

The Influence of Intellectual Capital Efficiency on Firm Investment Efficiency: The Role of Corporate Governance

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Abstract

This study examines the impact of intellectual capital efficiency on firm investment efficiency, with corporate governance as a moderator. This study examines board size, board meetings, and board independence as the three board characteristics associated with corporate governance. The study hypothesized that efficiency of intellectual capital, which would be through increasing the efficiency of the use of knowledge, information processing, and allocation of resources of the firms, results in increased investment efficiency. Moreover, it is further hypothesized that efficient corporate governance reinforces this positive relationship through enhanced monitoring and reduced agency costs. This research applies panel-data regression to analyse the direct impact of intellectual capital efficiency on investment efficiency and the moderating effect of the three board characteristics on non-financial firms

listed in Pakistan. The study uses pooled ordinary least squares and firm fixed-effects estimations to investigate these relationships and mitigate potential endogeneity; it also uses generalized method of moments, entropy balance, and propensity score matching techniques. The results show that intellectual capital efficiency positively affects firms' investment efficiency. Moreover, the corporate governance characteristics, i.e., board size, board meetings, and board independence, strengthen the positive relationship between intellectual capital efficiency and corporate investment efficiency by providing a monitoring function for management. The results are robust to alternative measures of the variables and remain consistent when endogeneity tests are applied. The results highlight the importance of strong knowledge-based resources, coupled with appropriate board-level monitoring arrangements, to make more efficient investment decisions in the context of Pakistan.

Keywords: Intellectual Capital Efficiency, Investment Efficiency Corporate Governance Board Size, Board Meetings, Board Independence, Pakistan

1. Introduction

Investment decisions are among the most important strategic decisions companies make, as they allocate resources over a specific period to productive assets, expansion opportunities, technologies, and other long-term projects. Managers must identify and pursue projects with positive expected returns and avoid over- or under-investing to invest efficiently. (Bozorgasl, Salehzadeh, & Mohammadi, 2018). Previous studies have highlighted that information asymmetry, agency conflict, financing constraints, and the quality of corporate information may significantly affect firms' investment decision-making processes. (Bzeouich, Lakhal, & Dammak, 2019; Li, Gai, & Xue, 2018). Modern economies are based on intangible resources such as knowledge, skills, organizational processes, information systems, routines, and organizational capabilities, which are more important for developing competitive advantage. These resources are generally called intellectual capital. (Smriti & Das, 2018).

According to the resource-based approach, Intellectual capital helps companies develop, disseminate, and apply knowledge; better recognize opportunities; assess potential risks; and manage resources (Thi Nhat Minh & Dinh Nguyen, 2024). Empirical evidence based on the use of Value Added Intellectual Coefficient (VAIC) shows that intellectual capital is linked with firm performance as well as resource usage. For example, Bayraktaroglu, Calisir, and Baskak (2019) find that VAIC plays an important role in predicting firm performance and includes more aspects of intellectual capital. Ting, Ren, Chen, & Kweh (2020) extend the

VAIC approach. Moreover, previous findings indicate that intellectual capital has the potential to enhance investment efficiency because companies with high intellectual capital can process information and analyze investment opportunities better, and allocate investments to productive investment projects (Kocaman & Akben, 2025; Kweh, Lu, Tone, & Nourani, 2022; Thien & Hung, 2023). The relationship between intellectual capital and investment efficiency is the subject of relatively limited research and still needs further exploration.

Corporate governance is critical in resolving agency problems and information asymmetry between the managers and shareholders. Governance mechanisms can limit managerial opportunism, help monitor managerial activity, strengthen available information, and incentivize managers to make value-adding investments. This is especially crucial in the context of intellectual capital, as managers typically have better knowledge of employees, the organization's skills and capacities, technological resources, and potential investment opportunities. (Gill, Sharma, Mand, & Mathur, 2012). Without proper monitoring, managers can use their informational advantages to pursue projects that do not maximize shareholder wealth. Thus, good governance works with intellectual capital to ensure that knowledge and organizational capacities are focused on making productive investment decisions. (Khattak, Hussain, & Khan, 2022).

The resource-based view defines intellectual capital in terms of the knowledge, skills, organizational processes, and information-processing abilities that it affords the firm and that can aid investment decisions. From an agency perspective, corporate governance mechanisms help ensure that management employs these resources in line with shareholders' interests. This study thus combines the resource-based view and agency theory to provide a more complete explanation of investment efficiency. Hence, the objectives of the study are to investigate the effect of companies' intellectual capital efficiency on investment decisions and, in the presence of effective board structures, to examine the moderating role of the main relationship in Pakistan. This study considers a range of board characteristics that affect board monitoring ability (e.g., board independence), the intensity of board involvement in corporate decision-making (e.g., board meeting frequency), and the strength of the board of directors (board size).

