

How does CEO career variety affect a firm's investment efficiency?

Nurul Fitriani¹, Iman Harymawan^{1,2*}, Norazlin Binti Ab Aziz³, Dirgahayu Almi Mahati¹

¹ Department of Accounting, Faculty of Economics and Business, Universitas Airlangga, Surabaya, Indonesia

² Center for Environmental, Social, and Governance Studies, Universitas Airlangga, Surabaya, Indonesia

³ Department of Finance, Faculty of Business and Economics, Universiti Malaya, Kuala Lumpur, Malaysia

*Corresponding Author(s) Email: harymawan.iman@feb.unair.ac.id

ABSTRACT

While prior studies have extensively examined CEO career variety in developed economies, its implications for investment efficiency in emerging markets remain limited. This study examines the relationship between CEO career variety and investment efficiency in non-financial firms listed on the Indonesia Stock Exchange during the 2018–2021 period, with a particular focus on firms exhibiting over- and underinvestment. Using 941 firm-year observations and established measures of CEO career variety, the analysis applies Coarsened Exact Matching and Heckman's two-stage regression to address potential endogeneity concerns. The findings indicate that greater CEO career variety is associated with lower overall investment efficiency. Further analyses reveal an asymmetric effect: CEOs with more diverse career backgrounds tend to mitigate overinvestment while intensifying underinvestment, suggesting that career variety shapes managerial risk preferences and resource allocation differently across investment contexts. These findings extend upper echelons theory by demonstrating the context-dependent value of executive career diversity. In emerging market environments characterized by institutional uncertainty and limited transparency, broad career experiences may weaken firm-specific knowledge and stakeholder embeddedness, thereby constraining effective investment decision-making.

Keywords: CEO Career Variety; Investment Efficiency; Overinvestment; Underinvestment; Upper Echelon Theory; Emerging Markets

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Introduction

The CEO career trajectory underwent significant transformations between the 1950s and 1990s (Kesner & Sebor, 1994; Mizruchi & Marshall, 2016). Prior to the 1980s, CEOs typically rose through the ranks within their initial employer, gradually accumulating experience and expertise (Cappelli & Hamori, 2005). However, this pattern shifted in the 1980s and 1990s, as firms began to prioritize strong structures and external institutional forces (Guillen in Heydebrand, 1997). This transformation was driven by globalization, which emphasized the importance of core competencies and dynamic abilities in strategic leadership positions (Hayes & Abernathy, 1980). Furthermore, this period saw the emergence of a new management paradigm, characterized by "detached management," which involved the use of management portfolios, short-term financial control, and unrelated job diversification (Ocasio & Hyosun, 1999).

The detached management era continued in the 2000s with the emergence of "professional managers" concepts, defined as individuals with general skills that can be applied in various conditions, not just in the current firm (Bertrand, 2009). This shift led to increased flexibility in hiring CEOs from outside companies, facilitated by the labour market (Hollenbeck, 2009; Murphy & Zabochnik, 2006; Ryan & Wang, 2012). Notably, research by Hamori & Kakarika (2009) and Murphy & Zabochnik (2006) revealed that CEOs and senior executives now spend less time in their current firm and more often reach their positions from outside firms compared to the 1970s. However, traditional career paths still exist, such as a single functional area within one company (Hamori, 2010).

The phenomenon of career variety towards the CEO position has been documented based on managerial career typology (Karaevli & Tim Hall, 2006). Managerial career typology categorizes careers based on functional and institutional factors (Smith & White, 1987). This framework is used to measure CEO career variety, which is defined by Karaevli & Tim Hall (2006) as the accumulation of diverse experiences across functional and institutional areas over time. Initially, the CEO's career variety focused on cross-company movements (Sullivan & Baruch, 2009). However, recent research has expanded this concept to include cross-industry (Chahyadi et al., 2021; Karaevli & Tim Hall, 2006), cross-functional (Briscoe et al., 2006; Çakmak-Otluoğlu, 2012), and cross-country (Georgakakis et al., 2016) movements.

Previous literature on career variety has generally focused on middle managers (Z. Chen et al., 2011) and top managers (Schmid & Mitterreiter, 2021a, 2021b). In contrast, this study focuses on career variety at the CEO level due to its significant influence on resource

allocation (Agnihotri & Bhattacharya, 2021; Peng & Chiu, 2022) and long-term strategies for creating shareholder value (Arranz-aperte & Berglund, 2008). This includes investment decisions, which are crucial in determining the optimal level of investment amidst uncertainty and risk (Naeem & Li, 2019). Naturally, the evolving phenomenon of CEO career variety also shifts the way CEOs approach decision-making. This phenomenon can lead to CEOs paying less attention to detail, having weaker relationships with stakeholders, and demonstrating lower commitment to the firm (Schmid & Mitterreiter, 2021b). Such conditions have the greatest impact on investment decision-making, which typically requires strong attention to detail and the ability to build relationships with stakeholders, particularly investors. However, the effect of career variety on investment efficiency remains underexplored, especially in Indonesia, where political connections are a frequent occurrence. Most prior studies have focused on developed countries and examined CEO career experiences in general, leaving a knowledge gap that this study aims to address.

Previous research has examined the relationship between CEO career experience and investment decisions (Ali et al., 2022; Ngelo et al., 2022; Peng & Chiu, 2022; Ullah et al., 2022). This study differs in that it examines the relationship between CEO career variety and investment efficiency. It aims to analyze the relationship between CEO career variety and investment efficiency in non-financial publicly listed companies in Indonesia. Specifically, it investigates whether variations in cross-company, cross-industry, cross-functional, and cross-country experience among CEOs affect the levels of overinvestment or underinvestment. The novelty of this study lies in its use of investment efficiency as a specific measure of investment decision performance, a metric rarely applied in career variety research. Furthermore, it is conducted within the context of a developing country characterised by an underdeveloped capital market, limited resources, and governance challenges, which distinguishes it from the majority of prior studies conducted in developed countries.

