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ORIGINAL RESEARCH

Corporate social responsibility and knowledge capital: does corporate social responsibility promote accumulating knowledge capital?

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Abstract
This study investigated the effects of corporate social responsibility (CSR) on the accumulation of knowledge capital, investment in research and development (R&D), and financial performance. The empirical results revealed that CSR engagement can enhance the accumulation of knowledge capital and R&D investment. Nonetheless, engaging in external CSR, disclosing CSR-related information, and having third-parties authenticate CSR reports is important to avoid agency problems and greenwashing. It is also important that firms establish internal CSR-related policies and measures governing environmental protection and employee and supplier rights to ensure innovative development, the accumulation of knowledge capital, and R&D investment. The resources invested in knowledge capital, R&D, or CSR promotion can negatively impact profitability; however, these effects were shown not to dampen investors' optimism about future competitive advantage or financial performance.

Keywords Corporate social responsibility · Knowledge capital · Research and development · Financial performance

JEL Classification G34 · G39

1 Introduction

Research and development (R&D) and knowledge capital have been widely adopted as a competitive strategy (Gu 2016; Peters and Taylor 2017), and engagement in corporate social responsibility (CSR) can enhance core competitiveness, create firm value (Porter and Kramer 2006) and improve financial performance (Jo and Harjoto 2011; Chen, Hung, and Lee, 2018). It has been argued that CSR increases operational costs (Moore 2001) and tends

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to cover up for the inadequacies of management (Hemingway and Maclagan 2004; Prior et al. 2008), which can decrease profitability (Chang 2009; Chang and Shen 2014). However, could CSR engagement strengthen the efficiency of R&D and accumulate knowledge capital to alleviate agency problems and improve financial performance? Thus, this study explores the impact of CSR on knowledge capital, R&D, and financial performance.

CSR refers to actions in the realm of environment, society, and governance (ESG) addressing environmental protection and social concerns (Starks 2009), which can influence the allocation of funding and selection of targets (Guenster et al. 2011). This implies that investors focus on profitability and corporate responses to environmental and social issues or their interactions with stakeholders. (Becchetti et al. 2012), and more than half of large firms in the United States (US) publish CSR reports (Galema et al. 2008). Pervious research has found that CSR engagement can reduce the cost of equity capital and uncertainty (Chen et al. 2020; Shiu and Yang 2017), improve the reputation of the firm and attracting investors (Lee et al. 2020; Shi, 2016; Flammer 2015). Jo and Harjoto (2011) argued that firms with better CSR performance increase profitability and found the R&D expenditures increasing. Some scholars explained that both R&D and CSR engagement can create assets and strengthen the competitive ability of firms (Padgett and Galan 2010; Fu et al. 2020), and higher R&D expenditure is accompanied by higher CSR engagement (Ho, Lin, Tam, and Tong, 2016).

R&D investing create knowledge, which determines innovative development (Hombrt and Matray 2018) and long-lasting competitive advantage (Peters et al. 2017), which can improve long-term operational performance, steady corporate growth, and increase stock returns (Clausen and Hirth 2016; Hsu et al. 2010; Eberhart et al. 2004; Chan et al. 2001). Peters and Taylor (2017) considered the accumulation and depreciation of R&D to estimate knowledge capital, which positively affects firm value (Chiu et al. 2021). Knowledge capital also can convert intangible assets into salable assets to mitigate financial risk (Hegde and Mishra 2023).

Previous studies focused on the impact of R&D on CSR (Padgett and Galan 2010; Fu et al. 2020), or the interactive effect between R&D and CSR (Ho, Lin, Tam, and Tong, 2016). They believed that R&D was an expense item and ignored the importance of capital expenditure and R&D in firms' intangible assets to improve financial performance. These researches also neglect how different components of CSR affects R&D. Therefore, this study estimated knowledge capital according to Peters and Taylor (2017) and R&D to explore the impact of knowledge capital and R&D on CSR engagement in this study.

The findings showed that CSR positively affects knowledge capital and R&D, which implies the firms with better CSR performance tend to accumulate knowledge capital and invest in R&D. The results also found that CSR can strengthen the efficiency of knowledge capital and R&D to increase financial performance rather than only firm value, enhance information transparency and alleviate the probability of agency problems and greenwashing. This study used instrumental variables, the generalized method of moments (GMM), and the Hausman Test (Hausman 1978) to control endogeneity concerns about CSR engagement. There are still supporting results.

The results of the present study have three primary contributions to the literature. First, this study provides insight into how the CSR engagement influence knowledge capital accumulating and R&D investing. Second, the analysis accounts for knowledge capital and R&D as a part of assets to influence financial performance rather than focusing on only firm

value, thereby providing a deeper understanding of why and how the effect of distinct CSR performance manifests between knowledge capital and R&D. Third, This research provides a contingency perspective on the said effect, as it examines the interactive effect of knowledge capital, R&D, and CSR on financial performance and firm value, thus contributing to a clearer understanding of the factors within this relationship.

The remainder of this study is organized as follows. Section 2 presents a review of the literature. Section 3 is the methodology and data. Section 4 presents empirical results. Conclusions are presented in Sect. 5.

2 Literature review

2.1 Knowledge capital

Jo and Harjoto (2011) found that CSR engagement can increase firm value, and also raise R&D expenditures. Does this imply that investing in CSR can enhance knowledge capital accumulation? The accumulation of knowledge capital affects the core competitiveness of firms, exerts a significant influence on improving their long-term financial performance, and increases firm value. (Chan et al. 2001; Eberhart et al. 2004).

Knowledge capital is more important in competitive industries. Gu (2016) found that knowledge accumulation is a core element determining the competitiveness of firms in competitive industries. Peters et al. (2017) argued that investment in knowledge capital can improve production efficiency and firm value. Hsu et al. (2010) considered that initial public offering (IPO) firms invest more resources in knowledge capital to solidify long-term core competitiveness. Hombrt and Matray (2018) also indicated that competition from Chinese firms has prompted firms in the US to utilize knowledge capital to differentiate their products, promote innovation, maintain profits, and avoid relegation from the market.

