GENDER DIVERSITY AND INTELLECTUAL CAPITAL EFFICIENCY OF LISTED MANUFACTURING FIRMS IN NIGERIA

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Abstract
Gender diversity has emerged as a strategic human-capital lever capable of shaping firms' knowledge productivity and value-creation outcomes. This study investigates how gender-balanced board and managerial structures influence intellectual capital efficiency among listed manufacturing firms in Nigeria's evolving industrial landscape from 2013 to 2022. This study adopts an ex-post facto research design, with a population of 66 manufacturing firms listed in the Nigerian Exchange Group as of 2012 and has not been delisted as of 31st December 2021, and 17 firms were selected through a purposive sampling technique. The ICE measurements derive from the Modified Value-Added Intellectual Coefficient (MVAIC) model. Research findings indicate that;combined explanatory variable accounted for approximately 30% (R^2 = 0.2297) of the variation in ICE,asFemale Chairperson (FC) is weakly and positively significant with ICE (β = 3.447, p = 0.065);female audit committee members (Fa) demonstrated a significant negative relationship with ICE (β = -8.645, p = 0.006);Female Directors (FD) had a negative but weak effect on ICE (β = -14.061, p = 0.055) and female CEO had a significant negative effect on intellectual capital effectiveness (ICE) (β = -8.457, p = 0.003). firm size has positive significant control effect (β=6.037,p=0.005) as firm age had negative but significant control effect on ICE (β=-0.481,p=0.000).In conclusion, this study reveals that female leadership positions at the head of manufacturing firms in Nigeria display weak positive relations toward ICE. The study recommends, among other things, that firms should entrench policies to make females more effective in leadership.

Keywords: Female CEO, female chairperson, female director, female audit committee, gender diversity and intellectual capital efficiency

1.0 Introduction

Increases in business sophistication and international competition have led to firms turning towards leveraging their intangible assets, primarily intellectual capital, as a tool for the enhancement of efficiency and sustaining long-term growth. Intellectual capital efficiency (ICE) has become a significant driver of firm performance, given that it depicts the effectiveness with which companies manage to utilize their human, structural, and relational capital to produce value. In manufacturing firms, where the efficiency of production, innovation, and technological improvement are the paramount determinants, effective ICE plays a pivotal role in achieving sustainable competitive advantages (Kweh et al., 2019). Though necessary, empirical works on the determinants of ICE, particularly corporate governance structures' contribution, remain limited in emerging economies like Nigeria. The manufacturing industry in the country faces a wide range of issues, such as unstable economic conditions, regulatory problems, and harsh market competition that need strategic management of intellectual capital. Board diversity, a good corporate governance practice, can be very effective in promoting ICE development through efficient resource allocation, innovation, and long-term sustainability (Mani et al., 2023).

Board diversity, primarily female on the corporate boards, has recently come under a stream of interest. This is in the belief that it affects firms' decision-making, risk, and firm-level performance (McGuinness et al., 2020; Obiora,P.E. 2021). It helps improve corporate governance by adding perspective, enhancing controls over finance, and preventing agency problems (Nadeem et al., 2017). The presence of female members on boards, including board chairs, directors, CEOs, and audit committee members, has been linked to greater transparency, ethical financial management, and better strategic decision-making. Female leaders are risk-averse and stakeholder-focused and therefore can bring beneficial influences on corporate policy and performance results (Chijoke-Mgbame et al., 2020). In Nigeria, the drive for gender representation on corporate boards has been gradual but ongoing, with regulatory institutions and parties calling for greater inclusive leadership compositions. The Nigerian Code of Corporate Governance promotes board diversity; yet cultural and structural hindrances persist in preventing the greater inclusion of female in top management (Ibrahim & Hamza, 2022). Consequently, the extent to which board gender diversity influences ICE in Nigerian listed manufacturing firms is significant both to research and practice.

Despite the growing recognition of intellectual capital as a critical driver of firm value, most manufacturing firms in Nigeria do not possess ideal ICE, which prevents them from striving for sustainable growth and competitiveness (Ozkan et al., 2017). ICE is even more crucial in manufacturing businesses, where process efficiency, technology development, and product innovation play a major role towards business success. Inefficient corporate governance structures that are ineffective create ineffective intellectual capital usage, suppressing the ability of firms to leverage their intangible assets to achieve long-term financial performance (Xu & Liu, 2020). Corporate governance, indeed, board diversity is posited by the existing literature to enhance ICE with more engaged decision-making and financial oversight (Mani et al., 2023). It can lead to better strategic decisions, greater corporate responsibility, and innovative expansion. The Nigerian business landscape is accompanied by unique challenges like regulation management, cultural bias, and corporate governance ineffectiveness, which can propel the achievement of board diversity in enhancing ICE.

Besides, the efficiency of specific board positions, like female chairpersons, directors, CEOs, and members of the audit committee, has not been properly studied in intellectual capital management. Studies have indicated that female board members of firms in developed economies emphasize more emphasis on transparency, compliance, and stakeholder engagement, which are drivers to optimize intellectual capital (McGuinness et al., 2020).

The manufacturing industry of Nigeria is becoming more knowledge intensive and highly competitive in which sustainable performance is no longer determined by the tangible assets but rather by the effective mobilisation of intellectual assets. Compared to the well-known importance of intellectual capital efficiency (ICE) as a key factor of productivity, innovation, and long-term competitiveness among manufacturing companies, empirical data regarding the governance practices that can amplify the ICE among emerging economies are particularly limited. Nigeria is one region where this gap is a major problem since the manufacturing companies have to contend with macroeconomic instability, unpredictable regulations and stiff competition in the marketplace which requires the strategic and efficient utilization of intangible resources. Although previous researches indicate that board diversity could enhance the intellectual capital development by enhancing oversight, innovation and allocation of strategic resources, very little is known on whether and how these governance advantages would translate to the manufacturing space in Nigeria. Subsequently, companies can still be exploiting intellectual capital as it does not enable them to reach the level at which they can attain sustainable growth and global competitiveness.

The urgency of the study is also increased by the fact that Nigeria is slowly but steadily moving towards inclusiveness of corporate governance with gender. Even though the representation of women in boards has been related in other settings to increased transparency, ethical decisions and stakeholder-based strategies, which are variables that are closely related to an efficient utilisation of intellectual capital, the relevance of the findings to the situation of manufacturing within Nigerian firms, is yet to be empirically established. Women are still not allowed to serve in key board positions because of cultural, institutional and structural obstacles which cast serious apprehensions whether the available governance reforms are working well to unlock the ICE potential of manufacturing companies. In the absence of stringent research on the association between ICE and gender diversity specifically the role of women in the strategic board, policy efforts and corporate change will be symbolic and not transformational. Research into this nexus is thus practically real as it offers evidence-based reforms in governance that would help to build better intellectual capital management, improve firm competitiveness, and sustainable industrial development in Nigeria. Additionally, researching this issue can aid in creating evidence-based recommendations in corporate governance for the enhancement of gender-friendly leadership structures, fostering business sustainability.

2.0 Literature Review and Hypotheses Development

Intellectual Capital Efficiency (ICE) is defined as the ability of a business to utilize its intangible capital (human, structural, and relational capital) toward building business performance and maintaining competitive leverage (Xu & Liu, 2020). Human capital involves employees' knowledge, capabilities, and innovations, while structural capital includes in-house procedures, databases, and technologies that provide operational efficiency. Relational capital includes outside networks, partnerships, and customers that contribute to firm value (Kweh et al., 2019). High ICE in manufacturing firms guarantees greater productivity, improved innovation, and long-term profitability with the efficient utilization of such intangible resources (Onumoh et al., 2024). Despite its significance, optimal utilization of ICE remains wanting in the majority of developing nations, including Nigeria, due to poor corporate governance frameworks and poor strategic direction.