This study used a sample of non-financial public companies listed on the Indonesia Stock Exchange (IDX) from 2018 to 2021. While research on CEO career variety has been conducted in developed countries like the US and Germany (Crossland et al., 2014; Schmid & Mitterreiter, 2021a, 2021b), this study focused on Indonesia, a developing country with resource constraints such as an underdeveloped capital market. Indonesia has the highest Incremental Capital Output Ratio (ICOR) value in ASEAN, indicating low investment efficiency (Elena, 2021). Additionally, Indonesia's high level of corruption (Corruption Perception Index, 2022) and suboptimal resource allocation (Agnihotri & Bhattacharya, 2021) further underscore the need for this study. This condition reflected on additional

analysis, with the majority of firms in Indonesia experiencing investment inefficiency, either overinvestment or underinvestment. Underinvestment occurs when a firm's actual investment level falls below the optimal threshold, whereas overinvestment refers to a situation where the firm's investment level exceeds the optimal point (Chen & Lin, 2013; Gan, 2019; Ullah et al., 2020).

This study provides a broader perspective within an institutional context by employing cross-country categories (Crossland et al., 2014), in line with the era of globalisation and increasing labour mobility (Ihara, 2023). The findings of this research make significant contributions both theoretically and practically. Theoretically, the results enrich the existing literature on CEO career variety and its relationship with investment decisions, while also providing a foundation for future research. Furthermore, the empirical evidence from this study supports the upper echelons theory, representing an important theoretical contribution. Practically, the findings provide valuable insights for companies experiencing high levels of overinvestment. By leveraging the role of CEOs with diverse career experiences, companies have the potential to reduce overinvestment, which is indicative of organizational slack and may threaten long-term sustainability if left unaddressed.

The remainder of this paper is organized as follows. Section 2 explains the literature review and hypothesis development. Section 3 provides the research methodology. Section 4 contains the results and discussion, while Section 5 delivers the conclusion.

Literature Review

Grand Theory

The upper echelons theory proposed by Hambrick & Mason (1984) is built on the premise of human limitations in accessing, processing, and utilizing information (Wang et al., 2016). An individual's background, values, experiences, and insights shape their character, influencing their vision, perception, and interpretation (Hambrick & Mason, 1984). When faced with objectively similar circumstances, decision-makers can make distinct decisions based on their preferences rooted in their backgrounds or experiences (Ngelo et al., 2022).

The upper echelons theory suggests that a CEO's character is shaped by their work experience, which has a significant impact on their decision-making and strategic goal implementation (Harymawan et al., 2020; Ngelo et al., 2022). CEOs' strategic decisions, including investment decisions, involve significant risks and aim to adjust the company's strategy, ultimately shaping a company's future (Wang et al., 2016).

This study relies on the upper echelon theory as its theoretical foundation, as it investigates the relationship between CEO career variety and investment decisions. CEO career variety refers to the breadth of a CEO's accumulated work experience across companies, industries, functions, and countries, capturing the diversity of their managerial exposure over time (Karaevli & Hall, 2006). In addition, Firm investment efficiency is the extent to which a company's investment level aligns with its growth opportunities, minimizing overinvestment and underinvestment relative to fundamentals (Biddle, Hilary, & Verdi, 2009). The choice is justified by the study's focus on CEO career experience variations, which previous studies have used to explain top management characteristics (Ali et al., 2022; Chahyadi et al., 2021; Crossland et al., 2014; Peng & Chiu, 2022; Wang et al., 2016).

Prior studies have shown that CEOs with broader career experiences accumulate diverse skills and knowledge that can improve strategic adaptability and capital allocation quality (Crossland et al., 2014; Guan et al., 2016). Others find that international and cross-industry experiences are linked to less managerially distorted investments (Peng & Chiu, 2022). However, some studies caution that excessive career variety may dilute firm-specific knowledge and increase the risk of overinvestment, particularly in weak governance settings (Agnihotri & Bhattacharya, 2021; Schmid & Mitterreiter, 2021b). Despite these insights, the link between CEO career variety and firm investment efficiency remains underexplored, especially in emerging markets like Indonesia, where capital market development is limited and political connections often influence investment decisions.

CEO Career Variety

Investment efficiency is a central concept in corporate finance, referring to the extent to which a firm's investment decisions align with value-maximising opportunities (Biddle, Hilary, & Verdi, 2009). In an efficient setting, firms allocate capital only to projects with positive net present value (NPV). Conversely, investment inefficiency occurs when actual investment deviates from the optimal level, leading to underinvestment or overinvestment (Chen & Lin, 2013; Gan, 2019; Ullah et al., 2020). Underinvestment occurs when firms invest less than optimally due to financial constraints or managerial risk aversion, thereby limiting their growth potential. Overinvestment occurs when firms allocate excessive capital to unprofitable projects, often driven by agency problems or managerial overconfidence (Jensen, 1986; Richardson, 2006). Both conditions reduce shareholder value and long-term sustainability.

Empirically, investment efficiency is commonly measured using residuals from expected investment models (Richardson, 2006; Biddle et al., 2009). Positive residuals indicate overinvestment, while negative residuals indicate underinvestment. In emerging markets, inefficiencies are more pronounced due to limited access to external financing, high information asymmetry, and weak governance (La Porta et al., 1998). Firms often face financing frictions and political interference that distort capital allocation. In Indonesia, an underdeveloped capital market, high ICOR, and weak investor protection exacerbate these inefficiencies (Elena, 2021; Harymawan & Nowland, 2016). Such institutional weaknesses make firms prone to both overinvestment and underinvestment. Distinguishing between the two is essential because each reflects different managerial and institutional challenges requiring distinct policy responses. Examining investment efficiency thus provides insights into how CEO characteristics and governance conditions shape firms' investment behavior in emerging economies.

Investment Efficiency

CEO career variety refers to the breadth of a CEO's accumulated work experiences across employers, industries, functional roles, and countries, reflecting a stock of generalist managerial human capital formed through mobility over time (Karaevli & Hall, 2006; Sullivan & Baruch, 2009). Rooted in managerial career typologies and upper-echelons logic, it captures how diverse backgrounds shape information processing, problem framing, and strategic choices (Smith & White, 1987; Hambrick & Mason, 1984). Inter-firm variety denotes movement across different companies, often via the external labour market that increasingly favours generalist managers (Murphy & Zabochnik, 2006; Hamori & Kakarika, 2009). Industry variety reflects experience spanning multiple sectors, exposing CEOs to heterogeneous competitive logics and resource configurations (Karaevli & Hall, 2006; Crossland et al., 2014). Functional variety refers to the breadth of assignments across various areas, including finance, operations, marketing, and R&D, which can enrich cross-functional coordination and capital budgeting discipline (Briscoe et al., 2006; Çakmak-Otluoğlu, 2012). International variety captures work across countries or regions, building sensitivity to institutional differences and global networks (Georgakakis et al., 2016). In practice, scholars measure career variety using counts of distinct employers/industries/functions/countries, or entropy/Herfindahl-type indices that weight both the number and balance of categories, often adjusted for tenure and career stage (Karaevli & Hall, 2006; Crossland et al., 2014).