However, when firms invest in R&D, profitability and stock returns are often underestimated. Hirshleifer, Hsu, and Li (2018) found that when investing in R&D, investors tend to disregard profitability and stock returns until the R&D achievements come to fruition, leading to long-term core competitiveness. Adner and Kapoor (2010) considered that internal innovation can attract upstream and downstream technological leaders to make up for a lack of external innovation, regardless of the maturity of the firm. Hirshleifer et al. (2013) further explained that the market cannot effectively predict innovation efficiency and the achievements of R&D expenditures but are of great help in improving future operating performance and increasing stock returns. Gao and Chou (2015) also found that large-scale multinational firms must continuously invest in R&D and create rigorous patent layouts to protect their niche market and prevent the erosion of profits. If small firms invest in R&D, they attract large firms to mergers and acquisitions. Phillips and Zhdanov (2013) argued that large firms' R&D and innovation capabilities are not better than small firms; however, large firms are able to engage in external innovation via mergers and acquisitions to maintain steady profitability. Chiu et al. (2021) also explained that powerful CEOs are a key factor affecting investment in innovation aimed at accumulating knowledge capital. Hegde and Mishra (2023) found that patented knowledge capital not only improves the transparency of R&D expenditures and converts intangible intellectual property into salable assets but also alleviates the financial risk and cost of equity capital.

According source-basic view, Padgett and Galan (2010) investigated the relationship between R&D intensity and CSR. The empirical results found that positive significantly related CSR in manufacturing industries. They pointed out that both R&D and CSR can create an asset and enhance competitiveness to improve the community's welfare and satisfy stakeholders' expectations related to the firm's prevailing environment. Ho et al. (2016) found that interaction between R&D and CSR significant positive affects firm value. they explained that the firm with higher CSR performance have to higher R&D valuation. Fu et al. (2020) also found that R&D positively significantly related to CSR, and argued that the financial slack is a moderator between R&D and CSR. Jadiyappa and Chauhan (2023) explored the different impact of CSR on R&D during the mandatory CSR regulation before and after in India. They demonstrated that CSR is an intangible resource that firm gains specialized knowledge from stakeholders and positive affects innovation based on the resource-based view. Du et al. (2024) investigated the impact of different sea level rise risk of firms in the U.S. on CSR and R&D. The empirical results found that the firm with higher sea level rise risk engage less in future-oriented actives including CSR and R&D, but firm with higher sea level rise risk and elder CEO promote the CSR engagement. Anzola-Román et al. (2024) pointed out that environmental CSR provides process innovation, and social CSR contributes only to process and technological innovations when internal firms engage.

Previous research found that the accumulation of knowledge capital and R&D can strengthen innovative capabilities, core competitiveness, and profitability (Hsu et al. 2010; Peters et al. 2017; Hombrt and Matray 2018). The firm has higher R&D expenditures to enhance CSR engagement (Ho et al. 2016; Fu et al. 2020). Some scholars considered that better CSR performance provide new channels for innovation (Jadiyappa and Chauhan, 2023; Anzola-Román et al. 2024). On the basis of the above, developing the hypothesis as follows.

H1a The firm with higher CSR performance has a positive effect on knowledge capital.

H1b The firm with higher knowledge capital has a positive effect on financial performance.

H2a The firm with higher CSR has a positive effect on R&D.

H2b The firm with higher R&D has a positive effect on financial performance.

2.2 Corporate social responsibility

CSR has become a crucial op erating strategy in firms; however, implementing CSR should invest firm resources, which can increase operational costs and reduce profitability (Moore 2001). Some scholars explained that managers promote CSR to further their interests and shift public focus away from managerial inadequate abilities (Hemingway and Maclagan 2004). Schuler and Gording (2006) argued that firms use CSR to polish their image and attract the attention of consumers to decrease R&D and profitability.

Barnea and Rubin (2010) used the over-investment hypothesis to explain that managers overinvest in CSR based on their self-interest motivation and a negative relationship between financial performance and CSR performance. Adhikari (2016) also indicated that

firms with better CSR performance are more susceptible to agency problems, influencing the evaluation of firms by financial analysts. Kao et al. (2018) found that Chinese state-owned firms increase agency costs and lowers financial performance, whereas private firms with better CSR promotion can tends to increase firm value. Nofsinger et al. (2019) considered when firms engage in social and environmental issues, it implies that the firms have more uncertainty, causing institutional investors to decrease their holdings and leading to a negative relationship between CSR and stock returns. (Chang 2009).

Firms engage in CSR to enhance communication with stakeholders and gain the trust of consumers and investors, reduce information asymmetry, improve reputation of the firm (Heal 2005). Vilanova et al. (2009) argued that firms' interactions with stakeholders can strengthen the core competitiveness of the firm to increase operating efficiency and financial performance. Groysberg et al. (2011) also explained that the firm that CSR engagement can improve long-term financial performance. Shiu and Yang (2017) reported that CSR engagement can reduce uncertainty and lessens the impact of sudden incident shifts on stock prices such as an insurance-like effect (Lööf et al. 2022). Similarly, Lins et al. (2017) found that CSR engagement can avoid a decrease in profitability during the financial crisis. Chen et al. (2018) reported that CSR promotion can reduce idiosyncratic risk during market recession. Nguyen et al. (2020) explained that firms with better CSR performance find it easier to attract institutional investment and increase shareholdings to maximize shareholder value. Tsang et al. (2021) also considered that engaging in CSR can promote productivity and innovation. Zhang et al. (2021) found that the firm with CSR information disclosure suffer the smaller firm value and reputation losses during the crisis period.

Additionally, Tseng and Demirkan (2021) indicated that CSR can alleviate and divert the risk from CEO overconfidence to reduce costs of equity. Yoo and Managi (2022) argued that engagement in CSR or ESG can enhance profitability and the value assessment of intangibles. Roy et al. (2022) reported that firms with better CSR performance have strong stock market liquidity and higher firm value in the long-term. Zhang and Zhang (2023) also found that firms can engage in CSR to build an interactive channel with stakeholders to reduce information asymmetry and financial constraints. Ho et al. (2024) demonstrated that CSR engagement mediates agency problems from controlling shareholders and cash holding with higher-risk firms.

There is a long-term debate on the relationship between CSR and financial performance. Most research found that CSR not only positively related to financial performance (Groysberg et al. 2011; Zhang et al. 2021) but also the positive relationship between CSR and R&D (Fu et al. 2020; Anzola-Román et al. 2024). Thus, based on the above, I consider the impact of the interactive effect with CSR, knowledge capital, and R&D on financial performance and propose the hypothesis as follows.

H3 The firm with better CSR and higher knowledge capital has a positive effect on financial performance.

H4 The firm with better CSR and higher R&D has a positive effect on financial performance.

