The Effects of Technology Innovation Activity on CSR: Emphasizing the Nonlinear and Heterogenous Effects

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Abstract: In this study, we systematically investigate several effects of technology innovation activity (TIA)—proxied by Korean listed corporations’ research and development investment—on the performance of corporate social responsibility (CSR) for sustainable corporate growth and value. We find that corporate TIA positively contributes to an increase in CSR performance. Furthermore, our quantile regression estimations point to a heterogeneous effect of TIA, with a significant positive impact on CSR performance at the middle and higher quantiles of the distribution of the dependent variable of CSR performance. Interestingly, we capture a U-shaped nonlinear effect of TIA on the CSR performance of Korean listed corporations. Our findings alert researchers and managers to the importance of a better understanding of the relationship between CSR and TIA for sustainable corporate growth and value.

Keywords: corporate social responsibility; technology innovation activity; R&D expenditure; nonlinearity; heterogeneity

1. Introduction

According to the resource-based view (RBV) of the firm developed by Pfeffer and Salancik [1], corporate social responsibility (CSR) and technology innovation activity (TIA) can be a crucial intangible asset or resource that allows firms to develop competitive advantages for sustainable growth and value. An outstanding work by [2], defined CSR as a reference and a counterplan for a variety of affairs surpassing firms economic, technical, and legal requisites [3]. CSR allows firms to enjoy social outcomes as well as traditional economic incomes for their sustainable success.

In a similar vein, an eminent scholar [4] also asserted that firms should pursue research and development (R&D) investment as it allows them to erect a barrier to entry and enjoy the benefits of economies of scale and product differentiation in a highly competitive industry. In practice, both CSR and TIA help enhance a firm’s reputation and know-how to substantially increase its sales, thereby eventually upgrading the firm’s value [5,6].

Thus, recent studies in management and innovation have paid much attention to the relationship between CSR and TIA [6–9]. An exact understanding of the relationship between CSR and TIA provides beneficial insights for firms studying the effects of CSR on their financial performance (e.g., return on assets, market value). We consider TIA as a variable proxied by the R&D investment (expenditure) of firms in a regression analysis model [6].

In addition, this study builds on recent studies on the relevance between CSR and financial outcome. Most studies on the relationship between CSR and TIA focus primarily on the effects of CSR on TIA [7,8,10]. Reference [7], one of the most important studies on this topic, suggested that CSR is positively associated with TIA, the latter proxied by R&D intensity. Similarly, other studies by [8,11,12] have corroborated the findings of [7]. As an exception, few [6] studied the impact of TIA, proxied by R&D intensity, on the CSR scores of U.S. firms [6].
Based on [6], our study aims to systematically analyze the effect of TIA on the CSR performance of listed corporations in South Korea, one of proactive countries for technological innovation. Moreover, the 2021 Bloomberg innovation index ranked South Korea in first place in terms of the innovation measured by the R&D activity [13]. In addition, South Korea is being ranked 2nd in R&D spending to gross domestic production ratio (4.52%) following Israel (4.97) in 2020 among OECD member countries [14].

We add to the literature by exploring whether there are U-shaped nonlinear effects of TIA on CSR, a subject on which prior studies are silent. Given that U or inverse U shaped-nonlinearity of TIA on CSR is captured, the finding can provide researchers and managers with deeper insights for determining a minimum or maximum level of TIA on CSR.

In addition, we provide an elaborate investigation into the heterogenous effects of TIA on CSR depending on the distribution of the dependent variable of CSR applying the quantile regression technique devised by [15], conditional on independent variables. Accounting for the heterogeneity of TIA, this analysis is also useful as it provides further insights into the effects of TIA on CSR. Therefore, this study is novel in that it determines both the heterogeneous and nonlinear effects of firms’ TIA on their CSR performance, as no prior studies examine the two effects, to the best of our knowledge.

From a theoretical perspective, we adopt the RBV, as mentioned earlier. Specifically, the initial stage RBV developed for industrial organizations suggests that external actors are critical for firm growth and success (see [16,17], among others). However, later theoretical studies such as those by [18], References [19,20] reconstructed the RBV, arguing that both internal and external factors are essential for firm success and value. Accordingly, based on the (reconstructed) RBV, holding assets that provide competitive advantages relative to rival firms is substantially beneficial for generating sustainable and superior financial profits, which then increases market value [6,21,22].