The literature identifies several potential benefits of career variety: broader skill sets and generalist capabilities that enhance strategic adaptability, more effective resource orchestration, and richer external networks that improve information access and capital allocation (Crossland et al., 2014; Guan et al., 2016; Peng & Chiu, 2022). Diverse careers can also reduce managerial myopia and improve screening of projects under uncertainty, thereby supporting investment quality (Peng & Chiu, 2022). At the same time, studies have noted possible downsides, including diluted firm-specific knowledge, shallower expertise, and attention dispersion, which may weaken stakeholder relationships or shorten tenures (Bertrand, 2009; Schmid & Mitterreiter, 2021b). Generalist mobility can induce risk aversion in unfamiliar settings or, conversely, encourage expansive but unfocused initiatives, including inefficient diversification, when governance is weak (Murphy & Zabojsnik, 2006; Agnihotri & Bhattacharya, 2021; Custodio, Ferreira, & Matos, 2013). Consequently, the effects of CEO career variety are contingent upon strategic fit and governance quality, yielding benefits when monitoring and incentives align, but harms when discretion is unchecked (Schmid & Mitterreiter, 2021a; Peng & Chiu, 2022). Overall, a theoretically grounded view treats CEO career variety as a multidimensional construct whose net impact depends on how its inter-firm, industry, functional, and international facets interact with organizational context and institutional conditions.

Hypothesis Development

We argue that CEO career variety mitigates investment inefficiency by broadening the scope of information, deepening access to networks for capital and expertise, and integrating cross-functional capital budgeting discipline. Karaevli and Tim Hall (2006) find that CEOs with diverse career variety accumulate knowledge and acquire a broad set of skills. This enables them to integrate various resources effectively, making critical decisions (Guan et al., 2016). These mechanisms operate through improved project screening, calibrated risk-taking, and tighter post-investment monitoring, which collectively reduce overinvestment during hot markets and underinvestment in the face of financing frictions.

Agnihotri and Bhattacharya (2021) contend that CEOs with career experiences spanning multiple industries may possess broader cognitive perspectives; however, such career breadth can also undermine attention to firm-specific details, weaken stakeholder embeddedness, and reduce organizational commitment, thereby contributing to shorter executive tenures (Schmid & Mitterreiter, 2021b). Moreover, when governance is weak, diverse experience may further exacerbate managerial discretion and diffuse strategic attention, increasing the likelihood of-

Table 1. Sample Selection Criteria

Description	Total
Companies listed on IDX from 2018 to 2021	3,170
Less:	
SIC 6	585
Missing data: CEOCARVAR	1,396
Missing data: INVEFF	157
Missing data: Control variables	91
Final Sample	941

inefficient investment outcomes, particularly overinvestment when CEO power is insufficiently constrained. Consequently, the value of CEO career variety is contingent upon governance quality and CEO–firm fit, a condition that is especially critical for long-term, capital-intensive investment decisions.

A lack of attention to detail among CEOs with diverse career experiences can lead to inaccurate projections and hidden risks, ultimately impacting investment decisions. Agnihotri and Bhattacharya (2021) find that the knowledge and skills CEOs acquire from various industries may not be directly applicable to investment decisions in their current firm, leading to heightened performance demands and an inability to build relationships with stakeholders. In developing countries such as Indonesia, where political connections are critical for success in dynamic and uncertain business environments (Harymawan & Nowland, 2016), CEOs' inability to establish relationships with stakeholders can significantly hinder their ability to secure capital resources, government connections, and information networks essential for investment decision-making (Schmid & Wurster, 2017). Therefore, this study argues that CEOs with a high degree of career variety face challenges in achieving optimal investment, as outlined in the following hypothesis:

H₁: CEO with more varied careers tend to have lower investment efficiency levels.

Methods

The population of this study is non-financial companies listed on the IDX during the 2018-2021 period. The sample period spans from 2018, taking into account the impact of the Otoritas Jasa Keuangan (OJK) or Indonesian Financial Services Authority Circular Letter No.30/SEOJK.04/2016 on the format and content of annual reports from public companies, as well as the Presidential Regulation of the Republic of Indonesia No.20 of 2018 regarding

the use of foreign workers. This time frame is expected to provide researchers with a more comprehensive and diverse dataset for analyzing CEO career variety. This study excludes companies in the financial sector (SIC 6) due to their distinct investment nature. This study also excludes samples with missing data due to their incomplete record of the CEO's career, resulting in 941 firm-year observations. The details of the sample selection criteria are presented in Table 1.

Furthermore, investment efficiency is characterized by the absence of distortions such as underinvestment or overinvestment, where no deviation from the expected investment level can foster investment efficiency (Huang, 2020). In measuring the level of investment efficiency, companies must first determine the abnormal investment value, which represents the deviation of their investment level from the expected investment level (Huang, 2020; Biddle, 2009; Ngelo et.al, 2022). This abnormal investment is quantified by calculating the residual value from a regression model, which is estimated using industry-year data, as outlined in the following model 1:

$$INVEFF_{i,t} = \beta_0 + \beta_1 MTB_{i,t-1} + \beta_2 SG_{i,t-1} + \beta_3 FCF_{i,t} + \beta_4 LEV_{i,t-1} + \beta_5 LOGSALES_{i,t-1} + Industry Dummies + Year Dummies + \varepsilon_{i,t} \quad (1)$$

Description:

INVEFF	= Total capital expenditure and R&D expenses divided by initial assets
MTB	= Market-to-book ratio, which is measured by subtracting the total value of assets from the book value of the common share and adding the market value of the common share, then dividing by the total assets.
SG	= Sales growth, which is calculated by subtracting the number of sales from the previous year's sales, and dividing by the previous year's sales
FCF	= Free cash flow, which is calculated by dividing the total operating cash flow by total assets
LEV	= Leverage calculated by dividing total debt by total assets
LOGSALE	= Natural logarithm of the firm's total sales

The residual value derived from the regression equation represents the disparity between the actual investment made and the investment value that the company should have made. To further refine this measurement, we follow the approach outlined in a prior study (Chen et al., 2011) by taking the absolute value of the residual. According to Liu & Tian (2021), a larger absolute residual value indicates less efficient investment project engagement. In our analysis, we multiply the residual value by a negative one, as suggested by Ngelo et al. (2022), to ensure that the resulting value is negative. This transformation facilitates easier interpretation and allows a positive value to represent higher investment efficiency.