3 Methodology and data

3.1 Methodology

This study employed the CSR index[1] from Chen et al. (2018) to measure the CSR performance of list firms in Taiwan. Based on the document, "Corporate Social Responsibility Best Practice Principles for TWSE/TPEx-Listed Companies" imposed by Taiwan Stock Exchange (TWSE) and the Taipei Exchange (TPEx), the index lists 24 items related to the following 6 indicators, which includes policy of CSR (Policy), the environment (Environment), employees and suppliers (Employee), information transparency of CSR (Information), others of CSR (Others), and the authentication of CSR practices by third parties (Authentication). The CSR index is shown as follows:

$$CSRI_{it}=Policy_{it}+Environment_{it}+Employee_{it}+Information_{it}+Others_{it}+Authentication_{it} \quad (1)$$

where $CSRI_{it}$ denotes the CSR index of firm *i* in year *t*; $Policy_{it}$ indicates CSR policies introduced of firm *i* in year *t* ; $Environment_{it}$ is an indicator of efforts to protect the environment of firm *i* in year *t*; $Employee_{it}$ is an indicator of efforts to protect the rights of employees rights and suppliers by firm *i* in year *t*; $Information_{it}$ refers to CSR-related information disclosed of firm *i* in year *t*; $Others_{it}$ encompasses other issues related to the external CSR implementation performance of firm *i* in year *t*, and $Authentication_{it}$ indicates whether the conditions of the CSR reports and product services of firm *i* in year *t* are authenticated or assured by third parties.

Furthermore, using the knowledge capital from Peters and Taylor (2017), which is based on the sum of annual R&D expenditures multiplied by a depreciation rate. Knowledge capital uses the following Eq. (2):

$$Knowledge_{it}=(1\text{-}\delta)\,Knowledge_{it-1}+R\&D_{it} \quad (2)$$

where $Knowledge_{it}$ indicates the knowledge capital of firm *i* in year *t*; $Knowledge_{it-1}$ denotes the knowledge capital of firm *i* in year *t-1*; $R\&D_{it}$ indicates the R&D expenditures divided by total assets of firm *i* in year *t*; and δ indicates the rate of depreciation rate based on the mean equipment depreciation rate of per firms.

To explore H1a and H2a regarding the impact of CSR performance on the accumulation of knowledge capital, I set the panel regression model as Eq. (3):

$$Knowledge_{it} = \alpha_0 + \alpha_t + \alpha_j + \alpha_j + \alpha_1 CSRI_{it} + \alpha_2 X_{it} + \varepsilon_{it} \quad (3)$$

Where $Knowledge_{it}$ includes the knowledge capital (Knowledge) and R&D of firm *i* in year *t*, the definitions of knowledge capital and R&D are the same as that in Eq. (2). $CSRI_{it}$ comprises the CSR indicators of firm *i* in year *t*, including CSR index, Policy, Environment, Employees, Information, Others, Authentication, and the difference between the CSR index

[1] The CSR index is based on the "Corporate Social Responsibility Best Practice Principles for TWSE/TPEx-Listed Companies" imposed by the Taiwan Stock Exchange (TWSE) and the Taipei Exchange (TPEx) to hand-collated qualitative data of CSR information into quantitative data from each firm to measure CSR performance. This is currently the complete CSR index of listed firms in Taiwan.

of firm *i* in years *t* and *t-1* (Net CSR). The definitions of the variables are identical to those in Eq. (1). X_{it} is a control variable based on Jo and Harjoto (2011), Chen et al. (2020), and Chiu et al. (2021), including CEO power, board capital, debt ratio, firm age, and firm assets. Finally, α_0 is the intercept term, α_t is the year fixed effect, and α_j is industrial fixed effect, and ε_{it} is an error term.

To test H1b and H2b, and employed a panel regression model to investigate the correlations among CSR, financial performance, and knowledge capital with the aim of controlling year and industrial fixed effects, as Eq. (4):

$$Performance_{it} = \alpha_0 + \alpha_t + \alpha_j + \alpha_1 Knowledge_{it} + \alpha_2 X_{it} + \varepsilon_{it} \tag{4}$$

Here $Performance_{it}$ is a proxy variable for profitability of firm *i* in year *t*, which includes ROA, ROE, and Tobin's Q; and the definitions of $Knowledge_{it}$ and $CSRI_{it}$ are identical to those in Eq. (2).

To examine H3 and H4, and used Eq. (5) explores the interaction effect between knowledge capital and CSR, as Eq. (5):

$$\begin{aligned} Performance_{it} =& \alpha_0 + \alpha_t + \alpha_j + \alpha_1 Knowledge_{it} + \alpha_2 Knowledge_{it} \\ & \times CSRDummy_{it} + \alpha_3 X_{it} + \varepsilon_{it} \end{aligned} \tag{5}$$

Here $Knowledge_{it} \times CSRDummy_{it}$ is the interaction term of knowledge capital and CSR performance. $CSRDummy_{it}$ is a dummy variable for the indicator of CSR performance, which serves as a proxy variable for firms with better CSR performance (Best CSR) and worse CSR performance (Worst CSR). *Best CSR* equals 1 if the CSR index of firm *i* in year *t* is equal to or greater than the mean CSR index plus 1 standard deviation, and otherwise 0, whereas *Worst CSR* equals 1 if the CSR index of firm *i* in year *t* is equal to or less than the mean CSR index minus 1 standard deviation, and otherwise 0. The definition of control variable X_{it} is identical to that in Eq. (3).

3.2 Data

The data set used in this study included firms listed on the TWSE and TPEx from 2011 to 2017. Empirical data related to finance was obtained from the Taiwan Economic Journal (TEJ). Associated data was hand-collected manually from the Market Observation Post System (MOPS) of the TWSE, firm websites, and CSR reports drawn up in accordance with "Sustainable Development Best Practice Principles for TWSE/TPEx Listed Companies." The sample included 1,487 firms with 9,551 annual datapoints.

4 Empirical analysis

4.1 Description

Table 1 lists the descriptive statistics of the empirical data used in this study. Panel A presents the variables describing the firm characteristics, including Knowledge Capital$_t$ and R&D$_t$ are 5.33 and 2.70. The mean ROA$_t$, ROE$_t$, and Tobin's Q$_t$ are 7.58%, 13.43%, and

Table 1 Descriptive statistics

	Mean	Median	Standard deviation	Max	Min
Panel A: Firm characteristics					
Knowledge capital$_t$	5.33	2.21	9.01	141.72	0.00
R&D$_t$	2.70	1.11	4.63	80.81	0.00
ROA$_t$	7.58	7.11	8.93	96.45	-59.42
ROE$_t$	13.43	13.26	16.19	237.09	-99.49
Tobin's Q$_t$	1.37	1.10	0.98	29.47	0.22
CEO power$_t$	1.52	1.00	1.17	4.00	0.00
Board capital$_t$	1.77	2.00	0.99	4.00	0.00
Debt ratio$_t$	42.09	41.68	19.20	97.82	0.61
Age$_t$	29.63	27.63	13.03	71.72	0.08
Assets$_t$ (million NTD)	54,405.29	4,105.69	345,333.95	8,841,510.29	34.99
Panel B: Corporate social responsibility					
Policy$_t$	1.80	2.00	1.04	3.00	0.00
Environment$_t$	3.12	4.00	1.15	4.00	0.00
Employee$_t$	4.26	5.00	1.02	5.00	0.00
Information$_t$	0.79	1.00	0.74	2.00	0.00
Others$_t$	2.44	2.00	2.28	8.00	0.00
Authentication$_t$	0.13	0.00	0.39	2.00	0.00
CSR index$_t$	12.53	12.00	4.57	24.00	0.00