Reference [21] categorizes a firm’s resources into three types: tangible, intangible, and personnel-based. Tangible resources comprise physical resources such as infrastructure, equipment, raw materials, and financial reserves [6]. Intangible resources include the firm’s social reputation and known technology. Personnel resources include the concepts of culture, training, commitment, loyalty, and knowledge [6]. According to [5], effective combinations of the three types of resources enable firms to be productive and allow them to grow and succeed because none of the resources are productive on their own [6].

Therefore, our study takes the RBV as a theoretical background to explore the effects of Korean listed corporations’ TIA on their CSR performance because the theory sheds light on the importance of intangible resources of know-how, corporate culture, and reputation. To effectively study the relationship between CSR and intangible resources, Reference [23] emphasized the usefulness of the RBV theory, given that these resources are difficult to duplicate and substitute [6].

For evidence on the relevance between CSR and TIA, most prior studies have focused chiefly on the effects of CSR on TIA, as mentioned previously. Specifically, Reference [10] showed that firms in the U.S. printing industry, which are sensitive to environmental management, are more likely to adopt productive technological innovation related to the environment. Reference [8] addressed corporate innovation through the moderating impact of CSR on the financial outcome of corporations. The authors stated that CSR more affects the financial outcome of low-innovation firms and in slightly differentiated industries. Similarly, Reference [7] reported empirical evidence, using a sample of listed U.S. corporations, that R&D investment, proxied by R&D intensity, should be controlled to accurately analyze the impact of CSR for financial outcome. Using data on a sample of corporations created from the 2002 SiRITM compiled by Sustainable Investment Research International (SiRI) [11], confirmed the relevance of the intangible resource of reputation or know-how through technological innovation activity for firms’ CSR performance. Investigating the moderating effect of social performance on the interaction between R&D investment and multi-nationality within large U.S. multinational corporations, Reference [12] found—using
a panel data regression—that the sample firms’ social performance empirically moderates the relationship between the two variables. Similarly, a recent study of [24] reports the positive effect of the R&D intensity of the CSR specialization, using a balanced panel data of firms in multicountry sample headquartered in 44 countries and mostly based in the US and Japan.

Hence, most empirical studies have focused on understanding the effects of CSR on TIA. Unlike the aforementioned studies [5], focused on the impacts of TIA, such as R&D investment, on firms’ CSR performance. Using a sample of U.S. firms, their panel study reports evidence that overall, firms’ R&D intensity is positively associated with their CSR performance. The positive effect of R&D intensity is significant in manufacturing industries but is not significant in non-manufacturing industries. Using the unbalanced panel data of international companies, Reference [25] used a logistic regression analysis to examine the bidirectional relationship between CSR practices and innovation based on the RBV theory. Reference [25] addressed that CSR and the innovation efforts of R&D investment make a negative bidirection, but the effect of the former on the latter is less significant.

The remainder of this paper is organized as follows. Section 2 explains the methods and materials used in this study. Section 3 presents the data. Section 4 discusses the empirical findings, and Section 5 concludes the study.

2. Materials and Methods

2.1. Conditional Quantile Regression

To examine the effects of Korean listed corporations’ TIA on their CSR performance, we use two types of regressions: the classical ordinary least squares (OLS) regression and the conditional quantile regression devised by [18]. In particular, the latter is useful for an elaborate examination of the heterogeneous effects of the independent variables depending on the levels of the dependent variable, given that the variables have serious outliers in their distribution. Here, we briefly explain the quantile regression method.

The quantile regression technique has the benefit of enabling researchers to estimate robust coefficients for the sample data, including serious outliers with large heterogeneity. Its advantage stems from the efficacious estimation of every distribution of the dependent variable conditional on the exogenous regressors. When the sample data have large outliers and non-normal error terms, a regression model relying on conditional mean estimators that assumes normality may be vulnerable to inaccurate estimations. If this is the case, the classical OLS regression may estimate possibly biased and inefficient coefficients. In this case, a quantile regression could be a robust alternative to satisfy the normal distribution condition of the sample data, because this method uses conditional median estimators ([3,26,27], among others).