Table 2. Operational Definition

Dependent Variables	Code	Measurement	Source
Investment Efficiency	INVEFF	The residual value of Huang's (2020) regression model, which has been the absolute value and multiplied by -1. This variable shows the value of investment efficiency.	OSIRIS
R&D Investment	RDSAL	R&D expense divided by total sales.	OSIRIS
	LNRD	Natural logarithm from R&D expense.	OSIRIS
Independent Variables	Code	Measurement	Source
CEO Career Variety	CEOCARVAR	The number of work experiences in different industrial sectors, different companies, different functional areas, and different countries before serving as a CEO in the focal company is divided by the number of years the individual worked before serving as a CEO in the focal company.	Annual report, company website, Dun & Bradstreet, Bloomberg
Controls Variables	Code	Measurement	Source
CEO Gender	CEOGENDER	An indicator variable takes the value of one if the CEO is male, zero if the CEO is female.	Annual report
CEO Local	CEOLOCAL	An indicator variable takes the value one if the CEO's nationality is the same as the country of the focal firm, zero otherwise.	Annual report
Number of Company Boards	BOARDSIZE	The number of the company's board of commissioners and board of directors	Annual report
Number of Independent Commissioners	INDCOMSIZE	Percentage of independent commissioners compared to the board of commissioners.	Annual report
Company Size	FSIZE	Natural logarithm of the market value of equity.	OSIRIS
Return on Assets	ROA	EBIT divided by total assets.	OSIRIS
Leverage	LEV	Total debt divided by total assets.	OSIRIS
Firm Loss	LOSS	An indicator variable takes the value one if the firm has a negative net income, zero otherwise.	OSIRIS
Liquidity Constraint	LIQUID	An indicator variable takes the value one if the firm has a negative operating cash flow, zero otherwise.	OSIRIS
SGA Expense	SGA	SGA expense divided by total sales.	OSIRIS
Dividend	DIV	An indicator variable takes the value one if the firm paid a dividend, zero otherwise.	OSIRIS

On the other hand, CEO career variety is defined as the breadth of work experience an executive has had before undertaking the CEO position in the local firm (Crossland et al., 2014). This study extends the measurement of CEO career variety used by Crossland et al. (2014) by adding career experience based on the number of countries. Thus, in this study, CEO career variety is measured by summing the different industries, companies, functional areas, and countries where the CEO has worked before assuming the position in the focal firm. The sum is then divided by the years spent in their professional career before becoming CEO of the focal firm.

The data on CEO career variety was collected manually (hand-collected). Following the guidelines outlined by Crossland et al. (2014), this study excluded samples with incomplete CEO job histories to ensure the integrity of the data. The CEO job histories were categorized into four distinct groups: industry, company, function, and country. To quantify career variety based on industries, this study utilized a set of 10 one-digit SIC (Standard Industrial Classification) codes, as suggested by Schmid & Mitterreiter (2021a). Additionally, the study divided the functional areas into eight distinct categories, mirroring the approach taken by Crossland et al. (2014): (1) production/operation, (2) R&D/technical, (3) accounting/finance, (4) management/administration, (5) marketing/sales, (6) HR/employee relations, (7) law, and (8) other functional areas. Furthermore, career variety was calculated based on company and country by counting the number of job histories in different companies and countries, respectively.

This study uses control variables based on previous research. The study uses CEO gender (CEOGENDER) and CEO local (CEOLOCAL) to capture CEO characteristics (Harymawan et al., 2020; Lai et al., 2020). CEO gender controls for differences in managerial behavior, while CEO local reflects familiarity with local business environments. Board size (BOARDSIZE) and independent commissioner size (INDCOMSIZE) represent corporate governance characteristics, controlling for board oversight capacity and monitoring independence (Harymawan et al., 2020). Firm characteristics include company size (FSIZE), return on assets (ROA), leverage (LEV), company losses (LOSS), liquidity (LIQUID), selling, general, and administrative expenses (SGA), and dividends (DIV) (Gan, 2019; Lu-Andrews & Yu-Thompson, 2015; Ngelo et al., 2022; Ullah et al., 2022). These variables control for firm scale, profitability, capital structure, financial condition, operational efficiency, and payout policy. Year and industry fixed effects are included to control for macroeconomic fluctuations and sectoral differences (Bae et al., 2017; Ratri et al., 2021). The operational definitions and measurements of each variable are explained in Table 2.

Finally, this study will examine the relationship between CEO career variety and investment efficiency. Investment efficiency serves as the dependent variable measured by Equation (1), while several firm-level controls and fixed effects are included. This equation is estimated using a clustered regression approach, which adjusts the standard errors for potential correlations of residuals within firms over time, ensuring more reliable statistical inference following Petersen (2009). We use regression analysis with the following model 2:

$$INVEFF_{i,t} = \alpha_1 + \beta_1 CEOCARVAR_{i,t} + \beta_2 CEOGENDER_{i,t} + \beta_3 CEOLOCAL_{i,t} + \beta_4 BOARD SIZE_{i,t} + \beta_5 INDCOMSIZE_{i,t} + \beta_6 FSIZE_{i,t} + \beta_7 ROA_{i,t} + \beta_8 LEV_{i,t} + \beta_9 LOSS_{i,t} + \beta_{10} LIQUID_{i,t} + \beta_{11} SGA_{i,t} + \beta_{12} DIV_{i,t} + \beta_{13} Year\ Fe_{i,t} + \beta_{14} Industry\ Fe_{i,t} + \varepsilon_{i,t} \quad (2)$$

Result and Discussion

Descriptive Statistics and Univariate Analysis

Panel A of Table 3 shows the sample distribution of the study based on industry and year. From Panel A, it can be observed that the number of samples tends to increase from year to year, except in 2020, the first year of the COVID-19 pandemic, which caused delays in the submission of annual reports to authorities and resulted in a decrease in the amount of financial data available in OSIRIS for that year. The research sample is dominated by companies in the food and furniture manufacturing industry (SIC 2) with 242 observations. This data supports Kiki Verico's statement in Darisman (2022) that Indonesia is dominated by the manufacturing industry, especially food and beverage. On the other hand, the lowest research sample comes from the service industry in law, health, and social services (SIC 8), with only 36 observations.