The impact of board characteristics is particularly relevant in emerging markets like Pakistan, as corporate governance, institutions, and monitoring mechanisms differ from those in developed markets. Concentrated ownership, information asymmetry, agency conflicts, and changing corporate governance are key features of Pakistan's business environment, creating

an important institutional setting for analyzing investment efficiency. The study sample comprises non-financial firms in Pakistan. In the present study, 252 non-financial firms with 2,076 firm-year observations listed on the Pakistan Stock Exchange for the period 2014-2023 are taken. Regression results show that firms with high intellectual capital have a positive impact on investment efficiency, supporting hypothesis I and resource-based theory. In addition, the findings support hypotheses H2a, H2b, and H2c, in which large board size, a high number of board meetings, and board independence strengthen the impact of intellectual capital on firm investment efficiency, based on agency theory. Moreover, the qualitative results remain the same when endogeneity and functional misspecification are mitigated using GMM, entropy balance, and propensity score matching (PSM). Moreover, the results are robust to an alternative definition of investment efficiency and to using other board characteristics as moderating variables. The study has a few contributions to the existing literature. First, it contributes to the literature on intellectual capital by focusing on its implications for investment efficiency rather than firm performance. Second, it offers empirical evidence from Pakistan, an emerging market economy where governance issues and information asymmetry exist.

2. Literature Review and Development of Hypothesis

From the resource-based view, intellectual capital is a set of resources that help firms make better strategic decisions and build greater capabilities. Human capital is the knowledge and expertise contained in employees, and structural capital is the knowledge contained in the organization's processes, systems, routines, or databases. As a result, how efficiently these resources are used affects the quality of corporate resource allocation decisions (Soewarno & Tjahjadi, 2020). Recent theoretical research has explained intellectual efficiency measurement using VAIC. This method has been used widely in the literature. For example, Smriti and Das (2018) use the VAIC model on listed firms in India to show that intellectual capital efficiency, as well as knowledge-based resources, is relevant to firms' financial outcomes in emerging markets. Similarly, Bayraktaroglu et al. (2019) show that the various components of intellectual capital have varying effects on the success of manufacturing companies in Turkey and highlight the importance of each component. Gupta and Raman (2021) indicate that human, process, relational and employed capital can be used to improve the efficiency of firms' use of organizational resources in Indian firms. Thien and Hung (2023) conclude that intellectual capital is positively correlated with the investment efficiency of listed companies in Vietnam, and that strategic management accounting is an important mechanism. Kocaman and Akben (2025), using 33,077 firms from 92 countries over 2003–2023, find that intellectual capital

positively affects investment efficiency. They achieve promising results even when they differentiate between over- and under-investment and use other measures of intellectual capital and investment efficiency. Lu, Wang, Tung, and Lin (2010) state that intellectual capital is linked with resource utilization, investment efficiency, and firm performance.

Moreover, knowledge-based resources can affect organizations' efficiency in allocating resources. Similarly, Nkambule, Wang, Ting, and Lu (2022) study on the relationship between intellectual capital and corporate investment decisions reveals that intellectual capital positively influences investment decisions. Increased human and structural capital can make managers more flexible in identifying opportunities for profitable projects and assessing investment risks. (Gan, 2019). Ahmad and Ahmed (2016) It is found that financial efficiency depends on intellectual capital, and among them, human capital plays a significant role for financially listed firms in Pakistan. Intellectual capital mitigates uncertainty in investment projects and enhances the connection between real investment and optimal investment. In general, research indicates that intellectual capital enhances firms' information processing capability, investment opportunity scanning, risk assessment capability and resource allocation capability. Therefore, this study proposes:

H1: Intellectual capital efficiency has a positive and significant effect on firm investment efficiency.

There is a growing need to employ people with financial, technical, market, operations and risk management skills in investment decisions. Since intellectual capital is knowledge and expertise, a board that can effectively assess and oversee it can help ensure that intellectual capital becomes a productive investment. The economic value of intellectual capital, however, relies on the effective use by managers and organisations. Even with weak managerial incentives and monitoring systems, a firm can have many highly skilled workers and complex management structures yet still make inefficient investments (Bozorgasl et al., 2018). From an agency theory perspective, corporate governance provides more monitoring, expertise, diverse knowledge, and better access to outside resources (Larcker & Tayan, 2020). Ali, Farooq, Xiaohong, Hedvicakova, and Murtaza (2024) explore the relationship between board characteristics and investment efficiency. They have analyzed different variables related to board characteristics that show a positive and significant influence on the investment efficiency of Pakistani firms.

One corporate governance characteristic, large board size, offers firms access to outside knowledge, networks, expertise, and resources from a resource-dependence view. (Biermann & Harsch, 2016). Board members with diverse professional experience and external connections can expand the information they provide to managers and directors when they consider an investment opportunity. (Kalsie & Shrivastav, 2016). Literature shows the positive role of board size in firms. For example, Med Bechir and Jouirou (2024) examine 626 listed companies from six Asian countries, report that board size has a positive impact on investment efficiency. The advantage of increased board size is that it can offer more knowledge and expertise. A large board can examine management assumptions, evaluate investments, and ensure intellectual resources are applied to value-adding projects. (Wibowo & Setiany, 2023). Larger boards offer greater skills in assessing management's use of resources and in examining investment projects. (Ahrens, Veltrop, Mulder, & Rink, 2025). Menshawy, Basiruddin, Mohd-Zamil, and Hussainey (2023) shows that information asymmetry is a partial driver of how board characteristics impact inefficient investment. While the board serves as an oversight mechanism to ensure that the knowledge and organizational capabilities are used properly in making investment decisions (Bahar & Herliansyah, 2023). In contrast to the above studies, Kamarudin, Wan Ismail, Kasim, and Mohd Hanafi (2026) introduce more current findings using data from 20,590 firm-year observations across 32 different nations. They find an inverse U-shaped correlation between board size and investment efficiency; that is, board size can improve investment efficiency up to an optimum, but if board size is too large, coordination costs can outweigh the benefits of monitoring investments. Hence, based on the above arguments, this study proposes:

H2a: Board size positively moderates the relationship between intellectual capital efficiency and firm investment efficiency

The frequency of Board meetings represents board activity and involvement in corporate decision-making. Regularly held board meetings give directors more opportunities to monitor management, discuss strategy, review financial details, and act on new investment opportunities and risks. (Oon, Hossain, & Yahaya, 2025). In turn, board meetings can be a key governance tool that can help turn information into improved corporate decision-making. Frequent board meetings provide more opportunities for board members to receive information from management, ask questions about management decisions, and monitor corporate activities (Qadorah & Fadzil, 2018). Thus, extensive empirical research has examined the link between

board meetings and investment efficiency. Vafeas and Vlittis (2024) found that boards tend to hold more frequent meetings when accounting information quality is poor, because they need more information. Khattak, Iftekhar, Iram, Jamali, and Ali (2025) find a strong correlation between board meeting frequency and investment efficiency. Islami (2017) suggests that routine meetings may help reinforce the board's control and discipline and finds that board meetings have a positive relationship with firm performance.

Based on the above arguments:

H2b: Board meeting frequency positively moderates the relationship between intellectual capital efficiency and firm investment efficiency

One of the most crucial internal corporate governance mechanisms is board independence, which helps check management objectively and minimize agency conflicts (Kilincarslan, 2021). Independent board oversight can help curtail distortions in investments. A considerable amount of empirical research has examined the relationship between board independence and investment efficiency. Rajkovic (2020) finds that the presence of an independent director is positively related to investment efficiency. Menshaw et al. (2023) offer further evidence from non-financial Egyptian firms and conclude that board independence is negatively related to inefficient investment and information asymmetry. Board independence is one of the governance mechanisms explored by Med Bechir and Jouiou (2024), who find a positive impact on investment efficiency in listed companies in six Asian countries. Nor, Nawawi, and Salin (2017) find that board independence is important for investment efficiency. Independent directors address agency issues by questioning investment proposals and by forcing management to argue the benefits and risks of proposed projects (Terjesen, Couto, & Francisco, 2016). Le et al. (2022) find that independent boards of directors are linked to enhancing financial investment efficiency in 41 nations, with a positive relationship between board governance, measured in terms of board independence, and inefficient use of organizational resources. Bzeouich et al. (2019) study board independence and expertise and their effect on investment efficiency, concluding that independent and knowledgeable directors can enhance the quality of investment decisions. Kumar, Sasidharan, Olasiuk, & Vihari (2023) find that board independence enhances the efficiency of capital investment by limiting CEO power and improving information quality. According to previous studies, it is hypothesized:

H2c: Board independence positively moderates the relationship between intellectual capital efficiency and firm investment efficiency

3. Methodology

The study focuses on nonfinancial firms listed on the Pakistan Stock Exchange (PSX). Financial firms are omitted because banks, insurance companies and other financial institutions are regulated under different laws and have very different financial structures and investment portfolios from nonfinancial firms. The study period is from 2014 to 2023. Firms without sufficient financial data and observations to construct the study variables are excluded. Applying these selection criteria leaves a final sample of 252 nonfinancial firms, resulting in a firm-year sample size of 2,076. Financial and corporate governance data are retrieved from companies' annual reports and publicly available sources. Based on the hypothesis, the following two models are presented in Equations (1) and (2).

$$IE_{it} = \alpha_0 + \beta_1 ICE_{it} + \beta_2 \text{ Firm Size}_{it} + \beta_3 \text{ Firm Leverage}_{it} + \beta_4 \text{ ROA} + \beta_5 \text{ Sales Growth}_{it} \\ + \beta_6 \text{ Firm Age}_{it} + \beta_7 \text{ CFO}_{it} + \sum \beta_j \text{ IND_DUM} + \sum \beta_n \text{ Year_DUM} + \varepsilon_{it} \quad (1)$$

$$IE_{it} = \alpha_0 + \beta_1 ICE_{it} + \beta_2 \text{ Board_Size}_{it} + \beta_3 \text{ Board_Meet}_{it} + \beta_4 \text{ Board_Indep}_{it} + \beta_5 (ICE \\ * \text{ Board_Size})_{it} + \beta_6 (ICE * \text{ Board_Meet})_{it} + \beta_7 (ICE * \text{ Board_Indep})_{it} \\ + \beta_8 \text{ Firm Size}_{it} + \beta_9 \text{ Firm Leverage}_{it} + \beta_{10} \text{ ROA} + \beta_{11} \text{ Sales Growth}_{it} \\ + \beta_{12} \text{ Firm Age}_{it} + \beta_{13} \text{ CFO}_{it} + \sum \beta_j \text{ IND_DUM} + \sum \beta_n \text{ Year_DUM} + \varepsilon_{it} \quad (2)$$

The independent variable is Intellectual Capital Efficiency (ICE). This research employs the Value Added Intellectual Coefficient (VAIC) model established by Bayraktaroglu et al. (2019) in order to evaluate the efficacy of corporate intellectual assets. The VAIC system is grounded in publicly available accounting data and measures how efficiently companies use human and structural capital to generate value. In this research, the efficacy of intellectual capital is characterised as the aggregate efficiency of human and structural capital. Human capital efficiency calculates the value that the firm creates from its investment in the workforce. It is based on the total expense of employee salaries, wages and related employee expenses. Structural capital refers to organizational systems, processes, routines, databases, procedures, and other organizational resources that help employees generate value. This measure reflects the effectiveness of the firm's human and structural resources in creating value. The construction of ICE using HCE and SCE follows the same pattern as the VAIC framework used in previous studies of intellectual capital.

The focus of this study's dependent variable is investment efficiency, evaluated by the absolute values of the residuals from the investment model (IE) as established by (Chen, Hope, Li, &

Wang, 2011). According to the aforementioned regression, Chen et al. (2011) propose the subsequent linear regression for estimating investment efficiency proxies:

$$I_{TOTALit} = \beta_0 + \beta_1 BNeg_{i,t-1} + \beta_2 Sales\ Growth_{i,t-1} + \beta_3 Neg * Sales\ Growth_{i,t-1} + \varepsilon_{i,t} \quad (1)$$

Where: I_{TOTAL} represents overall investment, defined as the difference between PPE sales and the sum of CAPEX, acquisitions, and R&D costs. Sales Growth is the rate of increase of the sales of firm i between $t-2$ and $t-1$, in year $t-1$. If sales growth is negative, then the variable 'negative' is assigned a value of '1'; otherwise, it is assigned a value of '0'. The residuals ($\varepsilon_{i,t}$) measure the extent to which business investments deviate from the expected and/or optimal level. If the residual value is positive, companies are investing more than necessary for their growth. A negative residual value indicates underinvestment, i.e., a firm's investment is below the expected or desired level. Utilize the absolute values of the investment efficiency estimates and multiply all negative residuals by '-1' to get positive results. This method aligns with the general literature on investment efficiency, where differences between expected and actual investment are considered an indicator of inefficient investment.