This table presents data descriptions pertaining to principal variables. Panel A presents descriptive statistics of firm characteristics. Panel B lists descriptive statistics of corporate social responsibility, including CSR-related policy of CSR (Policy), the environment (Environment), employees and suppliers (Employees), information transparency of CSR (Information), others of CSR (Others), and third-party authentication of CSR practices (Authentication), and the CSR index

1.37, indicates that the sample firms-maintained profitability throughout the study period. In addition, a Tobin's Q$_t$ exceeding 1 is an indication that the investors gave the firm a high valuation. Panel B presents the CSR indicators, which includes Policy, Environment, Employee, Information, Others, Authentication, and CSR index. The mean for Information$_t$ and Authentication$_t$ is 0.79 and 0.13 that were less than half of the full scores, which means that the sample firms were somewhat delinquent in having third parties authenticate disclosures related to CSR. Moreover, their overall CSR performance (CSR index) was only half of the full score.

Table 2 presents a Pearson correlation coefficient matrix of knowledge capital and the various CSR indicators. The significantly negative coefficients for Knowledge Capital, CSR index, R&D, and CSR indicate that firms investing in knowledge capital or R&D tended to neglect CSR. Information and Authentication were significantly negative at the 1% level of significance, which means that investment in R&D took precedence over Authentication of CSR-related reports by third parties. Thus, this study further investigates the relationship between CSR performance and knowledge capital, whether CSR promotion influenced knowledge capital accumulation, and whether knowledge capital accumulation influenced profitability and firm value.

Table 2 Pearson correlation coefficient matrix of knowledge capital and CSR

	Knowledge capital$_t$	*R*&D$_t$	Policy$_t$	Environment$_t$	Employee$_t$	Information$_t$	Others$_t$	Authentication$_t$	CSR index$_t$
Knowledge capital$_t$	1.00								
R&D$_t$	0.98***	1.00							
	(471.26)								
Policy$_t$	-0.02	-0.01	1.00						
	(-1.48)	(-0.89)							
Environment$_t$	-0.02**	-0.02	0.29***	1.00					
	(-2.21)	(-1.51)	(29.46)						
Employee$_t$	0.00	0.01	0.35***	0.41***	1.00				
	(0.13)	(0.61)	(36.81)	(43.33)					
Information$_t$	-0.04***	-0.04***	0.45***	0.24***	0.27***	1.00			
	(-4.06)	(-3.53)	(49.22)	(23.95)	(27.69)				
Others$_t$	-0.05***	-0.04***	0.38***	0.26***	0.26***	0.56***	1.00		
	(-4.59)	(-4.07)	(40.11)	(26.68)	(25.86)	(66.55)			
Authentication$_t$	-0.04***	-0.04***	0.25***	0.08***	0.10***	0.43***	0.44***	1.00	
	(-4.29)	(-4.02)	(25.74)	(7.97)	(10.23)	(45.98)	(47.34)		
CSR index$_t$	-0.04***	-0.03***	0.66***	0.58***	0.59***	0.70***	0.84***	0.47***	1.00
	(-4.17)	(-3.39)	(86.37)	(70.46)	(70.57)	(96.42)	(149.31)	(52.60)	

This table presents a Pearson correlation coefficient matrix of factors related to knowledge capital and the CSR index. The variables include Knowledge Capital, R&D, Policy, Environment, Employee, Information, Others, Authentication, and CSR index. The figures in parentheses are *t*-values, and *** indicates significance at the 1% level

4.2 Corporate social responsibility and knowledge capital

To examine H1a and H2a, the impact of CSR engagement on knowledge capital and use Eq. (3) and panel regression analysis to analyze. The control variables in regression analysis included CEO power, board capital, debt ratio, firm age, and the natural logarithm of total firm assets (Ln (assets)). We also considered the fixed effects of industry, year, and market from an empirical analysis.

Table 3 lists the results of regression analysis pertaining to the impact of CSR performance on knowledge capital and R&D. In Models (1), the regression coefficients of CSR index_t was 0.07 at the 1% level of significance, indicate that CSR engagement can promote the accumulation of knowledge capital. In Model (2), the regression coefficient of Net CSR was not significantly from 0. This shows that promoting CSR can lead to the accumulation of knowledge capital and strengthen core competitive advantage. In Models (3), the regression coefficients of CSR index_t were significantly positively related with R&D at the 1% level of significance. In Model (4), the regression coefficient of Net CSR was not significantly from 0, which indicates that engagement in CSR enabled firms to continuously re-examine the assessment and improvement of operations while promoting active investment in R&D. Furthermore, it shows that investments in R&D and CSR must be long-term. This supports the hypothesis H1a and H2a.

Regression analysis was also used to explore the impact of CSR indicators on knowledge capital and R&D in year *t*, the results of which are listed in Table 4. The dependent variables are knowledge capital for Model (1) to Model (6) and the R&D for Model (7) to Model (12). The coefficients of Policy_t, Environment_t, and Employees_t in Models (1), (2), and (3) were not significant. In Models (4), (5), and (6), the coefficient *t* values of Information_t, Others_t, and Authentication_t were significantly positively related with knowledge capital at the 1% level of significance. In Models (7), (8), and (9), the coefficients of Policyt, Environmentt, and Employeest also were not significant. In Models (10), (11), and (12), the coefficients of Information_t, Others_t, and Authentication_t were 3.48, 3.87, and 3.39 were significantly positively related with R&D. This implies that CSR engagement is crucial to investing in R&D and knowledge capital accumulation. CSR engagement was quite vital for firms. Investment in external CSR, information disclosure, and the assurance of sustainability reports by third parties can further confirm a firm's devotion to CSR to avoid agency problems, shift public focus, and greenwashing.