Reference [28] explained the estimation procedure and property for quantile regressions. \( X' \), the distribution function of a random variable \( X \) is defined as below

\[
F(x) = \Pr(X \leq x)
\]  

The \( \tau \)th quantile for \( 0 < \tau < 1 \) is

\[
Q(\tau) = \inf\{x : F(x) \geq \tau\},
\]

where \( (y_i, x_i), i = 1, 2, 3, \ldots, n \), is a sample with \( y_i \) as the dependent variable and \( x_i \) as a vector of regressors. Given the assumption that the \( \tau \)th quantile of the conditional distribution of \( y_i \) is linear in \( x_i \), the conditional quantile regression model is

\[
y_i = x_i' \beta_\tau + u_{\tau i}
\]

\[
Quant_\tau(y_i|x_i) \equiv \inf\{y : F(y|x)\tau \} = x_i' \beta_\tau
\]

\[
Quant_\tau(u_{\tau i}|x_i) = 0
\]
where \( \text{Quant}_\tau(y_i|x_i) \) denotes the \( \tau \)th conditional quantile of \( y_i \) on the regressor vector \( x_i \), and \( \beta_\tau \) is the vector of coefficients calibrated at heterogeneous values of \( \tau \in (0,1) \). \( u_\tau \) is the density function, while \( f_{u_\tau}(\cdot|x) \cdot F_{\tau}(\cdot|x) \) is the distribution function of \( y \) conditional on \( x \). By shifting the value of \( \tau \) from 0 to 1, we can calibrate every distribution of \( y \) conditional on \( x \). So, we can obtain the regression estimator for \( \beta_\tau \) by solving the following minimization problem:

\[
\text{minimize} \sum_{i=1}^{n} \rho_\tau(y_i - x'_i \beta_\tau),
\]

where \( \rho_\tau(u) = \begin{cases} \tau u, & \text{if } u \geq 0 \\ (\tau - 1)u, & \text{if } u < 0 \end{cases} \)

To solve the minimization problem, a linear programming technique is commonly used [15,26]. We obtain the standard errors for the regression coefficients at each quantile using the bootstrap simulation technique (see [29,30] for details).

2.2. Empirical Models and Variables

Here, we specify the classical OLS and conditional quantile regression models and the variables used to empirically study the effects of TIA on CSR in Korean listed corporations.

2.2.1. Empirical Models

**Classical OLS Regression Model**

Basically, the classical OLS regression in this study is

\[
\text{ln}_{-}\text{CSR}_{i,t} = \alpha_0 + \beta_1 \text{ln}_{-}\text{R}\&\text{DExp}_{i,t} + \beta_2 \text{ln}_{-}\text{Employee}_{i,t} + \beta_3 \text{ln}_{-}\text{Leverage}_{i,t} + \beta_4 \text{Turnover}_{i,t} + \beta_6 \text{SalesGrowth}_{i,t} + \sum_{y=2018}^{2014} \text{Year dummy} + \epsilon_i
\]

where \( \text{ln}_{-}\text{CSR}_{i,t} \) denotes the logarithm of the sample firms’ CSR index in year \( t \). The parameter \( \alpha_{0,t} \) is a constant in the regression specification. The regressor \( \text{ln}_{-}\text{R}\&\text{DExp}_{i,t} \) denotes the natural logarithm of the explanatory variable, a proxy for the degree of the firm’s TIA. The regressors \( \text{ln}_{-}\text{Employee}_{i,t} \) and \( \text{ln}_{-}\text{Leverage}_{i,t} \) are control variables, representing the logarithms of the number of employees and leverage ratios of the firm in year \( t \), respectively. \( \text{Turnover}_{i,t} \) and \( \text{SalesGrowth}_{i,t} \) are also control variables, representing the asset turnover ratio and growth in sales of the firm in year \( t \). \( \text{Industry dummy} \) and \( \text{Year dummy} \) represent the industry dummy grouped by the industry middle classification system of South Korea and a year dummy, respectively, to account for the industrial and time impacts in our whole sample. \( \epsilon_{i,t} \) is the idiosyncratic error term in the regression model.

**Conditional Quantile Regression Model**

To examine the heterogeneous effects on the relevance between Korean listed firms’ CSR performances and TIA, we specify the conditional quantile regression models as follows

\[
\text{Quant}_\tau(\text{ln}_{-}\text{CSR}|X_{i,t}) = \alpha_{\tau,0} + \beta_{11}\text{ln}_{-}\text{R}\&\text{DExp}_{i,t} + \beta_{12}\text{ln}_{-}\text{Employee}_{i,t} + \beta_{13}\text{ln}_{-}\text{Leverage}_{i,t} + \beta_{14}\text{Turnover}_{i,t} + \beta_{16}\text{SalesGrowth}_{i,t} + \sum_{y=2018}^{\text{Industry dummy}} + \sum_{y=2014}^{\text{Year dummy}} + \epsilon_{i,t}
\]

where \( \text{Quant}_\tau(Y_{i,t} = \text{ln}_{-}\text{CSR}|X_{i,t}) \) denotes the \( \tau \)th conditional quantile of \( Y_{i,t} (= \text{ln}_{-}\text{CSR}|X_{i,t}) \), and the logarithm of the sample firms’ CSR index in year \( t \). \( \tau \) denotes the level of each quantile. The explanatory, control, and dummy variables in the OLS model are also included for each quantile regression. \( \epsilon_{i,t} \) are the error terms for the individual quantiles.
2.2.2. Variables