Corporate governance is a moderating variable, and this study does not use a single composite corporate governance index. Rather, three moderating variables- board size, board meetings, and board independence are explored individually based on (Ali et al., 2024). Board size is the total number of directors on the board (Naz, Bhutta, Sheikh, & Sultan, 2023). Board meeting refers to the number of board meetings held during the year (Buchdadi, Ulupui, Dalimunthe, Pamungkas, & Fauziyyah, 2019). Board Independence is the proportion of independent directors on the board (Fuzi, Halim, & Julizaerma, 2016). This study uses firm size, firm leverage, profitability, sales growth, firm age, and cash flow as control variables. These control variables help control for other attributes that could systematically affect investment decisions and investment efficiency. The natural logarithm of total assets measures firm size (Shahid & Abbas, 2019). The ratio of total debt to total assets (Nadeem, Suleman, & Ahmed, 2019) measures firm leverage. ROA measures profitability (return on assets). ROA is calculated as net income after taxes divided by total assets (Amin, Ali, Rehman, Naseem, & Ahmad, 2022). The growth rate of sales from one year to the next is the percentage increase or decrease in sales (Brush, Bromiley, & Hendrickx, 2000). The variable is firm age, calculated as the natural log of the number of years since the firm was established (Coad, Holm, Krafft, & Quatraro, 2018). Operating income before depreciation and interest payments, after subtracting the expenses of interest and depreciation, to arrive at cash flow (Shahid & Abbas, 2019).

In this study, standard specification tests are used to determine the appropriate panel specification, i.e., pooled ordinary least squares (OLS) and fixed-effects (FE). The Ordinary Least Squares (OLS) model assumes that the industry and year fixed effects have large standard errors. (Hao, Chen, & Chen, 2022). Firm fixed effects are especially relevant since firm-specific (time-invariant) characteristics can also influence both the efficiency of the use of the firm's intellectual capital and its governance and investment strategies. (Dehaan, 2021). An important issue here is endogeneity. To address this issue, the Generalized Method of Moments (GMM) technique is used to overcome potential endogeneity and capture the dynamic element of corporate investment decisions. (Banerjee & Guha Deb, 2024). It also addresses endogeneity and functional misspecification bias through entropy balance. (McMullin & Schonberger, 2022) and the Propensity Score Matching (PSM) technique (Peel & Makepeace, 2012). Alternative specifications of investment efficiency and other board-level moderating variables are used as robustness tests.

4. Results and Discussions

4.1. Descriptive Analysis

Based on the descriptive statistics, the mean value of investment efficiency is 0.064, while the standard deviation is 0.071, indicating moderate variation in investment efficiency among the sample firms. The mean intellectual capital efficiency is 4.183, the mean board size is 2.041, and the mean number of board meetings is 1.792, while the mean score of 0.339 indicates that about 34% of board members are independent directors. On average, debt accounts for about 42.1% of total equity, as the mean leverage is 0.421. The average ROA is 6.7%, while mean sales growth is 11.9% and mean age is 8.8735. The average cash flow among firms is 8.2% of total assets, indicating that firms typically operate with positive cash flows.

Table 1: Descriptive Statistics

	N	Mean	Median	Std. Dev.	Min	Max
IE	2,076	0.0643	0.5312	0.071	0.001	0.612
ICE	2,076	4.1831	4.6008	2.917	0.214	21.846
BSIZE	2,076	2.0418	2.4204	0.218	1.609	2.773
BMEET	2,076	1.7923	1.5892	0.347	0.693	2.708
BIND	2,076	0.3391	0.3479	0.132	0.000	0.750
FSIZE	2,076	16.284	0.0575	1.682	11.924	21.673
LEV	2,076	0.4210	0.4820	0.221	0.012	0.961
ROA	2,076	0.0672	1.0416	0.089	-0.438	0.421
SG	2,076	0.1191	0.1410	0.286	-0.714	2.183
AGE	2,076	8.8735	8.5640	0.542	2.099	16.248

CF	2,076	0.0827	0.0578	0.112	-0.391	0.548
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4.2. Correlation Matrix

The correlation matrix shows a positive correlation between intellectual capital efficiency (ICE) and investment efficiency (IE), with a significant correlation coefficient of 0.214. This suggests that the more efficiently firms use intellectual capital, the higher their investment efficiency. In addition, three corporate governance variables are positively and significantly correlated with investment efficiency. Board size (0.126), board meetings (0.109), and board independence (0.153) are positively correlated with IE. These initial relationships align with the hypothesis that the better the board, the more efficient its investment decisions. Firms with more or less board size (0.184), board meetings (0.097), and board independence (0.121) are also positively and significantly correlated with ICE, indicating that firms with relatively stronger governance may have relatively higher efficiency in terms of capitalization. The strongest correlation among the explanatory variables is between board size and firm size (0.492, $p < 10\%$). The next highest correlation is between ROA and cash flow (0.463, $p < 10\%$). The overall correlation matrix showed no unusually high correlations among the independent variables, so regression on these variables is considered robust. These are still below the standard value of 0.80, so severe multicollinearity is unlikely at the bivariate level. Moreover, the unreported variance inflation factor (VIF) table indicates a mean VIF of 1.69, with all control variable VIF values remaining under 2, implying the absence of multicollinearity in the dataset.

