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Female directors in the boardroom and intellectual capital performance: Does the "critical mass" matter?

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Abstract

This research aims to investigate the influence of female directors on Intellectual Capital Performance (ICP) using a sample of manufacturing-listed companies in China. Our study investigates the link between having two or more female directors and the Modified Value-Added Intellectual Coefficient (MVAIC) methodology, employing the critical mass theory from 2004–2017. We find that having a critical mass of female directors (three or more) shows a significant positive impact on MVAIC and its components, including human capital efficiency, structural capital efficiency, relational capital efficiency, and physical capital efficiency, with physical capital being the critical driver. Our study reveals that the critical mass participation of female directors substantially influences the IC efficiency of privately owned companies compared to state-owned companies. Moreover, the number of female directors also affects the IC performance of manufacturing companies in multiple regions. Our findings support the validity of group classification identified by Kanter and Critical Mass Theory. To the best of our knowledge, this is one of the few pieces of research that studies the role of female board directors in IC performance and Chinese manufacturing firms using MVAIC as an IC measure.

Keywords: Corporate governance, Female directors, