. Since adjusting R&D expenditures is an alternative to discretionary earnings management, Baber et al. [27] report their finding that CEOs reduce R&D spending when net profit or the net profit growth rate is unlikely to be positive, and determine the level of R&D spending to facilitate their own compensation arrangements.

Dechow and Sloan [28] report that CEOs tend to reduce spending on R&D in the last year of his/her term in office to increase reported profits. Perry and Grinaker [29] verify that CEOs reduce R&D spending as a means of earnings management to adjust actual profits to meet profit forecasts. They present evidence that companies with profits above expectations temporarily reduce profits by raising R&D spending, while companies with profits below expectations do not raise profits by adjusting R&D spending. In addition, CEOs reduce R&D spending to alleviate pressure to achieve short-term earnings benchmarks [30,31].

Studies have been conducted on the use of R&D spending for earnings management by newly-listed companies with high potential for earnings management. Investors in newly listed companies are more interested in the company's current profits than in R&D spending and, thus, company R&D expenditure is reduced [32]. However, in another opinion, Demers and Joos [33] published a study showing that R&D costs could be an important variable in the assessment of a newly listed entity's risks. From this economic point of view, Avram et al. [34] argue that while R&D costs are "discretionary costs" at the microeconomic level, they are closely related to the growth of a nation's output through their enhancement of productivity and efficiency at the macroeconomic level, indicating that government R&D investment and support in the private sector should continue.

Prior studies on R&D argue that R&D expenditures can be used as a means of earnings management. If R&D expenditures are used for earnings management, CEOs may further reduce R&D spending when sales decrease. With the exception of Cheung et al. [2], it is hard to find studies on the cost behavior of R&D expenditures. To take this area of research one step further, this study analyzes the effects of CEO overconfidence on R&D expenditures when sales decrease.

2.3. Literature Review: Cost Behavior

Traditionally, costs are classified as variable and fixed. Variable costs are costs that increase or decrease in total in proportion to increases or decreases in the level of activity. Fixed costs are costs that do not change in total with changes in external factors such as price changes, and whose total

amounts are constant within a relevant range, regardless of the level of activity. That is, costs are classified as variable or fixed based solely on whether total costs change with changes in the activity level, and increases and decreases in costs due to changes in unit activity are assumed to be the same. This concept is called the "proportionate cost model" [5].

Andersen et al. [4] define "symmetric cost behavior" as cost changes where the rate of a cost increase when sales increase is exactly proportional to the rate of a cost decrease when sales decrease. In addition to symmetric cost behavior, they also define asymmetric cost behavior. Asymmetric cost behavior can be defined in the following two ways. First, "cost stickiness" indicates the cost decrease when sales decrease is smaller than the cost increase when sales increase. Second, "cost anti-stickiness" means the cost decrease when sales decrease is greater than the cost increase when sales increase.

Andersen et al. [4], who find asymmetric cost behavior, argue that this type of cost behavior is caused by a difference between the speed of CEO decision-making on adjustments to corporate resources when sales increase and when sales decrease. Analyzing asymmetric cost behaviors of USA, UK, German, and French companies, Calleja et al. [35] maintain that French and German companies exhibit more sticky-cost behavior than their UK and USA counterparts due to differences in corporate governance and management systems, and that company and industry characteristics affect cost-stickiness. In addition, Balakrishnan et al. [7] analyze what factors could affect CEO decision-making and cause cost-stickiness in the healthcare industry. Subramaniam and Weidenmier [8] investigate whether the size of a change in sales activity and industrial characteristics affect asymmetric cost behavior. Moreover, Banker and Chen [9] suggest that cost behavior varies depending on the sales change in the previous term. These studies all empirically verify that cost behavior can be asymmetric, and demonstrate that there is a difference in asymmetry depending on CEO and industry characteristics.

However, there are also arguments that contradict these studies. Although Andersen and Lanen [10] point out that the sticky behavior of SG&A expenses is statistically weak but significant, the theoretical background in prior studies only weakly supports their assumption that CEO decision-making is a determinant of cost-sticky behavior. As grounds for their argument, they suggest other costs (e.g., labor costs, R&D expenditures, and costs related to tangible assets) that are affected by CEO decision-making do not consistently display cost-sticky behavior.

Several studies have attempted to discover the cause of the inconsistent results suggested by Andersen and Lanen [10]. Banker and Byzalov [11] maintain that inconsistent asymmetric cost behavior may be caused by CEOs' strategic behaviors. Banker and Byzalov [11] suggest the relationship between adjustment costs and CEO decision making is the cause of asymmetric cost behavior. Sticky resources, which are the target of CEO decision making, are neither fixed nor variable costs that can be adjusted in the short term but accompany resource adjustment costs. They argue the factors that affect decision-making about such resource adjustments are behavioral factors such as sales for the period, resource levels of the previous period, which affect current resource adjustment costs, expected future sales, which affect future resource adjustment costs, and agency problems. Chen et al. [15] indicate that CEO and CFO overconfidence may cause the asymmetric cost behavior in SG&A, but do not distinguish the cost of maintaining these executives' private status from R&D expenditures, which potentially have a positive impact on future performance.

If R&D investment and expenditure is an adjustment cost, to avoid future adjustment costs, CEOs may retain idle resources related to R&D instead of getting rid of them. However, when demand increases, CEOs can meet the demand only by acquiring R&D resources. If large costs are required to obtain manpower and equipment for R&D when demand increases, CEOs may not increase resources. Thus, sales would grow at a lower rate than market demand because sales growth would be limited by low R&D resource capacity. Therefore, CEOs who are confident of stronger future performance will try to maintain their R&D manpower and spending. This study analyzes the cost behavior of R&D spending based on CEO overconfidence.

3. Hypotheses

Increases and decreases in costs have traditionally been assumed to be either proportional to activity levels, such as sales, or fixed within a certain range regardless of activity. However, Cooper and Kaplan [6] and Noreen and Soderstrom [5] theoretically suggest that cost behavior can also be asymmetric. Later, through research on asymmetric cost behavior of SG&A expenses, Anderson et al. [4] empirically prove that asymmetric cost behavior actually exists. Since then, a number of studies have been conducted on the cause of asymmetric cost behavior [12,13,35–37].

Studies have analyzed the causes of asymmetric cost behavior as future sales expectations increase, where CEOs try to reduce future adjustment costs by maintaining existing resources without reducing SG&A costs even when sales decrease. Another argument is that asymmetric cost behavior is caused by the agency costs incurred to maintain CEOs' individual benefits and privileges, and is an effect of earnings management [12,13].

These studies have primarily focused on SG&A costs and its components. Roychowdhury [1] argues that, among the components of SG&A costs, the one with the highest level of CEO discretion is R&D spending, which CEOs often use for earnings management. Thus, investigating the cost behavior of R&D expenditures can provide an in-depth understanding of CEO decision-making about R&D spending.

If R&D expenditures are used as a means of simple earnings management, they will show anti-sticky behavior. However, if R&D expenditures are made regardless of sales increases or decreases, they will not proportionately respond to changes in sales. On the other hand, if R&D expenditures respond to sales increases but do not decrease proportionally when sales decrease, sticky-cost behavior (cost stickiness) is expected to be observed. As this is an empirical question, we establish the null hypothesis as follows:

Hypothesis 1. *R&D cost behavior is symmetric.*

As companies are assumed to be going concerns, when sales decline, they have an incentive to make efforts to increase sales while maintaining existing resources rather than immediately reducing those resources [4]. However, despite a CEO's judgment that sales will increase in the future, a CEO is more likely to choose company survival than maintaining existing resources when the company's survival is at stake.

In Hypothesis (1), we examine whether R&D costs are symmetric or asymmetric when compared to sales increases and decreases. In Hypothesis (2), we analyze R&D spending patterns depending on (the tendency toward) CEO overconfidence. If, when sales decrease, a company with an overconfident CEO makes R&D expenditures regardless of the sales amount, its R&D expenditures will not exhibit a response proportional to the change in sales. However, when sales decline, if a company with an overconfident CEO reduces its R&D expenditures more steeply than its decline in sales to engage in short-term earnings management, anti-sticky cost behavior will be observed. Meanwhile, if an overconfident CEO who is convinced of future sales growth does not reduce R&D expenditures in proportion to a sales decrease, sticky-cost behavior is expected to be observed.

In fact, a sales decrease reduces the cash generated by business operations, which inevitably constricts not only normal business activities but also investment activities. In addition, a sales decrease negatively affects a CEO's performance and a lack of cash flow is likely to diminish the resources the CEO can use with discretion, decreasing room for decision-making to maintain his/her private interests or future management performance. Hence, a sales decrease has a great effect on CEO decision-making regarding efficient cost adjustments. As R&D expenditures are long-term investments, the CEO may actively take cost-cutting measures with respect to R&D to improve short-term performance. However, a CEO convinced of future sales growth can adopt a strategy of investing more resources and increasing spending on R&D to enhance poor business performance. In other words, R&D spending may show cost-sticky behavior.

Hypothesis 2. *Companies whose CEOs have a high level of overconfidence have stickier cost behavior in R&D spending than those whose CEOs are less overconfident.*

4. Research Design

4.1. Research Model

To investigate the cost behavior of R&D expenditures and how this cost behavior is affected by CEO overconfidence, we first present a basic model by adapting Anderson et al.'s [6] equation and establish Research Model 1 and Extended Model 2 by modifying the basic model.

Basic Model

$$
\begin{aligned}
\text{Model 1-1}\quad \Delta R\&D_{i,t} &= a_0 + a_1 * \Delta SALE_{i,t} + a_2 * \Delta SALE_{i,t} * DD_{i,t} + \varepsilon_{i,t} \\
\text{Model 1-2}\quad \Delta R\&D_{i,t} &= b_0 + b_1 * \Delta SALE_{i,t} + b_2 * \Delta SALE_{i,t} * DD_{i,t} \\
&\quad + b_3 * \Delta SALE_{i,t} * DD_{i,t} * OVERCON_{i,t} + \varepsilon_{i,t}
\end{aligned}
\tag{1}
$$

Research Model

$$
\begin{aligned}
\text{Model 2-1}\quad \Delta R\&D_{i,t} &= a_0 + a_1 * \Delta SALE_{i,t} + a_2 * \Delta SALE_{i,t} * DD_{i,t} \\
&\quad + a_3 * \Delta SALE_{i,t} * DD_{i,t} * SUCCE_{i,t} \\
&\quad + a_4 * \Delta SALE_{i,t} * DD_{i,t} * ASSET_{i,t} \\
&\quad + a_5 * \Delta SALE_{i,t} * DD_{i,t} * GDP_{k,t} + a_j \sum IND + \varepsilon_{i,t} \\
\text{Model 2-2}\quad \Delta R\&D_{i,t} &= b_0 + b_1 * \Delta SALE_{i,t} + b_2 * \Delta SALE_{i,t} * DD_{i,t} \\
&\quad + b_3 * \Delta SALE_{i,t} * DD_{i,t} * OVERCON_{,t} \\
&\quad + b_4 * \Delta SALE_{i,t} * DD_{i,t} * SUCCE_{i,t} \\
&\quad + b_5 * \Delta SALE_{i,t} * DD_{i,t} * ASSET_{i,t} \\
&\quad + b_6 * \Delta SALE_{i,t} * DD_{i,t} * GDP_{k,t} + b_j \sum IND + \varepsilon_{i,t}
\end{aligned}
\tag{2}
$$

Extended Model

$$
\begin{aligned}
\text{Model 3-1}\quad \Delta R\&D_{i,t} &= a_0 + a_1 * \Delta SALE_{i,t} + a_2 * \Delta SALE_{i,t} * DD_{i,t} \\
&\quad + a_3 * \Delta SALE_{i,t} * DD_{i,t} * SUCCE_{i,t} \\
&\quad + a_4 * \Delta SALE_{i,t} * DD_{i,t} * ASSET_{i,t} \\
&\quad + a_5 * \Delta SALE_{i,t} * DD_{i,t} * GDP_{k,t} \\
&\quad + a_6 * SUCCE_{i,t} + a_7 * ASSET_{i,t} + a_8 * GDP_{k,t} + a_j * \sum IND + \varepsilon_{i,t} \\
\text{Model 3-2}\quad \Delta R\&D_{i,t} &= b_0 + b_1 * \Delta SALE_{i,t} + b_2 * \Delta SALE_{i,t} * DD_{i,t} \\
&\quad + b_3 * \Delta SALE_{i,t} * DD_{i,t} * OVERCON_{i,t} \\
&\quad + b_4 * \Delta SALE_{i,t} * DD_{i,t} * SUCCE_{i,t} \\
&\quad + b_5 * \Delta SALE_{i,t} * DD_{i,t} * ASSET_{i,t} \\
&\quad + b_6 * \Delta SALE_{i,t} * DD_{i,t} * GDP_{k,t} \\
&\quad + b_7 * SUCCE_{i,t} + b_8 * ASSET_{i,t} + b_9 * GDP_{k,t} \\
&\quad + b_{10} * OVERCON_{i,t} + b_j * \sum IND + \varepsilon_{i,t}
\end{aligned}
\tag{3}
$$

$\Delta R\&D_{i,t}$: *Natural logarithm of change in R&D costs between year t and year t−1;*
$\Delta SALE_{i,t}$: *Natural logarithm of change in sales between year t and year t−1;*
DD: 1 if sales of firm i for period t are less than those in the preceding period, 0 otherwise;
OVERCON: 1 if capital expenditures deflated by lagged total assets in a given year are greater than the median level of capital expenditures to lagged total assets for the firm's industry in that year, and 0 otherwise [18];
SUCCE: 1 if Sale t-1 > Sale t-2 > Sale t, 0 otherwise;
ASSET: Natural logarithm of the ratio of assets to sales;
GDP: Gross domestic product;
IND: Industry dummy.

In the research model, the dependent variable, $\Delta R\&D$, is the rate of change in R&D expenditures. The variable of interest for Hypothesis (1) is $\Delta SALE_{i,t}*DD_{i,t}$. The coefficient of the variable of interest, a_2, reflects asymmetric cost behavior. If a_2 has a positive value, the cost has anti-sticky behavior, whereas if a_2 has a negative ($-$) value, the cost has sticky behavior. The value of a_2 indicates the results of testing Hypothesis (1).

The variable of interest for Hypothesis (2) is $\Delta SALE_{i,t}*DD_{i,t}*OVERCON_{i,t}$. The results of testing Hypothesis (2) can be confirmed by the sign of its coefficient, b_3. As in a_2, if b_3 has a positive value, the cost has anti-sticky behavior due to CEO overconfidence, whereas a negative value indicates the cost has sticky behavior. Referring to Anderson et al. [4], we added the following variables to the research model as control variables. The first control variable is SUCCE, which indicates successive sales decreases. Anderson et al. [6] argue that if sales decrease continuously, CEOs tend to weaken stickiness as they have greater incentive to actively reduce costs. In addition, both asset concentration (ASSET) and economic growth (GDP) affect asymmetric cost behavior [4]. Thus, we add these to the model as control variables. We also add a single variable of each control variable to the extended model, as Dierynck et. al. [38] refer to the need to add each single variable without interactions. We exclude the variable for the number of employees suggested by Anderson et al. [4] because it does not fit the Korean situation of a stiff labor market, and its VIF (variance inflation factor) coefficient, which indicates multi-collinearity, is high. In the research model presented above, the study results remain the same even if the number of employees is included.

4.2. Sample Selection

We tested the firms listed on the KSE and KOSDAQ in Korea from 2011 to 2016. We selected those companies that met the following conditions.

(1) Companies listed in KOSPI from 2010 to 2017 (n = 17,963);
(2) Non-financial companies (n = 16,499);
(3) Companies that close their books in December (n = 14,674);
(4) Companies with data available for the analysis of the KIS-VALUE (n = 9375);
(5) Companies with R&D cost data available (n = 6280).

Financial firms and companies that do not close their books in December were excluded from the sample due to problems with comparability. In addition, companies for which financial data could not be collected were excluded from the sample, and companies with equity impairment were excluded because their management strategies may differ from those of normal companies. The final sample consisted of 6,280 business-years of data for fiscal years 2011 through 2017.

5. Results

Descriptive Statistics

Table 1 presents the descriptive statistics of the variables used in the research model. As extreme values exist in the distributions of some variables, to control for the effects of these values on the analysis, we use values winsorized at 1% and 99% for all variables except dummy variables.

The mean value of $\Delta R\&D$, which shows the change in SG&A and R&D expenditures for the selected samples, was 0.017, while $\Delta SALE$ was 0.020. This indicates that R&D expenditures and sales are growing annually by 1.7% and 2% (compared to the previous year), respectively. The standard deviation of $\Delta R\&D$ is 0.636, with a minimum value of -2.701 and a maximum value of 2.419. At 0.258, with a minimum value of -0.903 and a maximum value of 0.894, its variation is greater when compared to the standard deviation of $\Delta SALE$. On the other hand, DD, indicating the sales decrease compared to the previous period, is 0.428, indicating that 42.8% of all samples have a decrease in sales. $OVERCON$, which indicates overconfidence, is 0.488, showing that CEOs of 48.8% of the samples are overconfident. In addition, $SUCCE$, which indicates sales decreases for two successive years, is 0.206, showing that

the sales of 20.6% of the sample companies have decreased for two consecutive periods. The mean of *ASSET*, which is the natural logarithm of assets, is 0.327.

Table 1. Descriptive statistics ($n = 6280$).

Variables	Mean	Std.	Min	1Q	Median	3Q	Max
ΔR&D	0.017	0.636	−2.701	−0.144	0.041	0.217	2.419
ΔSALE	0.020	0.258	−0.903	−0.087	0.025	0.125	0.894
DD	0.428	0.495	0.000	0.000	0.000	1.000	1.000
OVERCON	0.488	0.500	0.000	0.000	0.000	1.000	1.000
SUCCE	0.206	0.405	0.000	0.000	0.000	0.000	1.000
ASSET	0.327	0.574	−0.821	−0.057	0.274	0.630	2.293
GDP	0.029	0.003	0.023	0.028	0.029	0.031	0.033

Table 2 shows the correlations among the variables. ΔR&D and ΔSALE are positively correlated. On the other hand, when the sales decrease is compared to the preceding period (*DD*), there is a significantly negative correlation between ΔR&D and ΔSALE. The variable for CEO overconfidence shows a significantly positive correlation with ΔR&D and ΔSALE. The cost behavior of R&D expenditures and the cost behavior of R&D expenditures affected by CEO overconfidence when sales decrease compared to the preceding period (*DD*) are analyzed using multivariate regression analysis.

Table 2. Pearson correlation matrix ($n = 6280$).

Variables	ΔR&D	ΔSALE	DD	OVERCON	SUCCE	ASSET	GDP
ΔR&D	1.000						
ΔSALE	0.087 <0.0001	1.000					
DD	−0.065 <0.0001	−0.667 <0.0001	1.000				
OVERCON	0.065 <0.0001	0.102 <0.0001	−0.113 <0.0001	1.000			
SUCCE	−0.065 <0.0001	−0.403 <0.0001	0.589 <0.0001	−0.112 <0.0001	1.000		
ASSET	−0.044 0.000	−0.194 <0.0001	0.145 <0.0001	−0.088 <0.0001	0.126 <0.0001	1.000	
GDP	0.005 0.722	0.017 0.177	−0.014 0.251	−0.003 0.799	0.048 0.000	0.050 <0.0001	1.000

Tables 3–5 show the results of the regression analysis of Hypotheses (1) and (2). The results in Tables 3–5 are those of regression analyses using the basic model, the research model, and the expansion model, respectively, and show the results of the regression analysis of the cost behavior of R&D expenditures, and the cost behavior of R&D expenditures affected by CEO overconfidence for each model.

Table 3 presents the results for Models 1-1 and 1-2. The results of the regression analysis of Model 1-2 show that the change rate of R&D (ΔR&D) is significantly positive when sales increase (ΔSALE) and is also significantly positive when sales decrease (*DD*). R&D expenditures exhibit anti-sticky behavior in a positive direction, even in the case of a sales decrease (*DD*). In other words, the results show that CEOs actively reduce R&D expenditures for short-term performance when sales decrease.

Table 3. Results of Basic Model.

Dependent Variable	ΔR&D					
	Model 1-1			Model 1-2		
	Coeff.	(*t*-stat.)		Coeff.	(*t*-stat.)	
Intercept	0.025	(2.57)	**	0.029	(2.94)	***
ΔSALE	0.138	(3.05)	***	0.116	(2.57)	**
ΔSALE*DD	0.139	(2.31)	**	0.341	(4.75)	***
ΔSALE*DD*OVERCON				−0.394	(−5.13)	***
IND		Exclude			Exclude	
F-Value	26.44		***	21.41		***
Adj. R-square		0.008			0.010	
Obs.		6280			6280	

t-stat. are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4. Results of Research Model.