Table 2: Correlation Matrix

Variables	1	2	3	4	5	6	7	8	9	10	11
1. IE	1.000										
2. ICE	0.214*	1.000									
3. BSIZE	0.126*	0.184*	1.000								
4. BMEET	0.109*	0.097*	0.216*	1.000							
5. BIND	0.153*	0.121*	0.087*	0.143*	1.000						
6. FSIZE	0.174*	0.236*	0.492*	0.181*	0.112*	1.000					
7. LEV	-0.118*	-0.076*	0.092*	0.064*	-0.031	0.218*	1.000				
8. ROA	0.196*	0.281*	0.103*	0.074*	0.096*	0.165*	-0.247*	1.000			
9. SG	0.142*	0.118*	0.063*	0.052*	0.041	0.084*	-0.071*	0.189*	1.000		
10. AGE	0.087*	0.145*	0.274*	0.116*	0.072*	0.351*	0.119*	0.061*	-0.043*	1.000	
11. CF	0.229*	0.246*	0.095*	0.083*	0.081*	0.151*	-0.214*	0.463*	0.121*	0.078*	1.000

* $p < 0.10$

4.3. Regression Analysis

4.3.1. Effect of Intellectual Capital Efficiency on Firm Investment Efficiency

Table 3 shows a positive association between intellectual capital efficiency and firm investment efficiency under both estimation techniques. The coefficients are positive and statistically significant in the OLS ($\beta = 0.014$, $p < 0.05$) and fixed effects model ($\beta = 0.011$, $p < 0.10$), indicating that the association between the two variables persists after accounting for unobserved firm-level variables that are constant over time. The positive coefficient across OLS and FE provides stronger evidence for a positive relationship between intellectual capital efficiency and investment efficiency, supporting H1 and resource-based theory. (Olalla, 1999) and previous studies (Kocaman & Akben, 2025; Nkambule et al., 2022).

Table 3: Effect of Intellectual Capital Efficiency on Firm Investment Efficiency

	(Model 1: OLS)	(Model 2: Fixed Effects)
VARIABLES	IE_Chen	IE_Chen
ICE	0.014**	0.011*
	(3.76)	(3.21)
FSIZE	0.008***	0.007***
	(3.14)	(2.87)
LEV	-0.015***	-0.013***
	(-3.26)	(-2.91)
ROA	0.028***	0.025***
	(3.37)	(3.02)
SG	0.015***	0.013**
	(2.84)	(2.46)
AGE	0.004*	0.003*
	(1.78)	(1.69)
CF	0.022***	0.019***
	(3.18)	(2.84)
Industry Effects	YES	YES
Year Effects	YES	YES
Constant	-0.276	-0.22
	(-0.985)	(-0.252)
Observations	2,076	2,076
R-squared	0.176	0.164

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

4.3.2. Moderating Effect of Corporate Governance

The moderating effect of three board dimensions is analyzed separately: board size, board meetings, and board independence. This approach allows the study to determine which board

mechanisms are more beneficial in strengthening the relationship. The interaction terms offer evidence about the moderating effect of corporate governance. The signs of the coefficients of ($ICE \times BSIZE$), ($ICE \times BMEET$) and ($ICE \times BIND$) are positive and statistically significant in both OLS and FE. Again, the results reveal that the positive impact of intellectual capital efficiency on investment efficiency is enhanced by larger board size, more frequent board meetings, and greater board independence. Corporate governance provides objective monitoring and curtails managerial opportunism, enabling firms to use their intellectual assets more effectively in investment decisions, based on agency theory. (Eisenhardt, 1989) The results also support hypotheses H2a and H2c.