A. Dependent Variable
The dependent variable is the CSR performance of listed Korean corporations, for which we use the Best Corporate Citizen Index (BCCI) reported by the Korean Economic Justice Institute (KEJI), following prior studies [27,31]. Since 2000, the KEJI has announced the BCCI of the top 200 corporations by evaluating a variety of various aspects of corporations’ CSR.

We use the revised BCCI since 2010. The BCCI comprises “the soundness of shareholder composition, investment, and financing (25 points); fairness (20 points); social contribution (15 points); consumer protection (15 points); environmental management (10 points); and employee satisfaction (15 points)” [27,31]. Considering that CSR connotes a complex and complicated definition from various perspectives, the BCCI is very applicable for measuring CSR.

B. Explanatory Variable
To proxy for the TIA of Korean listed corporations, this study uses R&D expenditures. Many studies on innovation use R&D expenditure or R&D intensity as a proxy for firms’ TIA. For example, References [6,7,11,12] use R&D intensity—measured by R&D expenditure divided by total sales—as a proxy for firms’ TIA. Meanwhile, References [3,8,32] use R&D expenditure to account for the pure effect of R&D investment related to TIA on firms’ CSR performance. Based on [6], a distinctive study on the effects of TIA on firms’ CSR performance, we expect a positive effect of TIA on CSR performance proxied by the BCCI of Korean listed corporations.

C. Control Variables
Accounting for firm characteristics that may affect firms’ CSR performance, we include several control variables of firm size, firm risk, firm growth, and asset activity. These covariates are commonly used in corporate finance and innovation.

Previous studies suggest that firm size affects CSR performance [6,33–35]. Thus, we include firm size (ln_Employee), measured as the logarithm of the total number of employees at the end of year $t$, following [36]. We use the logarithm of the leverage ratio, denoted by ln_Leverage, as a proxy for firm risk. This is calculated as the logarithm of the total liabilities over the total assets at the end of year $t$. Related literature indicates that a firm implementing proactive CSR is likely to be keen to employ stakeholder management to reduce potential sources of business risk (e.g., governmental regulations, labor unrest, and environmental damage) [37]. To proxy for management risk tolerance, References [6,8] used the level of leverage, measured by the ratio of total debt to total assets of the firm. Reference [3], who examine the relationship between TIA and CSR, added an asset activity variable to consider the efficiency of the asset use. Therefore, we also include the asset activity variable (Turnover), calculated as sales over total assets in year $t$. To control for the effect of firms’ growth on their CSR performance, we include a growth variable (SalesGrowth), computed by dividing the sales in year $t$ into the ones in the previous year $t - 1$, as in [4]. In addition, including industry and year dummy variables in our regression specifications, we control for industry group and year effects.

3. Data
Our sample consists of firms listed on the main securities markets of South Korea: the Korean Stock Price Index (KOSPI) and Korean Securities Dealers Automated Quotations (KOSDAQ), for the entire period 1 January 2014 to 31 December 2018. The BCCI, the CSR performance index of Korean listed corporations, was collected from the KEJI, as explained previously. The financial data for R&D expenditure to proxy TIA, as well as the data for the explanatory variable and control variables (i.e., leverage ratio, employees, turnover, growth of sales) of the sample firms are collected from the FnGuide database, which is an official provider of corporate financial information for Korean financial markets. For accuracy, we exclude from the sample:

- Any firms without the CSR score over the entire sample period;
• Firms whose financial information is unavailable from FnGuide for the entire sample period;
• Any firms delisted during the sample period;

Through this process, our final sample consisted of 704 corporations listed in the Korean securities markets. The frequency of all variables is annual.

4. Findings

In this section, we discuss the empirical results estimated by both the classical OLS and conditional quantile regression models, controlling for firms’ financial characteristics. Prior to the actual regression analyses, we checked the descriptive statistics for all variables and correlations across exogenous independent variables.

First, Table 1 describes the summary statistics, with all variables showing high kurtosis. The explanatory variable of R&D expenditure, denoted by \( \ln_{R&DExp} \), shows a high negative skewness (−3.54) and a large positive kurtosis (21.57). These statistics suggest non-normality of the explanatory variable, presenting a steep slope and flatness toward the negative direction. This distribution of the explanatory variable supports the additional use of a conditional quantile regression to investigate the heterogeneous effects of TIA on Korean listed corporations’ CSR performance.