These results show that the promotion of CSR can lead to the accumulation of knowledge capital and investment in R&D. This supports H1a and H2a; however, the effectiveness of these measures depends on internal systems for the protection of the environment and employee rights. Thus, CSR engagement can build an environment where R&D investments, knowledge capital accumulates, and core competitive advantages can be fully exploited (Fu et al. 2020; Jadiyappa and Chauhan, 2023). Nonetheless, this process depends on the adoption of external CSR, the disclosure of relevant information, and third-party authentication of corresponding reports, which can reassure external stakeholders, avoid agency problems, and greenwashing to ensure that R&D and knowledge capital accumulation proceed in accordance with stakeholder expectations.

Table 3 Knowledge capital and CSR index

	Knowledge capital$_t$		*R*&D$_t$	
	Model (1)	Model (2)	Model (3)	Model (4)
Intercept	16.46***	15.85***	8.20***	7.82***
	(16.03)	(15.71)	(15.43)	(14.98)
CSR index$_t$	0.07***		0.04***	
	(3.29)		(3.93)	
Net CSR$_t$		0.02		0.02
		(0.97)		(1.23)
Control variables				
CEO power$_t$	0.04	0.04	0.02	0.02
	(0.65)	(0.69)	(0.69)	(0.75)
Board capital$_t$	0.24***	0.29***	0.13***	0.16***
	(3.01)	(3.62)	(3.11)	(3.84)
Debt ratio$_t$	-0.03***	-0.04***	-0.02***	-0.02***
	(-7.01)	(-7.29)	(-6.90)	(-7.23)
Age$_t$	-0.08***	-0.08***	-0.04***	-0.04***
	(-11.14)	(-11.13)	(-10.78)	(-10.77)
Ln (assets)$_t$	-0.79***	-0.70***	-0.40***	-0.34***
	(-10.85)	(-10.42)	(-10.65)	(-9.94)
Market effect	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes
Industrial effect	Yes	Yes	Yes	Yes
Adj-R^2	0.33	0.33	0.32	0.32
F-value	111.68	111.33	107.23	106.74

This table lists the regression results of knowledge capital and R&D on the CSR index and control variables over the period 2011 to 2017. *t*-values are in parentheses, and *, **, and *** denote significance at the 1%, 5%, and 10% levels, respectively

4.3 Knowledge capital and financial performance

Exploring the impact of knowledge capital on financial performance to test H1b and H2b using Eq. (4). In addition, I employed that Eq. (5) to examine H3 and H4, the interactive impact of knowledge capital and R&D on financial performance as well as the interactive effects between CSR and knowledge capital. I also set dummy variables for the CSR performance indicator as a proxy variable indicating firms with the best and worst CSR performance that Best CSR equals 1 if the CSR index of firm *i* in year *t* is equal to or greater than the mean CSR index plus 1 standard deviation, and otherwise 0, whereas Worst CSR equals 1 if the CSR index of firm *i* in year *t* is equal to or less than the mean CSR index minus 1 standard deviation. The control variables used in regression analysis included CEO power, board capital, debt ratio, firm age, and the natural logarithm of total firm assets (Ln (assets)). We also considered the fixed effects of industry, year, and market.

Table 5 lists the results of regression analysis pertaining to knowledge capital, CSR performance, and profitability. In Model (1), the coefficient of Knowledge capital$_t$ to ROA$_t$ was −0.14. In Model (2), the coefficient of Knowledge capital$_t$ × Best CSR$_t$ was 0.09, significantly positive at the 1% level. This implies that the simultaneous promotion of CSR and knowledge capital accumulation can enhance profitability. The regression coefficient of Knowledge capital$_t$ × Worst CSR$_t$ was −0.08 at the 1% level significantly negative

Table 4 Knowledge capital and CSR

	Knowledge capital$_t$						$R\&D_t$					
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)	Model (9)	Model (10)	Model (11)	Model (12)
Intercept	15.89***	15.78***	15.78***	16.63***	16.72***	16.89***	7.86***	7.77***	7.75***	8.25***	8.32***	8.36***
	(15.68)	(15.67)	(15.50)	(15.99)	(16.07)	(15.96)	(14.99)	(14.92)	(14.72)	(15.34)	(15.44)	(15.26)
Policy$_t$	0.07						0.05					
	(0.83)						(1.31)					
Environment$_t$		0.10						0.08**				
		(1.30)						(2.03)				
Employees$_t$			0.01						0.02			
			(0.12)						(0.46)			
Information$_t$				0.41***						0.23***		
				(3.21)						(3.48)		
Others$_t$					0.14***						0.08***	
					(3.51)						(3.87)	
Authentication$_t$						0.74***						0.39***
						(3.34)						(3.39)
Control variables												
CEO power$_t$	0.04	0.04	0.04	0.04	0.04	0.04	0.02	0.02	0.02	0.02	0.02	0.02
	(0.67)	(0.67)	(0.67)	(0.67)	(0.65)	(0.64)	(0.72)	(0.72)	(0.72)	(0.72)	(0.70)	(0.69)
Board capital$_t$	0.27***	0.28***	0.29***	0.25***	0.26***	0.27***	0.15***	0.15***	0.16***	0.14***	0.14***	0.15***
	(3.37)	(3.50)	(3.58)	(3.16)	(3.25)	(3.40)	(3.49)	(3.67)	(3.76)	(3.33)	(3.43)	(3.61)
Debt ratio$_t$	-0.03***	-0.03***	-0.04***	-0.03***	-0.03***	-0.03***	-0.02***	-0.02***	-0.02***	-0.02***	-0.02***	-0.02***
	(-7.25)	(-7.23)	(-7.30)	(-7.02)	(-7.08)	(-7.13)	(-7.17)	(-7.14)	(-7.23)	(-6.94)	(-7.00)	(-7.08)
Age$_t$	-0.08***	-0.08***	-0.08***	-0.08***	-0.08***	-0.08***	-0.04***	-0.04***	-0.04***	-0.04***	-0.04***	-0.04***
	(-11.15)	(-11.16)	(-11.14)	(-11.15)	(-11.14)	(-11.09)	(-10.79)	(-10.81)	(-10.78)	(-10.80)	(-10.78)	(-10.74)
Ln (assets)$_t$	-0.71***	-0.71***	-0.69***	-0.77***	-0.78***	-0.78***	-0.35***	-0.35***	-0.34***	-0.38***	-0.39***	-0.39***
	(-10.30)	(-10.45)	(-10.31)	(-10.87)	(-10.96)	(-10.89)	(-9.93)	(-10.09)	(-9.86)	(-10.49)	(-10.62)	(-10.45)
Market effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 4 (continued)

	Knowledge capital$_t$						$R\&D_t$					
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)	Model (9)	Model (10)	Model (11)	Model (12)
Industrial effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj-R^2	0.33	0.33	0.33	0.33	0.33	0.33	0.32	0.32	0.32	0.32	0.32	0.32
F-value	111.32	111.36	111.30	111.66	111.73	111.69	106.75	106.83	106.70	107.11	107.21	107.09