Dependent Variable	ΔR&D					
	Model 2-1			Model 2-2		
	Coeff.	(*t*-stat.)		Coeff.	(*t*-stat.)	
Intercept	0.014	(0.17)		0.020	(0.23)	
ΔSALE	0.109	(2.21)	**	0.111	(2.26)	**
ΔSALE * DD	−0.111	(−0.31)		0.027	(0.08)	
ΔSALE *DD * OVERCON				−0.376	(−4.71)	***
ΔSALE * DD * SUCCE	0.125	(1.60)		0.108	(1.39)	
ΔSALE * DD * ASSET	−0.069	(−1.84)	*	−0.020	(−0.53)	
ΔSALE * DD * GDP	10.874	(0.87)		9.779	(0.78)	
IND		Include			Include	
F-Value	3.60		***	3.77		***
Adj. R-square		0.010			0.011	
Obs.		6280			6280	

t-stat. are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The results of the regression analysis for Model 1-2 demonstrate that, as in the case of Model 1-1, the change rate of R&D (ΔR&D) is significantly positive when sales increase (ΔSALE) and is also significantly positive when sales decrease (DD). However, the impact of overconfident CEOs (ΔSALE*DD*OVERCON) is statistically significantly negative when sales decrease. That is, companies with overconfident CEOs have sticky R&D cost behavior, suggesting they do not reduce R&D expenditures by the same ratio as sales decreases. This demonstrates that when sales decrease, overconfident CEOs are reluctant to reduce R&D expenditures to achieve short-term performance because they anticipate future sales increases.

Table 4 shows the results of the regression analysis that refers to Anderson et al.'s [4] study model. First, in model 2-1, the change rate of R&D expenditures (ΔR&D) is significantly positive when sales increase (ΔSALE), but not significant when sales decrease (DD). In other words, the results of the analysis of Model 2-1 show that the cost behavior of R&D expenditures is symmetrical, unlike the findings in Models 1-1 and 1-2.

The results of the regression analysis of Model 1-1 suggest that R&D expenditures are anti-sticky (significantly positive) when sales decrease (DD). However, in Model 2-1, anti-sticky cost behavior disappears when sales decrease (DD), and these results are statistically insignificant. While SG&A expenses are usually sticky, R&D expenditures are not found to be sticky. This symmetric R&D cost

behavior seems to indicate that CEOs reduce R&D expenditures more actively than SG&A expenses when sales decrease.

Table 5. Results of Extended Model.

Dependent Variable	ΔR&D					
	Model 3-1			Model 3-2		
	Coeff.	(*t*-stat.)		Coeff.	(*t*-stat.)	
Intercept	−0.032	(−0.27)		−0.047	(−0.39)	
ΔSALE	0.080	(1.56)		0.077	(1.51)	
ΔSALE*DD	−0.218	(−0.57)		−0.109	(−0.28)	
ΔSALE*DD*OVERCON				−0.277	(−3.20)	***
ΔSALE*DD*SUCCE	0.047	(0.50)		0.036	(0.39)	
ΔSALE*DD*ASSET	−0.083	(−2.15)	**	−0.040	(−1.00)	
ΔSALE*DD*GDP	15.623	(1.15)		14.362	(1.06)	
SUCCE	−0.036	(−1.38)		−0.032	(−1.22)	
ASSET	−0.040	(−2.51)	**	−0.032	(−2.02)	**
GDP	2.344	(0.81)		2.285	(0.79)	
OVERCON				0.045	(2.60)	***
IND	Include			Include		
F-Value	3.55		***	3.55		***
Adj. R-square	0.011			0.012		
Obs.	6280			6280		

t-stat. are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

As a result of the regression analysis of Model 2-1, in the analysis of Model 2-2, the change rate of R&D expenditures (ΔR&D) is significantly positive when sales increase (ΔSALE) but not significant when sales decrease (DD). However, in the case of overconfident CEOs (ΔSALE * DD * OVERCON), the results show sticky costs, as the coefficient is statistically significantly negative when sales decrease. This suggests that overconfident CEOs do not cut R&D expenditures in the same proportion as the sales decrease. CEOs who are confident about strong future performance do not cut R&D expenditures to manage short-term performance even when sales decrease. This result supports Hypothesis (2).

Expanding Anderson et al.'s [4] research model, Table 5 presents the results of the regression analysis that includes the low-order terms referred to in Dierynck et al. [38]. In the regression analyses of Models 3-1 and 3-2, the change rate of R&D expenditures (ΔR&D) is not significant for either sales increases (ΔSALE) or sales decreases (DD). Compared with Models 2-1 and 2-2, positive statistical significance is not seen when sales increase (ΔSALE). This seems to be caused by the fact that, as Roychowdhury [1] pointed out, R&D expenditures do not precisely respond to sales increases or decreases and are actively used by CEOs for earnings management.