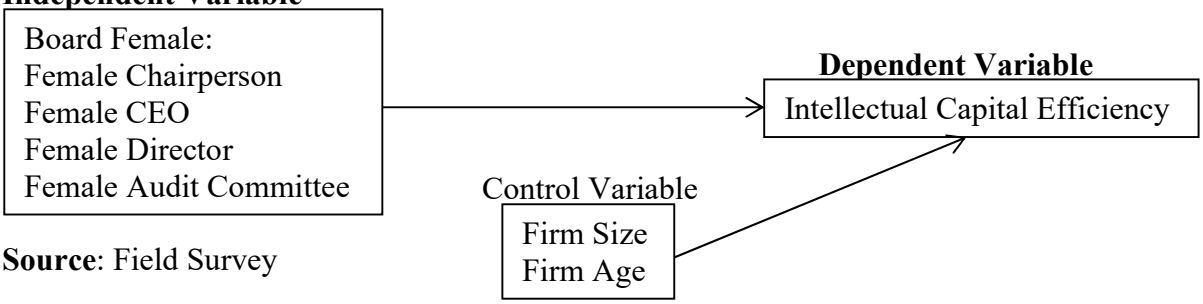
Boardroom female, who includes female in the boardroom, is a key force in shaping corporate governance practices that maximize ICE. Female directors bring distinct insights into decision-making, ethical governance, and strategic supervision, thereby influencing intellectual capital management and utilization in organizations (Chijoke-Mgbame et al., 2020). This current study examines four general categories of board female: female chairman, female director, female CEO, and female audit committee member.

A female chairperson is at the top level of the board with the leadership role, tasked with corporate governance, strategic direction, and risk management. Evidence indicates that female chairpersons demonstrate excellent ethical leadership, stakeholder orientation, and emphasis on the vision, which can help ICE by developing a knowledge creation and innovation culture (Mani et al., 2023). A female director is a member of the board and participates in corporate governance decision-making. Female CEOs are mostly attributed with greater board performance, risk management, and greater emphasis on corporate social responsibility, all of which put together help enhance ICE through maintaining transparency and accountability in knowledge management (Ozkan et al., 2017).

Overall implementation of the company's objectives is left to a female CEO. It has been studied that firms with female CEOs are more likely to pursue diversified strategies that are innovation-driven, possess robust mechanisms of knowledge sharing, and emphasize long-term value creation as the top priority (Xu & Liu, 2020). They facilitate the building of a learning and

growing corporate culture, which ultimately leads to ICE. In addition, a female member of the audit committee acts as a strong reason for fiscal control, internal management control, and risk assessment. However, female audit committee members are linked with more efficient mechanisms of compliance, improved accuracy in financial reports, and reduced earnings manipulation, all indirectly linked with intellectual capital management (Nadeem et al., 2017).

Fig. 1: Conceptual framework



Source: Field Survey

Theoretical Framework

The Resource-Based View (RBV) theory can offer a solid conceptual basis into analyzing the role of female leadership in increasing the efficiency of intellectual capital (ICE) and maintaining competitive advantage in manufacturing organizations. Basically, RBV holds that the existence of performance differentials between firms is due to the internal resources which are valuable, rare, inimitable and non-substitutable (VRIN) (Barney, 1991; Grant, 1996). The intangible resources in modern organisations, including leadership potential, governance standard, and intellectual capital, are more and more being identified as the core sources of the sustained competitive advantage and especially in knowledge-driven manufacturing settings (Al-Musalli and Ismail, 2014).

In the RBV framework, female leadership fits within the strategy of VRIN resources. Women executives, either in the position of a chairperson, CEO, director, or a member of the audit committee, are worthwhile since it enhances strategic control, good ethics, and long term focus. Empirical data indicates that female leadership is related to better transparency, stakeholder interest, and risk management being prudent, which all promote organisational learning and the efficient deployment of intellectual capital (McGuinness et al., 2020; Chijoke-Mgbame et al., 2020). All these attributes of governance contribute directly to efficiency in using human, structural, and relational capital.

The female leadership is also not common more so in the emerging economies like Nigeria whereby institutional and socio-cultural aspects have curtailed the representation of women in the top corporate positions. This scarcity makes female leadership a more strategic factor, since companies that implement women to senior governance format get to have access to views, competences and relational economies that are not shared by the competitors. In terms of RBV, this scarcity places female leadership as a symbol of leadership in governance to a competitive advantage source.

Furthermore, the female leadership is hard to emulate as its performance lies within the socially complex and path-dependent processes, such as style of leadership, ethical reputation, interpersonal trust, and organisational culture. Such attributes cannot be easily copied and duplicated by other competing companies. When the female leaders influence the knowledge sharing routines, the governance norms, and the relation between the stakeholders, the same becomes firm-specific capabilities, enhancing the sustained advantage (Barney,1991).

Gender leadership cannot also be substituted in an environment where the effectiveness of intellectual capital requires inclusion of decision-making, ethical supervisory, and relationship governance. Although formal controls or external regulations can somewhat recreate the governance outcomes, this cannot completely replace the integrative leadership functions of the female executives. Therefore, women leadership is an invaluable resource of governance in the RBV logic.

ICE is the process according to which the resources of VRIN are translated into competitive advantage. Intellectual capital which is a set of human, structural and relational capital creates value, but they can only do that effectively when managed. Female leaders contribute to improving ICE by creating an environment of teamwork, reinventing internal operations and controls and instilling transparency and accountability. These practices enhance the productivity of the human capital, the structural capital by the means of the effectiveorganisational processes and the relational capital by the means of the stakeholder trust and legitimacy.

Within the Nigerian manufacturing industry, where the companies are challenged by competitive forces, institutional frailties, as well as innovation drive, the RBV proposes that incorporation of female leadership in the corporate governance framework improves ICE and promotes sustainable performance. By converting gender diverse leadership into an efficiency increasing governance ability, firms can use intellectual capital in a manner that is hard to replicate hence attaining long-term competitive advantage.

Empirical Review and Hypotheses Development

The increasing focus on intellectual capital efficiency (ICE) is an indicator of increasing the value creation of firms moving away in tangible assets and moving to the resources based on knowledge. It is in this context that the corporategovernance especially gender in the board and executive leadership has received growing academic attention as a potential tool to improve ICE. Nevertheless, there are still gaps in empirical evidence in leadership positions, institutional settings, and methodology, as it is still piecemeal, particularly in developing markets like Nigeria.

At the top of the pyramid of board leadership, most indications have indicated that female chairpersons lead to some aspects of ICE, and these are the relational as well as structural capital. Research in Africa and Europe (Bello and Adekunle, 2022; Rodríguez et al., 2019) demonstrates that companies that have women in their seats have a better stakeholder relationship, good governance, and greater transparency, which contribute to the efficient use of intellectual capital. These results are aligned with the governance conceptions that associate inclusive leadership with better supervision and value creation in the long term. However, these studies tend to use cross-sectoral samples and neglect important firm-level controls, and explain manufacturing firms in particular less effectively. Furthermore, industry-specific evidence in the banking sector of Nigeria indicates that the impact of female chairpersons on ICE is insignificant (Isola et al., 2020), which indicates that the relationship between governance and ICE could be moderated by institutional environment and industry-specific factors. These discrepancies inform the importance of testing the hypothesis empirically on whether female chairpersons have a strong impact on ICE in the manufacturing industry in Nigeria (H_{01}).

Female chief executive officers (CEOs), in their turn, have been empirically supported somewhat more, especially in the context of the relationship between leadership style and innovation as well as knowledge management. According to studies in both developed and emerging markets, female CEOs always improve ICE by developing innovation cultures, promoting the sharing of knowledge, and investing in human capital development

(Javaherizadeh, 2021; Ghassan and Fathia, 2023; Saeed, 2025). Such studies usually use powerful methods, such as time-lagged regressions and structural equation modelling, which enhance causal inference. They have however been curtailed by the fact that they are based on non-African samples or have been based on subjective survey data, thus, preventing generalisability to manufacturing firms in Nigeria whose regulatory, cultural, and governance environment is different. The disaggregated leadership roles and outcome variables emphasize further when evaluating the gendered diversity in Nigeria (Obiora, 2021) where gender diversity introduces no significance to the performance of firms in the banking industry. The findings of these mixed results offer an excellent empirical justification to consider the impact of female CEO on ICE in Nigeria-based manufacturing companies (H_{02}).

On the grander framework of board composition, women directors there are mixed yet optimistic studies. The European and Asian studies indicate that female directors contribute to ICE by providing a better monitoring, quality of decisions, and knowledge management, especially in case of the critical mass of women in the board (García-Meca et al., 2015; Javaid and Hassan, 2023; Nadeem et al., 2017). Nevertheless, the issue of endogeneity makes interpretation a problem. As Li et al. (2022) show, the positive correlations found with the use of a static model can become insignificant when a dynamic estimation approach is used, which suggests that previously obtained results might be overstating the actual effect of female directors. In addition, the majority of the existing research is focused on non-African settings and seldom separates manufacturing companies, which restricts their applicability to the industrial sector in Nigeria. These contextual and methodological lapses will drive hypothesis H03, which will measure the significance of female directors in ICE in manufacturing firms based in Nigeria and listed there.

New literature has broadened the gender-ICE discussion to board subcommittees, especially audit committees, with the view that they could help to increase transparency, compliance, and ethical financial reporting that are major sources of structural capital efficiency. Empirical studies on European and Asian markets suggest that female audit committee members have a positive impact on ICE through improving the quality of governance and disclosure of intellectual capital (Mardini and Elluch, 2024; Nadeem et al., 2019; Ali et al., 2024). Such studies have the advantage of sophisticated econometric methods like system-GMM, which gets over the endogeneity problems. Nonetheless, they usually also pay little attention to the heterogeneity of the industry on the level of components of ICE, the impact of external institutions. Also, little emphasis is given to the role of regulatory implementation and cultural values in determining the efficiency of the female audit committee representation, which is especially relevant in the context of corporate governance in Nigeria. These restrictions support H04 hypothesis, which investigates the effects of female members of the audit committee on ICE in Nigeria-based manufacturing companies.

Altogether, the existing body of literature indicates that female involvement in the corporate leadership can contribute to the improvement of ICE, yet it depends on the leadership category, sector specifics, institutional setting, and research rigor. Although the evidence in the international arena tends to indicate a positive correlation between gender diversity and ICE, the scarcity of manufacturing-specific and country-specific research on the topic in Nigeria limits the generalisation of theories and their application to policy. This study fills such gaps and adds the contextually-based evidence to the governance-intellectual capital body of literature, by simultaneously analyzing female chairpersons, CEOs, directors, and audit committee members in the manufacturing sector of Nigeria.

3.0 Methodology

This study adopts an ex-post facto research design as it allows testing the effect of the

explanatory variables on the explained variable, and the data is based on past events that cannot be manipulated by the study. The population of the study comprises 66 manufacturing firms listed in the Nigerian Exchange Group as of 2012 and has not been delisted as of 31st December 2022. A purposive sampling technique is utilized to select a sample size of 17 firms based on firms that completed annual reports from 2013 to 2022. The 17 firms were purposively selected because only these manufacturing firms had complete, consistent, and accessible annual reports with all required variables for the full 2013–2022 study period, ensuring data reliability and longitudinal validity.. The data for measuring the variables were sorted from the firms' annual reports and include human capital efficiency, structural capital efficiency, rational capital efficiency, capital employed efficiency, modified value-added intellectual coefficient (MVAIC), the presence of female as chairperson, director, CEO, and member of the audit committee, and total assets and firm age. The study explored multiple regressions and analyzed the collected data through STATA 13 to investigate gender diversity and intellectual capital efficiency. The model is formulated as:

$$MVAIC_{it} = \beta 0 + \beta_1 FC_{it} + \beta_2 FCEO_{it} + \beta_3 FD_{it} + \beta_4 FAU_{it} + \beta_5 FS_{it} + \beta_6 FAGE_{it} + \varepsilon$$

where: MVAIC = Modified value-added intellectual coefficient, FC = Female Chairperson, FC = Female CEO, Female director, Female audit committee, FS = Firm size, FAGA = Firm age, β_1-$\beta 6$= Coefficients of determination, β_o= Intercept of the regression line, it = firm i time t, ε = Residual or error term.

Table 1
Variable Measurement

Variable	Measurement of Variable	Author(s)
Value-added (VA)	Operating Profit + Staff Cost + Depreciation + amortization	Nadeem et al. (2017)
Human Capital (HC)	Employees benefits	Nadeem et al. (2017)
Structural Capital (SC)	VA – HC	Nadeem et al. (2017)
Rational Capital (RC)	Advertising, selling and promotional costs	Ulum et al. (2017)
Capital Employed (CE)	Total Assets – Current Liabilities	Nadeem et al. (2017)
Dependent variable:		
Modified Value-Added Intellectual Coefficient (MVAIC)	HCE + SCE + RCE + CEE	Ulum et al. (2017)
Where		
Human Capital Efficiency (HCE)	VA/HC	Ijaz et al. (2024)
Structural Capital Efficiency (SCE)	SC/VA	Ijaz et al. (2024)
Rational Capital Efficiency (RCE)	VA/RC	Ulum et al. (2017)
Capital employed efficiency (CEE)	VA/CE	Ijaz et al. (2024)
Independent Variables		
Female Chairperson (C	Female as a chairperson 1, otherwise 0	Javaherizadeh (2021)
Female CEO (COE)	Female as a CEO 1, otherwise 0	Saeed (2025)
Female Director (DC)	Present o female as a director 1, otherwise 0	Javaid and Hassan (2023)
Female Audit Committee (FAU)	Present of female as in audit committee chairperson 1, otherwise 0	Mardini and Elluch (2024)
Control Variables		
Firm's age (FA)	The number of years since the firm was established	Buallay and Hamdan (2018);
Firm Size (FS)	natural logarithm of the total assets	Sanyaolu et al (2022)

Source: Authors' Compilation, 2025.

4.0 Results and Discussion

Table 2:
Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Mvaic	170	16.211	22.748	-31.12	163.46
Fc	170	.124	.33	0	1
Fceo	170	.124	.33	0	1
Fd	170	.871	.337	0	1
Fa	170	.676	.469	0	1
Fs	170	7.464	.986	4.76	8.79
Fage	170	49.5	20.569	8	99

Source: STATA 15 Output, 2025

Table 3:
Pairwise Correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) mvaic	1.000						
(2) fc	-0.081	1.000					
(3) fceo	-0.172	0.185	1.000				
(4) fd	-0.181	0.145	0.145	1.000			
(5) fa	-0.270	0.260	0.145	0.295	1.000		
(6) fs	-0.063	0.157	0.071	0.369	0.315	1.000	
(7) fage	-0.344	0.175	0.052	0.015	0.259	0.458	1.000

Source: STATA, 2025

Table 4:
Variance Inflation Factor

	VIF	1/VIF
Fs	1.54	.649
Fage	1.37	.73
Fd	1.288	.776
Fa	1.248	.801
Fc	1.118	.894
Fceo	1.057	.946
Mean VIF	1.27	.
Hottest		0.000
Hausman specification test		0.009

Source: STATA 15 Output, 2025.

Table 5:
Regression results of panel corrected standard errors

Mvaic	Coef.	St.Err.	t-value	p-value
Fc	3.447	1.727	1.85	0.065*
Fceo	-8.457	2.823	-3.00	0.003***
Fd	-14.061	7.320	-1.92	0.055**
Fa	-8.645	3.119	-2.77	0.006***
Fs	6.037	2.146	2.81	0.005***
Fage	-0.481	0.107	-4.29	0.000***
Constant	12.670	12.064	1.05	0.294
R-squared	0.2297	Number of obs		170
Wald Chi2	70.95	Prob > F		0.000

Source: STATA 15 Output, 2025

Discussion

The descriptive statistics reported in Table 2 describe the character and distribution of the variables utilized in this research. The standard deviation and mean of the dependent variable, MVAIC (Modified Value-Added Intellectual Coefficient), are 22.748 and 16.211, respectively, indicating high variability of intellectual capital efficiency (ICE) among the firms under observation. The lowest score of -31.12 indicates that some companies were inefficient in the use of intellectual capital, while the highest score of 163.46 signifies companies with extremely high ICE. The widespread signifies the presence of large differences in companies' ability to use intellectual capital in value creation. Independent variables are operationalized for board gender diversity. FC (Female Chairperson) and FCEO (Female CEO) both share a mean of 0.124 and a standard deviation of 0.33, i.e., just 12.4% of the firms sampled have a female holding these top executive positions. Under representation of female means that female still have enormous entry barriers in attaining the top executive positions in Nigerian manufacturing firms. FD (Female Director) has a mean value of 0.871 with a standard deviation of 0.337, indicating that 87.1% of the companies have one or more females on the board. This indicates that, although female presence at the director level is comparatively common, the top positions remain in the hands of men. FA (Female Audit Committee Member) is 0.676 with a standard deviation of 0.469, and it means that around 67.6% of the companies have female as audit committee members. This would indicate that females are more engaged in control functions of finance than executive functions, perhaps driven by regulatory incentives for gender representation on audit committees.

The pairwise correlation matrix in Table 3 provides the correlation of MVAIC with board gender diversity variables and firm characteristics. The values of correlation represent the strength and direction of such relationships and can be used to describe the possible influences on intellectual capital efficiency (ICE). The dependent variable MVAIC is negatively correlated with all the independent and control variables. Most notably, its relationship with FC (Female Chairperson) is weakly negative at -0.081, meaning a low negative correlation. It shows that a female chairperson might not significantly contribute to intellectual capital efficiency due to a lack of powers or pressures from the outside. In the same manner, FCEO also possesses a weak negative correlation of -0.172 with MVAIC, meaning that companies with female CEOs will possess a little less ICE, but not significantly enough to conclude anything. FD (Female Director) correlates with MVAIC at -0.181, showing a slightly negative correlation. This suggests that further female representation on boards is not necessarily going to rise ICE, perhaps due to structural pressures or tokenism in board appointments of female. Similarly, FA (female audit committee member) is also negatively correlated with MVAIC at -0.270, which suggests that although the presence of female on audit committees enhances financial monitoring, this is not necessarily going to enhance intellectual capital management. The correlations between independent variables indicate that there is no strong correlation among them, signifying that there is no presence of multicollinearity. However, Panel-Corrected Standard Errors (PCSE) apply to panel data estimation to deliver robust, efficient standard errors, which help in making valid statistical inferences by addressing heteroskedasticity and both cross-sectional dependence and serial correlation.

Table 5 reveals that the combined explanatory variable accounted for approximately 30% (R^2 = 0.2297) of the variation in ICE. The overall model is statistically significant, as shown by the Wald Chi^2statistic (70.95) and the probability value (Prob > F = 0.000), implying that the model is well combined and used.

Female Chairperson (FC) is weakly and positively insignificant with ICE (β = 3.447, p = 0.065),at 0.05 level of significance, suggesting that firms with female chairpersons are more

intellectually capital-efficient. This provides evidence to reject the alternate hypothesis. This is a bit consistent with the findings of Bello and Adekunle (2022) and Mardini and Elluch (2024), whose view is that female's leadership brings about strategic decision-making. The contention here is that gender diversity within the board of directors may facilitate improved management of intangible assets, although its impact is not necessarily significant.

A female CEO has a significant but negative effect on intellectual capital effectiveness (ICE) (β = -8.457, p = 0.003). This study also rejects the null hypothesis. The study aligns with Uwuigbe et al. (2021), which shows that emerging economy female CEOs experience structural obstacles that reduce their performance in intellectual capital utilization. Saeed (2025), Ghassan and Fathia (2023), Shahzad et al. (2020), and Nadeem et al. (2017) found that female CEOs are responsible for increased knowledge-sharing and innovation in developed economies. This difference suggests that gender differences in leadership performance can be based on institutional and cultural determinants.

Female Directors (FD) have a negative, but significant effect on ICE (β = -14.061, p = 0.055), whereby greater female representation on the board of directors does not necessarily lead to better intellectual capital utilization. This provides evidence to reject the null hypothesis ($H0_3$). This discovery contradicts studies such as Javaid and Hassan (2023), Al-Musalli and Ismail (2014), García-Meca et al. (2015), which emphasize the contribution of female CEOs to knowledge development and governance of the firm. The implication here is that gender diversity will not be enough to trigger intellectual capital effectiveness without other governance mechanisms.