Table 1. Summary statistics for the dependent and independent variables.

| Variables    | Mean   | Std. Dev. | Skewness | Kurtosis | Min.   | Median | Max.   | Obs.  |
|--------------|--------|-----------|----------|----------|--------|--------|--------|-------|
| \( \ln_{CSR} \) | 4.13   | 0.05      | −0.52    | 4.42     | 3.85   | 4.14   | 4.29   | 1300  |
| \( \ln_{R&DExp} \) | 21.80  | 3.772     | −3.54    | 21.57    | −1.00  | 22.17  | 30.54  | 704   |
| \( \ln_{Employee} \) | 6.20   | 1.35      | 0.08     | 4.62     | 0.69   | 6.11   | 11.54  | 1270  |
| \( \ln_{Leverage} \) | 4.08   | 1.13      | −0.12    | 5.10     | −2.30  | 4.09   | 7.79   | 1270  |
| Turnover     | 0.94   | 0.52      | 1.66     | 8.72     | 0.00   | 0.86   | 4.33   | 1.189 |
| SalesGrowth  | 5.85   | 29.95     | 8.27     | 111.47   | −100   | 2.78   | 515.15 | 1188  |

Note: S.D.: Standard deviation; Min.: Minimum; Max.: Maximum; Obs.: Observations.

Table 2 shows the correlation matrix for each pair of exogenous independent variables in our regression models. Except for the pair \( \ln_{Leverage} \) and Turnover, which shows a high correlation coefficient of 0.4390, most pairs across the variables have low values. This result suggests that there is no serious multicollinearity issue across all the covariates (independent variables), even though we include them simultaneously in our regression analyses.

Table 2. Correlation matrix of the exogenous covariates.

| Variables     | \( \ln_{R&DExp} \) | \( \ln_{Employee} \) | \( \ln_{Leverage} \) | Turnover | SalesGrowth |
|---------------|-------------------|----------------------|---------------------|----------|-------------|
| \( \ln_{R&DExp} \) | 1.0000            |                      |                     |          |             |
| \( \ln_{Employee} \) | 0.3627            | 1.000               |                     |          |             |
| \( \ln_{Leverage} \) | −0.0035           | 0.3419              | 1.000              |          |             |
| Turnover      | −0.1026           | 0.2612              | 0.4390             | 1.000    |             |
| SalesGrowth   | 0.0192            | 0.0074              | 0.0532             | 0.2309   | 1.000       |

Table 3 presents the estimates of the classical OLS regressions to analyze the effects of TIA on the CSR performance of Korean listed corporations. Specifically, Regression 1, which has no control variables, has a very significant positive coefficient (0.0026) at the 1% level on the \( \ln_{R&DExp} \) variable, a proxy for the TIA of Korean listed corporations. This result suggests that for Korean listed corporations, the TIA—as proxied by R&D expenditure—is positively associated with CSR performance. The statistically significant positive estimates for the \( \ln_{R&DExp} \) variable are confirmed for all estimates (0.0012, 0.0011, 0.0011, and 0.0011 for Regressions 2, 3, 4, and 5, respectively) after adding the control variables. The positive impact of TIA on the CSR performance of Korean listed corporations in Table 3 is in line with [6], who reported a positive contribution of R&D intensity to U.S. firms’ CSR scores.
Table 3. Baseline results of the classical OLS regressions.