This table lists the regression results of the CSR index on knowledge capital, R&D, and control variables over the period 2011 to 2017. *t*-values are in parentheses, and *, **, and *** denote significance at the 1%, 5%, and 10% levels, respectively

Table 5 Knowledge capital, CSR, and profitability

	ROA_t		ROE_t		Tobin's Q_t	
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Intercept	-13.55***	-12.48***	-38.27***	-36.95***	2.19***	2.21***
	(-11.99)	(-10.93)	(-18.54)	(-17.71)	(17.39)	(17.35)
Knowledge $capital_t$	-0.14***	-0.13***	-0.19***	-0.18***	0.02***	0.02***
	(-12.14)	(-9.45)	(-9.03)	(-7.07)	(14.05)	(10.67)
Knowledge $capital_t \times$ Best CSR_t		0.09***		0.11**		0.00*
		(3.79)		(2.55)		(1.81)
Knowledge $capital_t \times$ Worst CSR_t		-0.08***		-0.09***		0.00
		(-4.08)		(-2.74)		(1.09)
Control variables						
CEO $power_t$	-0.04	-0.04	-0.14	-0.13	-0.01*	-0.01
	(-0.61)	(-0.59)	(-1.04)	(-1.02)	(-1.65)	(-1.65)
Board $capital_t$	0.51***	0.47***	0.81***	0.77***	0.03**	0.03**
	(5.71)	(5.36)	(5.02)	(4.78)	(2.56)	(2.55)
Debt $ratio_t$	-0.14***	-0.14***	-0.06***	-0.06***	0.00***	0.00***
	(-25.31)	(-25.29)	(-5.83)	(-5.79)	(-7.29)	(-7.31)
Age_t	-0.07***	-0.07***	-0.12***	-0.12***	-0.01***	-0.01***
	(-8.40)	(-8.34)	(-8.23)	(-8.19)	(-11.36)	(-11.36)
Ln $(Assets)_t$	1.98***	1.91***	4.02***	3.94***	-0.01	-0.01
	(26.57)	(25.51)	(29.54)	(28.70)	(-0.96)	(-1.12)
Market effect	Yes	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
Industrial effect	Yes	Yes	Yes	Yes	Yes	Yes
Adj-R^2	0.17	0.17	0.15	0.15	0.14	0.14
F-value	45.00	44.09	40.84	39.50	37.49	35.91

This table lists the regression results of the interactive effect of knowledge capital and the CSR index on profitability and control variables over the period 2011 to 2017. *t*-values are in parentheses *, **, and *** denote significance at the 1%, 5%, and 10% levels, respectively

related to ROA_t. This implies that when firms neglected to promote CSR while investing in knowledge capital accumulation decreased profitability. In Models (3) and (4), the results of regression analysis pertaining to ROE_t were identical to those for ROA_t. In Model (5), the coefficient of Knowledge $capital_t$ to Tobin's Q_t was significantly positive, indicating that the accumulation of knowledge capital can increase firm value. In Model (6), the coefficient of Knowledge $capital_t \times$ Best CSR_t was 0.00, significantly positive at the 10% level related to Tobin's Q. This indicates that the simultaneous promotion of CSR and accumulation of knowledge capital can more increase firm value. The coefficient of Knowledge $capital_t \times$ Worst CSR_t was not differed significantly from 0, indicating that the accumulation of knowledge capital could improve the profitability and firm values. These results support H3 but partially support H1b.

Table 6 presents the analysis results of R&D, CSR, and profitability. In Model (1), the coefficient of $R\&D_t$ to ROA_t was −0.29, significantly negative at the 1% level of significance. This implies that increasing R&D expenditures had a negative impact on ROA. Considering the interaction effects in Model (2), the regression coefficient of $R\&D_t \times$ Best CSR_t was 0.17, significantly positive related to ROA_t, and the *t*-value of $R\&D_t \times$ Worst CSR_t was −4.47, significantly negative at the 1% level. This implies that the simultaneous

Table 6 R&D, CSR, and profitability

	ROA_t		ROE_t		Tobin's Q_t	
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Intercept	-13.47***	-12.37***	-38.11***	-36.73***	2.22***	2.25***
	(-11.95)	(-10.87)	(-18.50)	(-17.64)	(17.68)	(17.67)
$R\&D_t$	-0.29***	-0.27***	-0.40***	-0.37***	0.03***	0.03***
	(-13.23)	(-10.44)	(-9.99)	(-7.80)	(12.75)	(9.91)
$R\&D_t \times$ Best CSR_t		0.17***		0.20**		0.01*
		(3.73)		(2.42)		(1.71)
$R\&D_t \times$ Worst CSR_t		-0.17***		-0.22***		0.00
		(-4.47)		(-3.27)		(0.53)
Control variables						
CEO $power_t$	-0.04	-0.04	-0.13	-0.13	-0.01	-0.01
	(-0.60)	(-0.57)	(-1.02)	(-1.00)	(-1.64)	(-1.64)
Board $capital_t$	0.51***	0.48***	0.82***	0.78***	0.03***	0.03**
	(5.79)	(5.47)	(5.09)	(4.86)	(2.57)	(2.54)
Debt $ratio_t$	-0.14***	-0.14***	-0.06***	-0.06***	0.00***	0.00***
	(-25.42)	(-25.42)	(-5.90)	(-5.87)	(-7.38)	(-7.39)
Age_t	-0.07***	-0.07***	-0.12***	-0.12***	-0.01***	-0.01***
	(-8.49)	(-8.43)	(-8.32)	(-8.27)	(-11.53)	(-11.53)
Ln $(Assets)_t$	1.97***	1.91***	4.01***	3.93***	-0.01	-0.01
	(26.58)	(25.50)	(29.54)	(28.67)	(-1.16)	(-1.35)
Market effect	Yes	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
Industrial effect	Yes	Yes	Yes	Yes	Yes	Yes
Adj-R^2	0.17	0.17	0.15	0.16	0.14	0.14
F-value	45.77	44.92	41.34	40.07	36.56	35.00

This table lists the regression results of the interactive effect of R&D and CSR on profitability and control variables over the period 2011 to 2017. *t*-values are in parentheses *, **, and *** denote significance at the 1%, 5%, and 10% levels, respectively

promotion of CSR while investing in R&D can improve financial performance. In Models (3) and (4), the results of regression analysis pertaining to ROE were identical to those for ROA. In Model (5), the regression coefficient of $R\&D_t$ to Tobin's Q_t was 0.03, significantly positive at the 1% level. This implies that investment in R&D benefited future financial performance, which resulted in positive evaluations from investors. In Model (6) to account for interaction effects, the coefficient of $R\&D_t \times$ Best CSR_t was 0.01, significantly positive at the 10% level of significance. The coefficient of $R\&D_t \times$ Worst CSR_t to Tobin's Q_t was not differ significantly from 0, indicating that the firm increase R&D expenditures and CSR to attract the investors' attention and investment to the extent that raises firm value. This supports H4 and partially supports H2b.