Data reveals that female audit committee members (Fa) demonstrate a significant negative relationship with ICE (β = -8.645, p = 0.006). Their presence thus does not directly improve knowledge efficiency levels. Javaherizadeh (2021) proved that female audit committee members strengthen financial control, but their impact on ICE possibly operates through compliance rather than innovative practices. Contrarily, Isola et al. (2020) found that female audit committee members (Fa) demonstrate an insignificant relationship with ICE. The exact influence of female audit committee members on ICE deserves additional study for developing governance systems.

5.0 Conclusion and Recommendations

This research analyzed how female representatives in leadership positions in boardrooms influence the efficiency of intellectual capital within Nigerian publicly listed manufacturing companies. Gender-diverse boards present various effects on intellectual capital efficiency according to the study findings. A female chairperson (FC) was insignificantly and positively related, which meant that firms with a female chairperson would be able to take advantage of improved strategic decision-making and knowledge management, but it was not significant.

Conversely, the study indicated that FCEO negatively and significantly affects ICE. This agrees with Uwuigbe et al. (2021), who argue that female CEOs in developing economies are hindered by structural barriers that inhibit them from tapping intellectual capital. This is, however, contrary to Xu and Liu (2020), who stated that female CEOs in developed economies enhance knowledge sharing and innovation. The difference opens the question of whether contextual factors, such as institutional frameworks and cultural forces, can indeed influence the quality of female leadership in ICE governance.

Similarly, female directors (FD) were found to have a significant but negative influence on ICE, inferring that an increase in female on the board does not necessarily translate into enhanced intellectual capital utilization. This implies that gender diversity is not enough to enhance ICE without robust corporate governance structures.

The female audit committee members (Fa) show a significant negative relationship with ICE, which strongly suggests their contribution to enhancing intellectual capital utilization is limited. The weak links between female audit committee members and ICE are caused by their main role in governance and compliance, instead of contributing to strategic knowledge development.

Based on the findings and the conclusion of this study, it was recommended that:

i. Regulators should introduce mandatory board gender diversity disclosure requirements and set minimum female representation thresholds for listed manufacturing firms (e.g., at least one female chairperson/director or 30% female board representation), alongside enforcement-linked compliance reviews within annual corporate governance filings to ensure that female leadership is not symbolic but institutionally embedded in intellectual capital oversight.

ii. Firms should institutionalize female leadership effectiveness by mandating board-level intellectual capital oversight committees or agenda items in which female chairpersons, CEOs, or directors are explicitly responsible for supervising human, structural, and relational capital efficiency, with measurable KPIs tied to innovation outcomes, knowledge-sharing systems, and process efficiency.

iii. Targeted executive capacity-building programmes should be co-developed with professional bodies (ICAN, ANAN, IoD Nigeria) to equip current and pipeline female leaders with advanced competencies in intellectual capital measurement (e.g., MVAIC), innovation governance, and strategic resource allocation, ensuring their contributions translate into observable ICE improvements.

iv. Boards should expand the mandate of audit committees with female membership beyond statutory compliance to include formal evaluation of intellectual capital risks and investments, supported by specialized training in intangible asset valuation, knowledge-risk assessment, and innovation-related internal controls, with results reported in annual corporate governance and sustainability disclosures.

Policy Implication And Suggestions For Further Studies

The document synthesizes policy implications and research directions concerning the role of female leadership in enhancing intellectual capital efficiency (ICE) within Nigerian manufacturing firms. It argues for stronger corporate governance reforms through mandatory gender diversity disclosure and minimum female board representation, repositioning gender diversity as a regulated governance mechanism aligned with value creation in knowledge-intensive environments. The discussion emphasizes institutionalizing intellectual capital oversight at the board level, particularly through defined roles for female leaders, to embed ICE within strategic accountability frameworks. It further highlights the need for national executive capacity-building initiatives, supported by professional and governance institutions, to develop leadership competencies in intangible asset management and innovation governance. Additionally, the expansion of audit committee mandates to include intellectual capital risk and investment assessment is proposed as part of an integrated governance and sustainability reporting framework. Finally, the document identifies future research priorities, including cross-sectoral and comparative studies, longitudinal and mixed-method approaches, and the examination of contextual moderating factors, to deepen understanding of how gender-diverse leadership influences intellectual capital efficiency.

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