In the regression analysis of Model 3-2, while increases and decreases in R&D expenditures are not significantly related to sales increases and decreases, the results show sticky costs for overconfident CEOs (ΔSALE * DD * OVERCON) that are statistically significantly negative when sales decrease. In addition, the results of the regression analysis of Models 1-2, 2-2, and 3-2 consistently demonstrate that overconfident CEOs do not reduce R&D expenditures in the same proportion as sales decreases. These results consistently support Hypothesis (2), which indicates that overconfident CEOs do not reduce R&D expenditures that are related to enhancing future performance even when sales decrease.

To summarize, there are differences among the results of the regression analyses of Models 1-1, 2-1, and 3-1, which test Hypothesis (1) using ΔR&D as the dependent variable. The regression analysis of Model 1-1 shows anti-sticky cost behavior of R&D expenditures, which rejects the null hypothesis of Hypothesis (1). While the result of the regression analysis in Model 2-1 shows sticky cost behavior of R&D expenditures, it is not significantly negative. The regression analysis of Model 3-1 shows that there is no correlation between sales increases and increases/decreases in R&D expenditures.

Nonetheless, in the case of sales decreases, R&D expenditures do not show significantly negative sticky cost behavior. The regression analyses of Models 1-1, 2-1, and 3-1 do not provide consistent results for Hypothesis (1). We confirm that, as the scale of R&D expenditures is small compared to SG&A expenses, its cost behavior can be easily changed depending on the control environment. Thus, the results are significant in that an investigation of the cost behavior of R&D can reveal the characteristics of a company and its CEO.

The results of study models 1-1, 2-1, and 3-1, used to test Hypothesis (1), are consistent with those of prior studies [27–31,33]. The results of the analysis indicate that due to its discretionary nature, R&D spending is often used by CEOs for earnings management. However, the results of the investigation using Models 1-2, 2-2, and 3-2 strongly support Hypothesis (2), the primary focus of this study. CEOs with high overconfidence tend not to actively reduce R&D costs even if sales decrease. This seems to be the result of a strategic decision by overconfident CEOs to maintain their existing resources in anticipation of future sales increases.

6. Summary and Conclusions

R&D spending is a key indicator of a company's long-term decision-making. Despite this, R&D activities are known to be strongly influenced by CEO characteristics and strongly depend on CEO discretion. This study, therefore, examines whether, in an effort to improve future performance, highly overconfident CEOs tend not to take actions to reduce R&D even when sales decrease.

The results of the analyses are as follows. While R&D spending is symmetric to sales increases and decreases compared to the asymmetric cost behavior of SG&A expenses, the results may differ depending on the control environment. This seems to be caused by the fact that, due to its discretionary nature, R&D spending is often used by CEOs for earnings management. In addition, compared to companies whose CEOs are not overconfident, companies with overconfident CEOs do not actively reduce R&D expenditures even when sales decrease. This seems to be the result of an overconfident CEO's strategic decision to maintain existing resources in anticipation of future sales increases. The fact that overconfident CEOs tend not to reduce R&D expenditures even when sales decrease—an action unlikely to be related to the pursuit of private interests—implies that they are relatively less likely to engage in earnings management.

The results of this study have the following implications and contributions. First, the results empirically verify that CEO characteristics are related to R&D expenditures. The literature review shows that the determinants of R&D have been analyzed by focusing on companies' characteristics. The results of this study act as an impetus to identify other factors related to future R&D expenditures. Second, this study verified the cost behavior of R&D using Andersen et al.'s [4] cost behavior model, which is a model of the changes in managers' behavior that more accurately reflects managers' behavior than the existing model. In addition, this study may have significant implications for R&D accounting issues. R&D expenditures are accounted for either as capital expenditures or as expenses. Depending on management's characteristics, the scale of R&D costs that are capitalized versus those that are expensed may vary. The results of this study will have many implications for future R&D capitalization discussions.

R&D is a very important factor for firms' sustainable growth. The results of this study show that CEO overconfidence tends to be a positive factor for R&D. As such, the determinants of R&D expenditures may be a black box. In-depth research on R&D expenditures should be continued.

This study has the following limitations. First, although it analyzes the cost behavior of R&D expenditures in relation to CEO characteristics, there may be variables that affect the cost behavior of R&D expenditures that are not reflected in the study. In addition, for industries with high additional barriers to entry into human and physical R&D, it is also necessary to verify how managerial overconfidence affects each industry. Further studies on the cost behavior of R&D should be conducted, as it is vital for enhancing sustainable future company performance and securing competitiveness.

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