| Variables          | Reg. 1       | Reg. 2       | Reg. 3       | Reg. 4       | Reg. 5       |
|--------------------|--------------|--------------|--------------|--------------|--------------|
| Constant           | 4.0876 ***   | 4.0618 ***   | 4.0744 ***   | 4.0745 ***   | 4.0999 ***   |
|                    | (0.0237)     | (0.0232)     | (0.0238)     | (0.0238)     | (0.0239)     |
| ln_R&DExp          | 0.0026 ***   | 0.0012 ***   | 0.0011 ***   | 0.0011 ***   | 0.0011 ***   |
|                    | (0.0004)     | (0.0004)     | (0.0004)     | (0.0004)     | (0.0004)     |
| ln_Employee        | 0.0081 ***   | 0.0090 ***   | 0.0090 ***   | 0.0091 ***   | 0.0091 ***   |
|                    | (0.0011)     | (0.0012)     | (0.0012)     | (0.0012)     | (0.0012)     |
| ln_Leverage        | −0.0034 **   | −0.0031 **   | −0.0030 **   | −0.0030 **   | −0.0030 **   |
|                    | (0.0014)     | (0.0015)     | (0.0015)     | (0.0015)     | (0.0015)     |
| Turnover           | −0.0012      | −0.0022      | −0.0022      | −0.0022      | −0.0022      |
|                    | (0.0032)     | (0.0033)     | (0.0033)     | (0.0033)     | (0.0033)     |
| SalesGrowth        | Yes          | Yes          | Yes          | Yes          | Yes          |
| Industry_Dummy     | Yes          | Yes          | Yes          | Yes          | Yes          |
| Year_Dummy         | Yes          | Yes          | Yes          | Yes          | Yes          |
| Num. of Obs.       | 704          | 704          | 704          | 702          | 701          |
| R²                 | 0.397        | 0.438        | 0.442        | 0.443        | 0.445        |
| F – value          | 34.96 ***    | 38.43 ***    | 36.45 ***    | 34.14 ***    | 32.25 ***    |
| (p-values)         | (0.000)      | (0.000)      | (0.000)      | (0.000)      | (0.000)      |

Notes: *** < 1%, ** < 5%, Standard errors in the parentheses.

Regarding the effects of the control variables, Regressions 2, 3, 4, and 5 return significantly positive estimates of 0.0081, 0.0090, 0.0091, and 0.0091, respectively, for ln_Employee (firm size). The estimates suggest the positive effects of firm size, proxied by the total number of employees in the firm, on CSR performance. This finding is counter to [5], who find that firm size has no effect on CSR performance.

Regressions 3, 4, and 5 estimate significantly negative coefficients of −0.0034, −0.0031, and −0.0030, respectively, for the ln_Leverage variable of firm risk. The results suggest that firm risk, proxied by the leverage ratio, has a reverse relationship with CSR performance. Unlike the case with firm size, this finding is in agreement with [6], who report that firm risk is negatively associated with the CSR performance of their sample firms.

It is worth exploring the nonlinearity of the effect of TIA on the CSR performance of Korean listed corporations to gain deeper insight into their relationship. To this end, we simultaneously include the ln_R&DExp for the linear TIA and ln_R&DExp², the square of ln_R&DExp for the nonlinear TIA in our regression models. The regression results are presented in Table 4. In Regression 1, which has no control variables, the linear variable ln_R&DExp shows a statistically significant negative coefficient of −0.0039, whereas the nonlinear variable ln_R&DExp² has a positive value of 0.00021, significant at the 1% level. The opposing estimates of the two variables related to our sample corporations’ TIA generate a regular U-shaped curve that monotonically increases following a monotonic decrement. Interestingly, the U-shaped curve between the linear and nonlinear TIA variables reflects a nonlinear effect of TIA32 on CSR performance, suggesting that firms with proactive TIA ramp up their CSR performance, but that general TIA leads to a decline in CSR performance. The U-shaped relationship addresses a minimum threshold of TIA to contribute in an increase in the CSR performance of Korean listed corporations. The nonlinearity of the effect of TIA on CSR performance is clearly observable from Regressions 2 and 3, which include the control variables. However, Regression 4 shows a significant positive value only for the nonlinear variable ln_R&DExp².
Table 4. The OLS regression results for the nonlinear effects of TIA on CSR.

| Variables       | Reg. 1          | Reg. 2          | Reg. 3          | Reg. 4          |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Constant        | 4.1353 *** (0.0246) | 4.1379 *** (0.0256) | 4.1650 *** (0.0255) | 4.1142 *** (0.0263) |
| $\ln_R&DExp$    | $-0.0039 *** (0.0012)$ | $-0.0040 *** (0.0012)$ | $-0.0040 *** (0.0012)$ | $-0.0014 (0.0013)$ |
| $\ln_R&DExp^2$  | 0.00021 *** (0.00003) | 0.00021 *** (0.00003) | 0.00021 *** (0.00003) | 0.00009 *** (0.00004) |
| $\ln_Employee$ |                  |                  |                  | 0.00004 (0.0014) |
| $\ln_Leverage$ | $-0.0009 (0.0015)$ | $-0.0008 (0.0015)$ |                  |                  |
| Turnover        | 0.0026 (0.0032) | 0.0020 (0.0033) |                  |                  |
| SalesGrowth     |                  |                  |                  | 0.00004 (0.0004) |
| Industry_Dummy  | Yes             | Yes             | Yes             | Yes             |
| Year_Dummy      | Yes             | Yes             | Yes             | Yes             |
| Num. of Obs.    | 704             | 702             | 701             | 704             |
| $R^2$           | 0.426           | 0.427           | 0.428           | 0.442           |
| $F$ – value     | 36.52 ***       | 31.95 ***       | 30.08 ***       | 36.41 ***       |
| $(p$-values)    | (0.000)         | (0.000)         | (0.000)         | (0.000)         |

Notes: *** < 1%, Standard errors in the parentheses.