These empirical results indicate that accumulating knowledge capital and R&D investment can improve firm value. The interaction effects of knowledge capital accumulation and CSR promotion were enhanced to be particularly effective in promoting profitability. A negative relationship existed between R&D investment and profitability. It appears that the simultaneous promotion of CSR and R&D could improve profitability. In contrast, the long-term rise of CSR in conjunction with the accumulation of knowledge capital and investment

in R&D could have a pronounced positive effect on profitability (Jadiyappa and Chauhan, 2023).

4.4 Robustness

This study also considered the endogenous relationship between CSR and knowledge capital, dynamic endogenous effects, and self-selection bias, which employ. instrumental variables, the generalized method of moments (GMM), and the Hausman Test (Hausman 1978) to robustness check.

First, investigating the endogenous effect, I use Herfindahl-Hirschman index (HHI) as an instrumental variable. The results of regression analysis are shown in Table 7. Model (1) is first-stage regression for the CSR index, which the HHI_t as the instrumental variable was 2.05, significantly positive at the 5% significance level. This indicates that the HHI_t moderated the endogenous relationship. Models (2) and (3) are the second-stage regression of knowledge capital and R&D, respectively, the coefficients of CSR $index_t$ _hat are

Table 7 CSR and knowledge capital: instrumental variable

	CSR $index_t$	Knowledge $capital_t$	*R*&D_t	Net CSR_t	Knowledge $capital_t$	*R*&D_t
	First Regression	Second Regression		First Regression	Second Regression	
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Intercept	-11.07***	17.09*	4.84	-1.72**	14.35	11.08*
	(-12.92)	(1.73)	(0.95)	(-2.50)	(1.30)	(1.94)
HHI_t	2.05**			-0.37		
	(1.99)			(-0.45)		
CSR $index_t$ _hat		0.13	-0.30			
		(0.13)	(-0.58)			
Net CSR_t_hat					-0.73	1.67
					(-0.13)	(0.58)
Control variables						
CEO $power_t$	0.03	0.04	0.03	-0.04	0.02	0.08
	(0.81)	(0.57)	(0.89)	(-1.41)	(0.08)	(0.77)
Board $capita_{lt}$	0.65***	0.20	0.35	-0.07**	0.23	0.28
	(16.40)	(0.30)	(1.03)	(-2.30)	(0.57)	(1.31)
Debt $ratio_t$	-0.02***	-0.03	-0.02**	0.00	-0.04***	-0.01
	(-8.12)	(-1.62)	(-2.29)	(-1.03)	(-3.03)	(-2.36)
Age_t	0.00	-0.08***	-0.04***	0.00	-0.09***	-0.03**
	(-0.36)	(-10.96)	(-10.73)	(-1.63)	(-3.10)	(-2.33)
Ln $(Assets)_t$	1.34***	-0.87	0.07	0.15***	-0.59	-0.58
	(40.66)	(-0.64)	(-0.09)	(5.49)	(-0.72)	(-1.38)
Market Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry Effect	Yes	Yes	Yes	Yes	Yes	Yes
Adj-R^2	0.37	0.33	0.32	0.06	0.33	0.32
F-Value	129.39	111.30	106.70	15.72	111.30	106.70

This table lists the regression results of knowledge capital, R&D, instrumental variables, and control variables over the period 2011 to 2017. *t*-values are in parentheses *, **, and *** denote significance at the 1%, 5%, and 10% levels, respectively

not significantly differed from 0. This means that it has significant endogeneity with CSR, knowledge capital, and R&D. I also considered endogeneity with Net CSR, knowledge capital, and R&D to use HHI_t as an instrumental variable moderating endogeneity, as shown in Model (4), and that result was not significantly related. I performed a second-stage regression analysis, in which the regression coefficients of CSR $index_t$ _hat in Models (5) and (6) could not differ significantly from 0.

Further, considering the dynamic endogenous effects, I employ the GMM to robustness test in Table 8. In Models (1) and (2), the *t*-values of CSR $index_t$ were 3.23 and 3.83, which were both significantly positive at the 1% level of significance. This means that when considering dynamic endogenous effects, the implementation of CSR could still promote the accumulation of knowledge capital and investment in R&D. In Models (3) and (4), the coefficients of Net CSR_t were not differed significantly from 0, which again indicates CSR promotion must be implemented over the long term in order to benefit knowledge capital accumulation and R&D investment.

Finally, exploring self-selection bias, this study employed the Hausman test and two-stage least square regression (2SLS) to examine the relationships among knowledge capital, CSR, and profitability, the results of which are listed in Table 9. Models (1) and (2) respectively refer to the Hausman tests for knowledge capital and R&D. As shown in Table 3, the values for the residual of Model (1) and Model (4) both differed significantly from 0 at the 1% significance level, which indicates an endogenous relationship among with CSR index,

Table 8 CSR and knowledge capital: GMM

	Knowledge $capital_t$	$R\&D_t$	Knowledge $capital_t$	$R\&D_t$
	Model (1)	Model (2)	Model (3)	Model (4)
Intercept	16.46***	8.20***	15.85***	7.82***
	(15.93)	(15.41)	(15.74)	(15.15)
CSR $index_t$	0.07***	0.04***		
	(3.23)	(3.83)		
Net CSR_t			0.02	0.02
			(1.02)	(1.29)
Control variables				
CEO $power_t$	0.04	0.02	0.04	0.02
	(0.67)	(0.72)	(0.71)	(0.77)
Board $capital_t$	0.24***	0.13***	0.29***	0.16***
	(3.11)	(3.21)	(3.78)	(4.04)
Debt $ratio_t$	-0.03***	-0.02***	-0.04***	-0.02***
	(-6.80)	(-6.75)	(-7.09)	(-7.08)
Age_t	-0.08***	-0.04***	-0.08***	-0.04***
	(-14.06)	(-13.74)	(-14.02)	(-13.70)
Ln $(assets)_t$	-0.79***	-0.40***	-0.70***	-0.34***
	(-10.37)	(-10.25)	(-9.94)	(-9.58)
Market effect	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes
Industrial effect	Yes	Yes	Yes	Yes
S.D. Dependent Var.	9.01	4.63	9.01	4.63