Table 3. Sample Distribution of Panel A

Panel A. Sample Distribution Based on Year and Industries					
Industry	Year				Total
	2018	2019	2020	2021	
Agriculture, forestry, fishing (SIC 0)	12	10	9	13	44
Mining and construction (SIC 1)	26	30	25	28	109
Food and furniture manufacturing (SIC 2)	59	64	56	63	242
Metal and equipment manufacturing (SIC 3)	36	40	31	36	143
Transportation and public utilities (SIC 4)	35	40	41	48	164
Retail and wholesale trade (SIC 5)	22	29	28	35	114
Business, hotel, and amusement services (SIC 7)	22	22	19	26	89
Law, health, and social services (SIC 8)	8	10	9	9	36
Total	220	245	218	258	941

Table 4. Sample Distribution of Panel B

Panel B. Sample Distribution Based on Industry and Under/Over Investment			
Industry	Underinvestment	Overinvestment	Total
Agriculture, forestry, fishing (SIC 0)	29	15	44
Mining and construction (SIC 1)	65	44	109
Food and furniture manufacturing (SIC 2)	129	113	242
Metal and equipment manufacturing (SIC 3)	103	40	143
Transportation and public utilities (SIC 4)	111	53	164
Retail and wholesale trade (SIC 5)	49	65	114
Business, hotel, and amusement services (SIC 7)	35	54	89
Law, health, and social services (SIC 8)	27	9	36
Total	548	393	941

Table 5. Descriptive Statistics

	Mean	Median	Minimum	Maximum
INEFF	-0.001	-0.000	-0.016	-0.000
CEOCARVAR	0.594	0.478	0.125	4.500
CEOGENDER	0.911	1.000	0.000	1.000
CEOLOCAL	0.874	1.000	0.000	1.000
BOARDSIZE	8.531	8.000	4.000	18.000
INDCOMSIZE	0.410	0.375	0.167	0.800
FSIZE	28.228	28.176	24.346	33.128
ROA	0.056	0.048	-0.282	0.523
LEV	0.539	0.485	0.039	2.915
LOSS	0.305	0.000	0.000	1.000
LIQUID	0.211	0.000	0.000	1.000
SGA	0.148	0.090	0.006	1.028
DIV	0.497	0.000	0.000	1.000
RDSAL	0.000	0.000	0.000	0.014
LNRD	2.824	0.000	0.000	24.435

Panel B of Table 4 shows the sample distribution based on the tendency of inefficient investment (underinvestment or overinvestment) in each industry. From Panel B, underinvestment happened in the agriculture, forestry, and fishing industry (SIC 0), mining and construction industry (SIC 1), manufacturing industry (SIC 2 & 3), transportation and public utilities industry (SIC 4), and law, health, and social services (SIC 8). Conversely, in the retail and wholesale trade industry (SIC 5) and business, hotel, and entertainment services (SIC 7), most of the research samples tend to indicate overinvestment.

The results of the descriptive analysis are presented in Table 5. The average residual value for investment efficiency measurement is -0.000, which means that, on average, the

companies in this research sample tend to experience underinvestment. This result supports the information in Table 3, where 58% of the total sample (548 observations) are companies that tend to experience underinvestment. Meanwhile, the INVEFF value, which is the absolute value of the residual multiplied by -1, has a minimum value of -0.016 and a maximum value of -0.000.

Pearson Correlation

Table 6 shows the results of the Pearson correlation test. From the table, CEOCARVAR has a positive but not significant correlation with INVEFF. One possible explanation for the insignificant relationship between CEOCARVAR and INVEFF is that other factors of INVEFF need to be controlled in the analysis to measure the relationship between CEOCARVAR and INVEFF more clearly. Unfortunately, Pearson correlation cannot capture this because the test only looks at the linear relationship between two variables. Therefore, a multivariate test is used to answer the research question, specifically, regression analysis, which is further shown in this research. The Pearson correlation matrix also shows that no pairwise correlation exceeds 0.8, indicating no serious multicollinearity issues among independent variables. This is further confirmed through the Variance Inflation Factor (VIF) test, where all values remain below the commonly accepted threshold of 5.

Regression Analysis

The regression analysis using the cluster approach (Petersen, 2009) in Table 7 demonstrates that CEOCARVAR has a significantly negative effect on INVEFF at the 5% significance level (coefficient = -0.023, t -value = -1.97), leading to the acceptance of the Alternate Hypothesis (H_1). This finding suggests that higher CEO career variety is associated with lower investment efficiency. The result aligns with prior studies showing that CEOs with extensive career variety may exhibit less attention to detail (Schmid & Mitterreiter, 2021b), leading to inaccurate forecasts and the omission of critical factors, potentially embedding latent risks in future investment projects. Agnihotri and Bhattacharya (2021) also note that the knowledge and skills gained from diverse industries may not be directly applicable to the investment needs of the current firm, creating a mismatch between expertise and strategic requirements. Furthermore, CEOs with highly varied careers may have weaker proximity to key stakeholders and demonstrate lower firm commitment (Schmid & Mitterreiter, 2021b), making it harder to leverage elite networks that could secure high-quality investment opportunities (Schmid & Wurster, 2017).

Table 6. Pearson Correlation

		[1]	[2]	[3]	[4]	[5]	[6]
[1]	INVEFF	1.000					
[2]	CEOCARVAR	0.002 (0.945)	1.000				
[3]	CEOGENDER	0.021 (0.517)	-0.142*** (0.000)	1.000			
[4]	CEOLOCAL	0.164*** (0.000)	0.080** (0.015)	-0.052 (0.112)	1.000		
[5]	BOARDSIZE	-0.122*** (0.000)	-0.142*** (0.000)	0.013 (0.699)	-0.120*** (0.000)	1.000	
[6]	INDCOMSIZE	-0.071** (0.030)	0.023 (0.481)	-0.004 (0.892)	0.020 (0.542)	-0.200*** (0.000)	1.000
[7]	FSIZE	-0.232*** (0.000)	-0.099*** (0.002)	0.005 (0.884)	0.012 (0.714)	0.561*** (0.000)	-0.006 (0.854)
[8]	ROA	-0.306*** (0.000)	-0.060* (0.066)	-0.065** (0.047)	-0.034 (0.300)	0.218*** (0.000)	0.063* (0.052)
[9]	LEV	0.036 (0.275)	-0.029 (0.376)	0.067** (0.041)	-0.010 (0.759)	-0.058* (0.076)	-0.023 (0.482)
[10]	LOSS	0.108*** (0.001)	0.047 (0.149)	0.045 (0.163)	-0.033 (0.317)	-0.188*** (0.000)	-0.021 (0.529)
[11]	LIQUID	0.108*** (0.001)	-0.017 (0.602)	0.071** (0.030)	-0.030 (0.358)	-0.131*** (0.000)	0.015 (0.650)
[12]	SGA	-0.111*** (0.001)	0.043 (0.186)	-0.043 (0.190)	-0.108*** (0.001)	0.015 (0.654)	0.005 (0.885)
[13]	DIV	-0.127*** (0.000)	-0.155*** (0.000)	-0.024 (0.462)	0.020 (0.533)	0.374*** (0.000)	-0.048 (0.142)

		[7]	[8]	[9]	[10]	[11]	[12]	[13]
[7]	FSIZE	1.000						
[8]	ROA	0.403*** (0.000)	1.000					
[9]	LEV	-0.133*** (0.000)	-0.147*** (0.000)	1.000				
[10]	LOSS	-0.338*** (0.000)	-0.556*** (0.000)	0.308*** (0.000)	1.000			
[11]	LIQUID	-0.244*** (0.000)	-0.250*** (0.000)	0.105*** (0.001)	0.222*** (0.000)	1.000		
[12]	SGA	0.002 (0.952)	0.083** (0.011)	0.277*** (0.000)	0.094*** (0.004)	-0.016 (0.630)	1.000	
[13]	DIV	0.456*** (0.000)	0.426*** (0.000)	-0.197*** (0.000)	-0.447*** (0.000)	-0.229*** (0.000)	0.025 (0.451)	1.000

Note. *p*-values in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7. Regression Results for CEO Career Variety and Investment Efficiency

Variables	Coefficient	t-value
CEOCARVAR	- 0.023**	- 1.97
CEOGENDER	0.018	0.58
CEOLOCAL	0.074**	2.37
BOARDSIZE	0.002	0.56
INDCOMSIZE	0.123	- 1.42
FSIZE	- 0.029***	- 4.58
ROA	- 0.520***	- 3.87
LEV	0.024	1.26
LOSS	- 0.050***	- 2.61
LIQUID	0.030**	2.41
SGA	- 0.174***	- 2.91
DIV	0.029*	1.68
Constant	0.671***	3.74
Year Fixed Effects	Yes	
Industry Fixed Effects	Yes	
R ²	0.335	
Adjusted R ²	0.319	
Observations	941	

Note. The dependent variable is investment efficiency (INVEFF). *t*-statistics are reported in the third column. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

In the Indonesian context, these challenges are magnified. Indonesia's business environment is characterized by intense market competition, uncertainty, and relatively high investment risk. Failed investments are often viewed as a waste of scarce resources, reducing competitiveness (Agnihotri & Bhattacharya, 2021) and damaging a CEO's reputation, particularly in emerging markets where resource constraints are more severe (Chen et al., 2018). Moreover, the relatively low level of corporate transparency in Indonesia exacerbates information asymmetry, making accurate risk–return assessment for investments more difficult. In such an environment, CEOs with diverse career backgrounds may be more risk-averse, potentially opting to limit investment activity due to lower confidence in their ability to evaluate projects precisely and weaker access to influential local networks.

From a theoretical perspective, these findings extend the upper echelons theory (Hambrick & Mason, 1984) by showing that CEO career variety, while often associated with broader perspectives and strategic adaptability, can also introduce decision-making constraints in certain institutional contexts. In markets characterized by weak transparency and high uncertainty, the potential drawbacks of career variety (reduced detail orientation,

weaker stakeholder ties) may outweigh its informational benefits. This underscores the need to consider contextual moderators, such as governance quality, market maturity, and local relationship norms, when applying upper echelons theory to explain executive decision-making and capital allocation outcomes.

From a practical standpoint, the results carry several important implications. First, for boards of directors, CEO selection should weigh not only the breadth of a candidate's prior experience but also its relevance to the firm's industry, market, and governance environment. In emerging markets like Indonesia, deep firm-specific or industry-specific knowledge and strong local networks may be more critical to investment success. Second, governance and oversight mechanisms—including rigorous capital budgeting processes, independent board review, and post-investment audits—should be emphasized to counteract potential inefficiencies under CEOs with high career variety. Third, capacity-building programs such as targeted training or mentoring can help bridge gaps between a CEO's past experience and the firm's specific investment context. Finally, investors and analysts should incorporate CEO career profiles into their assessments of firm investment strategies, especially in environments with high information asymmetry, as these profiles can influence investment aggressiveness, capital allocation discipline, and long-term value creation.

Robustness Test of Coarsened Exact Matching (CEM)

Endogeneity can arise when the observation sample lacks homogeneity, introducing sample selection bias (Nasih et al., 2022). In business and management studies, matching methods, such as CEM regression, are commonly employed to address this issue (Blackwell et al., 2009; Nasih et al., 2022). This study divides the sample into treatment and control groups based on the median value of the independent variable as suggested by Nasih et al. (2022). The CEOCARVAR variable is converted into an indicator variable, D_CARVAR, where 1 represents CEOs with varied careers above the median score and 0 represents those below. Each observation in the treatment group is matched with a control group observation based on continuous control variables (BOARDSIZE, INDCOMSIZE, FSIZE, ROA, LEV, SGA) stratified into five groups, as described in Harymawan et al. (2022). The matching results are summarized in Table 8 below. The CEM test confirms the main analysis, revealing a negative and significant relationship between CEO career variety and firm investment efficiency (coefficient = -0.021, t -value = -2.31).

Table 8. CEM Result of The Relationship Between The CEO's Career Variety and Investment Efficiency

Matching Summary (2018 – 2021)		
	D_CARVAR = 0	D_CARVAR = 1
All	473	468
Matched	344	361
Unmatched	129	107
Variables	Coefficient	t-value
CEOCARVAR	- 0.021**	- 2.31
CEOGENDER	- 0.031*	- 1.68
CEOLOCAL	0.067**	2.40
BOARDSIZE	0.009***	2.99
INDCOMSIZE	0.019	0.29
FSIZE	- 0.020***	- 3.17
ROA	- 0.626***	- 2.66
LEV	- 0.041	- 1.47
LOSS	- 0.049**	- 2.13
LIQUID	0.020*	1.77
SGA	- 0.265**	- 2.12
DIV	0.033**	2.19
Constant	0.420**	2.31
Year Fixed Effects		Yes
Industry Fixed Effects		Yes
R ²		0.306
Adjusted R ²		0.284
Observations		705

Note. *t*-statistics are reported in the third column. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Heckman Two-Stage Regression

The second robustness analysis focuses on unobserved variable issues, ensuring that the error term does not correlate with dependent variables. One commonly used approach to address this issue is Heckman's two-stage regression (Harymawan et al., 2022). In the context of the relationship between CEO career variety and investment efficiency, an instrumental variable can be used to control the effect of unobserved CEO characteristics that may affect both CEO career variety and investment efficiency. Therefore, this study used incremental CEO career variety (INC_CARVAR) as an instrumental variable. INC_CARVAR measures how much above or below the industry-year norm the individual CEO's career variety is.