Table 5. The quantile regression results for heterogeneity across CSR levels.

| Variables       | OLS          | $\tau_5$          | $\tau_{10}$         | $\tau_{25}$         | $\tau_{50}$         | $\tau_{75}$         | $\tau_{90}$         | $\tau_{95}$         |
|-----------------|--------------|-------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Constant        | 4.0999 ***   | 4.1058 ***        | 4.1128 ***          | 4.0935 ***          | 4.1177 ***          | 4.0951 ***          | 4.0933 ***          | 4.0983 ***          |
|                 | (0.0239)     | (0.0268)          | (0.0260)            | (0.0289)            | (0.0268)            | (0.0255)            | (0.0246)            | (0.0261)            |
| $\ln_R&DExp$    | 0.0011 ***   | 0.0013            | 0.0007              | 0.0007              | 0.0013 ***          | 0.0007              | 0.0016 **           | 0.0011 *            |
|                 | (0.0004)     | (0.0011)          | (0.0011)            | (0.0008)            | (0.0005)            | (0.0007)            | (0.0008)            | (0.0006)            |
| $\ln_Employee$ | 0.0091 ***   | 0.0044 ***        | 0.0049 ***          | 0.0061 ***          | 0.0067 ***          | 0.0119 ***          | 0.0108 ***          | 0.0130 ***          |
|                 | (0.0012)     | (0.0014)          | (0.0014)            | (0.0016)            | (0.0013)            | (0.0026)            | (0.0023)            | (0.0025)            |
| $\ln_Leverage$ | $-0.0030 **$ | $-0.0019$         | $-0.0023$           | $-0.0028$           | $-0.0016$           | $-0.0006$           | $-0.0011$           | $-0.0065$           |
|                 | (0.0015)     | (0.0023)          | (0.0019)            | (0.0021)            | (0.0015)            | (0.0023)            | (0.0033)            | (0.0044)            |
| Turnover        | $-0.0022$    | $-0.0018$         | $-0.002$            | $-0.0007$           | $-0.0032$           | $-0.0079$           | $-0.0064$           | $-0.0064$           |
|                 | (0.0033)     | (0.0044)          | (0.0037)            | (0.0039)            | (0.0055)            | (0.0068)            | (0.0086)            | (0.0086)            |
| SalesGrowth     | 0.0001       | $-0.00006$        | $-0.00005$          | 0.0007              | 0.00006             | 0.00002             | 0.0002              | 0.0001              |
|                 | (0.0001)     | (0.00008)         | (0.00011)           | (0.00010)           | (0.00005)           | (0.00010)           | (0.0001)            | (0.0001)            |
| Industry_Dummy  | 4.0999 ***   |                   |                     |                     |                     |                     |                     |                     |
|                 | (0.0239)     |                   |                     |                     |                     |                     |                     |                     |
| Year_Dummy      | 0.0011 ***   | Yes               | Yes                 | Yes                 | Yes                 | Yes                 | Yes                 | Yes                 |
|                 | (0.0004)     |                   |                     |                     |                     |                     |                     |                     |
| $R^2$           | 0.445        | 0.422             | 0.389               | 0.302               | 0.245               | 0.227               | 0.240               | 0.266               |

Homogeneity $F$ statistic across all the quantiles: 2.04 *** (0.000)

Notes: *** < 1%, ** < 5%, * < 10%. Standard errors bootstrapped with 1000 replications in parentheses.