This table presents the GMM results of CSR, knowledge capital, and R&D over the period 2011 ~ 2017. The values in parentheses are *t*-values and *, **, and *** respectively denote significance at the 10%, 5%, and 1% levels

Table 9 CSR and knowledge capital: Hausman test

	Hausman Test		Second regression					
	ROA_t		ROA_t		ROE_t		Tobin's Q_t	
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)
Intercept	-52.94***	-46.03***	-15.80***	-16.29***	-40.79***	-41.28***	1.99***	1.28**
	(-7.94)	(-8.43)	(-13.19)	(-12.73)	(-18.71)	(-17.71)	(14.93)	(2.08)
Knowledge $capital_t$	2.36***		-0.09***		-0.22***		0.01***	
	(5.66)		(-3.33)		(-4.68)		(4.80)	
RD_t		3.89***		-0.17***		-0.47***		0.15**
		(5.67)		(-2.73)		(-4.17)		(1.97)
Residual of Model (1) in Table 3	-2.50***							
	(-5.99)							
Residual of Model (4) in Table 3		-4.19***						
		(-6.09)						
Control variables								
CEO $power_t$	-0.15**	-0.14**	-0.05	-0.05	-0.15	-0.15	-0.01*	-0.02*
	(-2.07)	(-1.97)	(-0.74)	(-0.75)	(-1.14)	(-1.13)	(-1.69)	(-1.94)
Board $capital_t$	-0.21	-0.15	0.51***	0.51***	0.87***	0.88***	0.03***	0.01
	(-1.42)	(-1.05)	(5.68)	(5.67)	(5.28)	(5.31)	(3.00)	(0.40)
Debt $ratio_t$	-0.05***	-0.06***	-0.14***	-0.13***	-0.06***	-0.06***	0.00***	0.00
	(-3.06)	(-4.47)	(-24.13)	(-23.59)	(-5.89)	(-5.73)	(-7.14)	(-1.46)
Age_t	0.14***	0.10***	-0.05***	-0.05***	-0.10***	-0.11***	-0.01***	-0.01*
	(3.86)	(3.48)	(-5.76)	(-6.16)	(-6.20)	(-6.64)	(-9.66)	(-1.68)
Ln $(assets)_t$	3.71***	3.40***	1.98***	2.00***	3.93***	3.96***	-0.01	0.03
	(12.44)	(13.83)	(26.28)	(26.14)	(28.57)	(28.37)	(-1.64)	(1.15)
Market effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industrial effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj-R^2	0.17	0.17	0.14	0.15	0.14	0.14	0.12	0.12
F-value	44.96	45.74	46.87	42.29	43.81	39.37	36.51	32.33

This table lists the results of the 2SLS Hausman test's two-stage least square regression of knowledge capital, R&D, and profitability including ROA, ROE, Tobin's Q over the period 2011 ~ 2017. The values in parentheses are *t*-values and *, **, and *** respectively denote significance at the 10%, 5%, and 1% levels

knowledge capital, and R&D. The second-stage regression was performed while taking endogenous relationships into account by examining the impact of knowledge capital and R&D on profitability and firm value. In Models (3) and (4), the coefficients of knowledge capital and $R\&D_t$ to ROA_t were both significantly negative at the 1% level of significance. In Models (5) and (6), the coefficients of $knowledge\ capital_t$ and $R\&D_t$ versus ROE_t were

both significantly negative at the 1% level of significance. In Models (7) and (8), the coefficients of Knowledge capital$_t$ and R&D$_t$ to Tobin's Q$_t$ were significantly positive at the 1% and 5% levels of significance, respectively. This implies that when considering endogenous relationships, firms must spend capital expenditures to accumulate knowledge capital and promote R&D, which affects profitability and firm value.

This study obtained using instrumental variables, GMM, and the Hausman Test to perform robustness tests that the implementing CSR could promote the accumulation of knowledge capital and investment in R&D; however, CSR commitments must be long-term to offer meaningful benefits. The investment of substantial resources in knowledge capital, R&D, or CSR promotion can have a negative impact on profitability; however, this was shown not to deter investors, who remained optimistic about the future competitive advantages of firms, which increased firm value.

5 Conclusions

The accumulation of knowledge capital and investment in R&D are crucial to the core competitiveness of firms. Most previous studies focused on the impact of knowledge capital on firm value and profitability (Phillips and Zhdanov 2013; Gao and Chou, 2015; Chiu et al. 2021). However, some scholars have argued that CSR is one of the critical factors in core competitiveness and profitability (Heal 2005; Vilanova et al. 2009; Groysberg et al. 2011). In this study, I address this gap in relevant research and employ the CSR index to investigate the relationship among CSR, knowledge capital, and profitability.

The empirical analysis revealed a positively significant correlation with CSR, knowledge capital, and R&D, implying CSR engagement can enhance the accumulation of knowledge capital and investment in R&D. In addition, it is important to engage in external CSR (Others), disclose CSR-related information (Information Transparency of CSR), and have third parties authenticate CSR reports (Authentication) to avoid agency problems and greenwashing. The results also found that firms establish internal CSR policies (Policy), environmental protection (Environment), and employee and suppliers' rights (Employees) to ensure innovative development, the accumulation of knowledge capital, and investment in R&D. The investment of substantial resources in knowledge capital, R&D, or CSR promotion can have a negative impact on profitability; however, this was shown not to deter investors, who remained optimistic about the future competitive advantages of firms, which increased firm value.

This study also employed an instrumental variable, the generalized method of moments (GMM), the Hausman Test (Hausman 1978), and two-stage least square (2SLS) to explore the impact of knowledge capital, R&D, and CSR performance on financial performance and control the effect of endogeneity in robustness. The results also found that after controlling for the endogeneity, CSR can enhance knowledge capital and R&D to strengthen financial performance and firm value. These indicated that CSR engagement can avoid agency problems, shift public focus and greenwashing, and increase R&D efficiency and financial performance.

This research is the most detailed study of CSR, knowledge capital, R&D, and financial performance. These results revealed that the firm accumulates knowledge capital and increases R&D, negatively affecting financial performance. I also observed that CSR

engagement can improve the efficiency of knowledge capital and R&D to avoid agency problems and increase financial performance. The empirical analysis serves as a valuable reference for knowledge capital and R&D in CSR engagement around the world, even with the significant contribution of this paper. However, this study was limited to the listing firms in Taiwan. Future research should consider the impact of capital expenditure on CSR or the use of cross-nation samples for examination.

Declarations

Conflict of interest Authors have no conflicts of interest.

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