This difference can provide insight into how a CEO's career variety compares yearly to others in their industry.

Our Heckman's two-stage regression result is provided in Table 9. The first-stage regression shows that INC_CARVAR has a statistically significant relationship with D_CARVAR (coefficient = 15.525, t -value = 9.35). Conversely, in the second regression stage, we find a negative relationship between CEOCARVAR and INVEFF (coefficient = -0.029, t -value = -2.29). The inverse Mills' ratio (MILS) shows insignificant results on INVEFF (coefficient = -0.004, t -value = -0.80). The result confirms that our model did not experience endogeneity issues, especially with unobserved variables.

Table 9. Heckman's Two-Stage Regression Result of The Relationship Between CEO Career Variety and Investment Efficiency

Variables	First Stage		Second Stage	
	(1) D_CARVAR		(2) INVEFF	
	Coefficient	t -value	Coefficient	t -value
INC_CARVAR	15.525***	9.35		
CEOCARVAR			- 0.029**	- 2.29
CEOGENDER	0.417	1.33	0.017	0.54
CEOLOCAL	- 0.270	- 1.27	0.076**	2.40
BOARDSIZE	- 0.033	- 0.88	0.002	0.66
INDCOMSIZE	- 1.816***	- 2.63	- 0.118	- 1.39
FSIZE	0.031	0.56	- 0.029***	- 4.63
ROA	- 0.044	- 0.04	- 0.521***	- 3.88
LEV	- 0.467*	- 1.86	0.025	1.33
LOSS	0.067	0.27	- 0.051***	- 2.63
LIQUID	0.298*	1.66	0.030**	2.36
SGA	- 1.701***	- 3.44	- 0.173***	- 2.91
DIV	0.011	0.05	0.029*	1.69
MILS			- 0.004	- 0.80
Constant	- 0.169	- 0.10	0.681***	3.78
Year Fixed Effects		Yes		Yes
Industry Fixed Effects		Yes		Yes
R ² _pseudo		0.778		-
R ²		-		0.335
Adjusted R ²		-		0.319
Observations		941		941

Note. t -statistics are reported in the third column. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

The Relationship Between CEO Career Variety and Investment Efficiency in Under/Over Investment Firms

To further investigate the relationship between CEO career variety and investment efficiency, this study divided the sample firms based on their tendency towards investment inefficiency, namely underinvestment and overinvestment (Huang, 2020; Ngelo et al., 2022). Underinvestment is a condition where a company's actual investment level is lower than optimal. Conversely, overinvestment is when a company's existing investment level is higher than optimal (Chen & Lin, 2013; Gan, 2019; Ullah et al., 2020). Table 10 shows the results of the relationship between CEO career variety and investment efficiency in under (over) companies. The results show that in underinvestment companies, CEO career variety is negatively and significantly related to investment efficiency (coefficient = -0.046, t -value = -3.29).

Table 10. The Regression Result of The Relationship Between CEO Career Variety and Investment Efficiency Under/Over Investment Firms

	Underinvestment Firms			Overinvestment Firms	
	(1) INVEFF			(2) INVEFF	
Variables	Coefficient	t -value		Coefficient	t -value
CEOCARVAR	- 0.046***	- 3.29		0.052*	1.66
CEOGENDER	- 0.026	- 1.50		0.049	0.80
CEOLOCAL	0.090**	2.17		0.076	1.56
BOARDSIZE	0.009***	2.91		- 0.003	- 0.53
INDCOMSIZE	- 0.008	- 0.09		- 0.110	- 0.85
FSIZE	- 0.032***	- 5.37		- 0.029**	- 2.38
ROA	- 0.441***	- 2.65		- 0.620***	- 3.03
LEV	- 0.039	- 1.41		0.078**	2.43
LOSS	- 0.058**	- 2.15		- 0.067**	- 2.44
LIQUID	0.044***	2.79		0.023	1.10
SGA	0.037	0.78		- 0.429***	- 3.60
DIV	0.038*	1.84		0.010	0.34
Constant	0.736***	4.41		0.619*	3.78
Year Fixed Effects		Yes			Yes
Industry Fixed Effects		Yes			Yes
R ²		0.381			0.370
Adjusted R ²		0.355			0.333
Observations		548			393

Note. t -statistics are reported in the third column. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Conversely, in overinvestment companies, CEO career variety is positively and significantly related to investment efficiency (coefficient = 0.052, t -value = 1.66). These results indicate that CEOs with more varied careers tend to be involved in lower investments that are useful in mitigating overinvestment, thus driving higher investment efficiency. This is caused by their inability to gather power and the connection that comes from the minimum intention to build a relationship with stakeholders (Schmid & Wurster, 2017). It brings them to be more conservative in overinvestment or underinvestment since they tend to pay less attention to detail, have less intense stakeholder relationships, and lower commitment to the firm, resulting in short tenure (Schmid & Mitterreiter, 2021b). However, investment efficiency is more possible when the CEO has accuracy in their analysis of investments, gathers important connections, especially with stakeholders, and has a long-term commitment because the investment project could be multi-year.