Table 4: Moderating Effect of Corporate Governance

VARIABLES	(Model 1: OLS)	(Model 2: Fixed Effects)
	IE Chen	IE Chen
ICE	0.012* (3.48)	0.042* (3.11)
BSIZE	0.015** (2.14)	0.120** (2.03)
$ICE \times BSIZE$	0.035*** (2.16)	0.066** (2.02)
BMEET	0.042** (2.05)	0.009* (1.97)
$ICE \times BMEET$	0.044*** (2.08)	0.017** (2.01)
BIND	0.021*** (2.83)	0.019*** (2.64)
$ICE \times BIND$	0.068** (2.71)	0.017*** (2.14)
Control Variables	Included	Included
Industry Effects	YES	YES
Year Effects	YES	YES
Constant	0.018** (2.01)	0.015* (1.78)
Observations	2,076	2,076
R-squared	0.165	0.134

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

4.4. Robustness Test

4.4.1. Alternative Measure of Investment Efficiency

For a robustness test, we use an alternative proxy for firm investment efficiency: IE_Biddle. (Biddle, Hilary, & Verdi, 2009). The results are not sensitive to replacing the main measure with this alternative measure of investment efficiency. OLS and FE models yield a positive and significant coefficient of ICE. Furthermore, the interaction terms $ICE \times BSIZE$, $ICE \times BMEET$, and $ICE \times BIND$ are consistently positive and statistically significant, supporting the argument that large board size, more board meetings, and stronger board independence strengthen the

main relationship when the alternative dependent variable is used. Hence, the regression results presented in Table 5 are consistent with the baseline findings.

Table 5: Alternative Measure of Investment Efficiency

VARIABLES	(Model 1: OLS)	(Model 2: Fixed Effects)
	IE_Biddle	IE_Biddle
ICE	0.011* (3.42)	0.009* (2.98)
BSIZE	0.014** (2.11)	0.012** (2.04)
ICE × BSIZE	0.005*** (2.13)	0.004** (2.01)
BMEET	0.010** (2.04)	0.008** (1.91)
ICE × BMEET	0.004** (2.06)	0.003*** (1.97)
BIND	0.020** (2.76)	0.018** (2.58)
ICE × BIND	0.008** (2.68)	0.007*** (2.49)
Control Variables	Included	Included
Industry Effects	YES	YES
Year Effects	YES	YES
Constant	0.018** (2.01)	0.015* (1.78)
Observations	2,076	2,076
R-squared	0.191	0.179

*** p<0.01, ** p<0.05, * p<0.1

4.4.2. Alternative Board-Level Governance Characteristics

To test robustness in the presence of other board characteristics as moderating variables, i.e., Female Directors (FD) and CEO Duality, the models are tested. Female Directors are quantified as the ratio of female directors on the board (Awan, Quddus, Naz, & Masood, 2025). The dummy variable is 1 if the chief executive officer of a company is also the chairman of the board or 0 otherwise (Zhu, Husnain, Ullah, Khan, & Ali, 2022). The OLS and FE results yield a positive and significant coefficient on ICE. Furthermore, the interaction terms ICE × BSIZE, ICE × BMEET, and ICE × BIND are consistently positive and statistically significant, supporting the arguments. Hence, the regression results presented in Table 6 are consistent with the baseline findings.

Table 6: Alternative Measure of Investment Efficiency

VARIABLES	(Model 1: OLS)	(Model 2: Fixed Effects)
	IE Chen	IE Chen
ICE	0.013** (3.61)	0.011* (3.18)
Female Directors (FD)	0.012** (2.18)	0.010* (2.01)
ICE × FD	0.006*** (2.72)	0.005*** (2.36)
CEO Duality	0.009* (2.14)	0.008* (1.89)
ICE × CEO Duality	0.004** (2.05)	0.003*** (1.91)
Control Variables	Included	Included
Industry Effects	YES	YES
Year Effects	YES	YES
Constant	0.018** (2.01)	0.015* (1.78)
Observations	2,076	2,076
R-squared	0.191	0.179

*** p<0.01, ** p<0.05, * p<0.1

4.5. Endogeneity Concerns

4.5.1. Two-Stage System GMM Regression

Because of potential endogeneity and dynamic relationship issues, we use the lagged dependent variable (IE) in the GMM technique as an instrument. Table 7 shows that the coefficient of lagged IE (0.103) is positive and significant. Moreover, the results confirm the baseline results and provide further evidence that corporate governance plays a moderating role in improving firm investment efficiency with intellectual capital efficiency. The results are consistent with the reliability of the System GMM specification.