For deeper insight into the effects of TIA on the CSR performance of Korean listed corporations, we analyze the heterogeneous effects of TIA on CSR performance across the distribution of the dependent CSR performance variable by running conditional quantile regressions. Table 5 presents the results estimated from the quantile regression models with all the covariates, along with the classical OLS estimates (as in Table 3) based on the mean estimation for comparison.
Regarding ln_R&DExp, the explanatory variable, the classical OLS regression estimates a highly significant coefficient (0.0011) at the 1% level, and, on average, suggests a positive effect of the TIA of the Korean corporations, as Table 3 shows. The quantile regressions provide further detailed and robust information on the effects of TIA (ln_R&DExp) on CSR performance depending on the level of the firm’s CSR (ln_CSR). That is, the quantile regressions at the lower quantiles of \( \tau_{0.05}, \tau_{0.10}, \) and \( \tau_{0.25} \) estimate insignificant coefficients for ln_R&DExp, while the quantile regressions at the middle quantile of \( \tau_{0.50} \) and the upper quantiles of \( \tau_{0.90} \) and \( \tau_{0.95} \) estimate significant positive values of 0.0013, 0.0016, and 0.0011, respectively. The results suggest that the heterogeneous effects of TIA depend on the level of CSR performance and provide evidence that for corporations shouldering more than an appropriate burden of CSR activity, the TIA of R&D investment contributes to an increase in CSR performance.

Regarding the control variables, ln_Leverage (firm risk) has a significant negative OLS coefficient (−0.0030) and shows no heterogeneity across the quantiles of the dependent variable of CSR as all the quantile regressions return insignificant estimates. ln_Employee (firm size) has a significant positive OLS value (0.0091) and significantly larger positive estimates, suggesting stronger effects of TIA on CSR performance as we move toward the higher quantiles of the dependent variable of CSR performance. This finding implies a heterogeneous effect of TIA on the CSR performance of the sample firms across all quantiles.

To determine whether the coefficients across all quantiles are homogenous, we conducted a homogeneity F test. The homogeneity F statistic of 2.04 for the independent variables across all quantiles strongly rejects the null of the identical coefficients across all quantiles, suggesting different impacts of the variables across quantiles.

Figure 1 graphs the heterogeneous coefficients for the regressors across the quantiles of the dependent variable for the entire sample period. In Figure 1, we clearly observe heterogeneous variations in the coefficients for the exogenous covariates for CSR performance across all quantiles of the dependent variable of the CSR performance of the sample firms.
Figure 1. Variations in the coefficients estimated for the exogenous independent variables across quantiles of the dependent variable. Notes: The quantiles of the CSR performance distribution conditional on the independent variables on the x-axis are. The intercept from 0 to 1 on y-axis. The light gray area around the green lines indicating the 95% confidence intervals (bootstrapped) around the quantiles. The OLS estimates with 95% confidence intervals in the horizontal lines.
5. Conclusions

Using the classical OLS and conditional quantile regression estimations, our study investigates several effects of TIA—proxied by firms’ R&D expenditures—on the CSR performance of Korean listed corporations. Based on the RBV, both TIA and CSR are considered strategic and intangible assets that rivals cannot easily imitate or substitute, thereby contributing to the sustainable growth of firms.

Through our classical OLS regression analysis, the TIA of Korean listed corporations has a linear positive relationship with CSR performance. Importantly, we find a nonlinear, U-shaped relationship in which R&D expenditure has a significant negative coefficient, but its square has a significant positive coefficient for the dependent variable of CSR performance when our regression models simultaneously include the two explanatory variables related to TIA. In addition, our conditional quantile regressions indicate that the TIA of the Korean firms heterogeneously enhances their CSR performance in the middle ($\tau_{50}$) and upper ($\tau_{90}$, $\tau_{95}$) ranges of the dependent variable, CSR performance. This finding suggests that corporations with a strong sense of CSR tend to be keen on their TIA as well.

Our findings effectively suggest that the significant relationship between CSR and TIA in managerial practice is overall in line with the RBV theory which addresses the importance of intangible assets and their relationships to achieve competitive advantages and ensure sustainable growth and success of corporations. Unlike most previous studies on the effects of CSR on firms’ TIA, our study focuses on the various effects of TIA on firms’ CSR and thus adds to the literature. In practice, our findings provide the helpful implication that managers should consider the bidirectional relationship between CSR and TIA when crafting strategies to invest in intangible assets such as CSR and TIA. Moreover, the nonlinear effect of TIA on firms’ CSR performance observed in this study also provides a valuable guideline regarding the minimum level of TIA investment to maximize CSR performance. In addition, the heterogeneous effect of TIA on CSR performance is informative for the level of firms investing in CSR activities, in association with the effect of TIA on CSR performance.

This study has several limitations that present avenues for future studies. Our study targets corporations listed on the Korean securities market only. It would be worth further generalizing the various effects of TIA on firms’ CSR performance by analyzing panel data on firms in major countries such as the US, the UK, Germany, and Japan, which are characterized by a proactive managerial practice of investing in intangible assets such as TIA and CSR. This surpasses the scope of this study and then remains a meaningful area for future study.

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