Table 11. The Regression Result of The Relationship Between CEO Career Variety and R&D Investment

(1) LNRD				(2) RDSAL	
Variables		Coefficient	t-value	Coefficient	t-value
CEOCARVAR	-	0.698**	- 2.52	- 0.013**	- 1.97
CEOGENDER	-	0.607	- 0.80	- 0.053	- 1.62
CEOLOCAL	-	0.242	- 0.29	- 0.051*	- 1.83
BOARDSIZE		0.310***	3.17	0.005*	1.80
INDCOMSIZE		4.659**	2.25	0.263***	3.05
FSIZE		0.368**	2.11	0.012**	2.14
ROA		3.652	1.22	0.204**	2.05
LEV	-	0.861	- 1.47	- 0.049***	- 3.22
LOSS		0.362	0.64	0.030**	2.04
LIQUID		0.125	0.24	- 0.004	- 0.39
SGA		5.276***	3.67	0.194***	3.66
DIV		1.091**	1.99	- 0.006	- 0.44
Constant	-	10.789**	- 2.29	- 0.346**	- 2.04
Year Fixed Effects			Yes		Yes
Industry Fixed Effects			Yes		Yes
R ²			0.138		0.142
Adjusted R ²			0.117		0.121
Observations			941		941

Note. The dependent variables are LNRD and RDSAL. t -statistics are reported in the third column.

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 12. The Regression Result of The Relationship Between CEO Career Variety and Investment Efficiency Used a Lead-Lagged Model

Panel A Lead model	(1) INVEFF_{t+1}	Panel B Lagged model	(2) INVEFF
CEOCARVAR	- 0.032* - (1.66)	CEOCARVAR _(t-1)	- 0.032* - (1.66)
CEOGENDER	0.022 (0.54)	CEOGENDER _(t-1)	0.021 (0.52)
CEOLOCAL	0.061 (1.50)	CEOLOCAL _(t-1)	0.062 (1.51)
BOARDSIZE	0.001 (0.22)	BOARDSIZE _(t-1)	0.001 (0.24)
INDCOMSIZE	- 0.088 - (0.86)	INDCOMSIZE _(t-1)	- 0.095 - (0.92)
FSIZE	- 0.029*** - (3.81)	FSIZE _(t-1)	- 0.029*** - (3.83)
ROA	- 0.819*** - (3.88)	ROA _(t-1)	- 0.803*** - (3.83)
LEV	0.018 (0.66)	LEV _(t-1)	0.018 (0.68)
LOSS	- 0.074*** - (2.75)	LOSS _(t-1)	- 0.076*** - (2.82)
LIQUID	0.014 (0.70)	LIQUID _(t-1)	0.016 (0.78)
SGA	- 0.178** - (2.18)	SGA _(t-1)	- 0.173** - (2.12)
DIV	0.030 (1.43)	DIV _(t-1)	0.029 (1.38)
Constant	0.649*** (2.83)	Constant	0.667*** (2.88)
Year Fixed Effects	Yes	Year Fixed Effects	Yes
Industry Fixed Effects	Yes	Industry Fixed Effects	Yes
R ²	0.361	R ²	0.360
Adjusted R ²	0.338	Adjusted R ²	0.337
Observations	610	Observations	610

Note. *t*-statistics are reported in the third column. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

The Relationship Between CEO Career Variety and R&D Investment

To strengthen the research argument that CEO with more varied careers tend to be involved in lower investment activities, this study examines the influence of CEO career variety on a company's R&D investment. Previous literature states that R&D investment is a source of competitive advantage for growth and sustainability (Harymawan et al., 2020). On

the other hand, R&D investment is an activity with high uncertainty and potential failure (Guldiken & Darendeli, 2016). Previous studies indicate that firm-specific knowledge (Wang et al., 2009) and industry-specific knowledge (Faleye et al., 2018) that the CEO possess is crucial in helping companies determine efficient R&D investments. Supporting Agnihotri & Bhattacharya (2021) and Chahyadi et al. (2021), this study found that CEOs with more varied careers are involved in lower R&D investments. Thus, these findings reinforce the research argument that CEOs with more varied careers have a less in-depth understanding of the company's firm-specific knowledge and the relevant industry-specific knowledge.

The research conducted by Gan (2019), Jin & Yu (2018), and Rajkovic (2020) used a lagged model to investigate the influence of CEO managerial ability on investment efficiency. The reason is that companies generally prepare investment budgets at the beginning of the fiscal year. Therefore, using a lead-lagged model, this study examines the relationship between CEO career variety and investment efficiency as presented in Table 11. Panel A of Table 12 shows the test results using the lead model, while Panel B uses the lagged model. Using both the models in Panel A and Panel B, the test results indicate that CEO career variety is negatively and significantly related to investment efficiency. In other words, the test results are consistent with the main finding that CEOs with more varied careers drive lower investment efficiency.

Conclusion and Suggestion

This study investigates the relationship between CEO career variety and investment efficiency in non-financial firms listed on the Indonesia Stock Exchange during the 2018–2021 period. Using established measures of CEO career variety and addressing endogeneity concerns through Coarsened Exact Matching and Heckman's two-stage regression, the findings consistently show that greater CEO career variety is associated with lower investment efficiency. These results contribute to the growing literature on executive characteristics and investment decisions by providing robust evidence from an emerging market context.

The findings extend upper echelons theory by demonstrating that the benefits of diverse career experiences are context-dependent. In institutional environments characterized by high uncertainty and limited transparency, such as Indonesia, broad career variety may dilute firm-specific knowledge and weaken stakeholder embeddedness, thereby constraining effective investment decision-making. This study thus highlights the importance of aligning executive

career backgrounds with organizational and institutional demands, rather than assuming that greater experiential breadth universally enhances managerial effectiveness.

From a practical perspective, the results offer guidance for boards, investors, and policymakers by emphasizing the need to evaluate the relevance of CEOs' prior career experiences when making executive appointments and investment assessments. While data limitations related to CEO disclosure and industry classification remain, future research could refine measurement accuracy and explore moderating factors such as governance quality, CEO–firm fit, and political connections, as well as conduct cross-country comparisons to assess the generalizability of these findings across emerging markets.

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About the Authors

Nurul Fitriani was responsible for developing the initial research concept and overall study design, and led the preparation of the original manuscript draft. She also coordinated the research process, managed project administration, and ensured the timely completion of all research activities.

Iman Harymawan provided research funding and access to essential resources, and played a key role in data curation and investigation. He supervised the research process, offered strategic guidance throughout the study, and ensured the rigor and relevance of the empirical analysis.

Norazlin Binti Ab Aziz designed the research methodology and conducted the formal statistical analyses. She was responsible for software implementation, data processing, and robustness testing, and also contributed to proofreading to enhance the technical accuracy and clarity of the manuscript.

Dirgahayu Almi Mahati contributed to manuscript review and editing, visualization of results, and validation of the findings. She provided critical feedback across all stages of the research, ensured coherence between theory and empirical results, and supported the overall quality and consistency of the study.