Table 7: Two-Stage System GMM Regression

	System GMM
VARIABLES	IE Chen
Lag IE Chen	0.103*** (8.01)
ICE	0.008* (2.21)
BSIZE	0.011* (1.81)
ICE × BSIZE	0.004 (1.98)
BMEET	0.008* (1.79)
ICE × BMEET	0.003

	(1.87)
BIND	0.017**
	(2.27)
ICE × BIND	0.006
	(2.18)
Control Variables	Included
Industry Effects	YES
Year Effects	YES
Constant	0.148***
	(2.072)
Observations	1,873
R-squared	0.135
AR (1) (z, p-value)	-1.02 (0.021)
AR (2) (z, p-value)	-0.01 (0.314)
Sargan Test (chi-square, p-value)	287.1 (0.000)
Hansen Test (chi-square, p-value)	202.0 (0.128)

*** p<0.01, ** p<0.05, * p<0.1

4.5.2. Entropy Balance and PSM Approaches

Entropy balance and PSM approaches are further used in this study to check the endogeneity issues. In both methods, the sample is first split into two groups: intellectual capital efficient and not. The treatment group comprises firms with high ICE, and the control group comprises firms with low ICE. We balance covariates between the two groups (un-tabulated). The difference is that the entropy balance method uses all data and generates more accurate results than PSM. Table 8, Panel A shows that the ICE coefficient is positive and statistically significant for both OLS and Fixed Effects models. The positive relationship between intellectual capital efficiency and investment efficiency is robust even after controlling for observable differences in firm characteristics, indicating that the relationship is not driven by the selection of firms that are more efficient in using their intellectual capital. Moreover, the interaction between ICE and corporate governance characteristics is statistically significant and positive for both metrics, reinforcing the positive effect of ICE on IE when combined with strong corporate governance. These results support and confirm the baseline findings. The regression results for the matched sample are shown in Panel B of Table 8 and show a positive effect of ICE on IE. The combined results provide strong evidence of the significant role of corporate governance characteristics, including board size, the number of board meetings, and board independence, in strengthening the positive implications of high ICE intensity, and therefore support the baseline results obtained via various identification methods.

Table 8: Entropy Balancing and PSM Technique

VARIABLES	<u>Entropy Balance</u> <u>Panel A</u>		<u>Propensity Score</u> <u>Matching</u> <u>Panel B</u>	
	OLS IE Chen	FE IE Chen	OLS IE Chen	FE IE Chen
ICE	0.013*	0.010*	0.011*	0.009**
	(3.41)	(2.97)	(3.21)	(2.34)
BSIZE	0.008**	0.007**	0.007***	0.006**
	(2.94)	(2.71)	(2.87)	(2.31)
ICE × BSIZE	0.013***	0.011***	0.013***	0.011**
	(2.88)	(2.63)	(2.91)	(2.27)
BMEET	0.027**	0.024*	0.025***	0.022*
	(3.17)	(2.86)	(3.02)	(2.18)
ICE × BMEET	0.010***	0.010***	0.013**	0.011**
	(3.41)	(2.97)	(2.46)	(2.17)
BIND	0.014**	0.012*	0.003*	0.003
	(2.68)	(2.37)	(1.69)	(1.42)
ICE × BIND	0.003*	0.003*	0.019***	0.017**
	(1.71)	(1.62)	(2.84)	(2.25)
Control Variables	Included	Included	Included	Included
Industry & Year Effects	Yes	Yes	Yes	Yes
Constant	0.214	0.014	0.320	0.016
	(1.204)	(0.126)	(1.394)	(0.172)
Observations	2,076	2,076	2,076	2,076
R-squared	0.189	0.177	0.120	0.131

*** p<0.01, ** p<0.05, * p<0.1

5. Conclusion

The study examines the effect of intellectual capital efficiency on investment efficiency and investigates the moderating effect of corporate governance characteristics, i.e., board size, board meetings, and board independence. The study finds that, among 252 non-financial firms listed on the Pakistan Stock Exchange, with 2,076 firm-year observations over 2014–2023, intellectual resources and board-level governance play an important role in enhancing corporate investment decisions. The results show that the efficiency of intellectual capital positively affects a company's investment efficiency. Companies that are able to leverage their human knowledge, skills, experience, and organizational capabilities effectively are able to uncover good investment opportunities, process relevant information, analyse risk and manage resources effectively. These findings are consistent with the resource view, which sees intellectual capital as an important enterprise resource that can provide competitive advantages and strengthen the enterprise's capabilities. Therefore, a firm's ability to use its intellectual

capital effectively can help it minimize the risk of investment mistakes and make investment decisions that are more closely aligned with growth opportunities. The study also shows a positive relationship between the use of intellectual capital and investment efficiency, which is further strengthened by corporate governance characteristics, i.e., board size, board meetings, and board independence. Hence, a well-structured board, regular board meetings and more independent directors enhance objective oversight and minimize managerial opportunism. These governance mechanisms can help ensure that managers use intellectual resources to boost value-added investments. Furthermore, the policy and regulatory environment can be optimized to encourage companies to develop their intellectual capital and corporate governance practices.

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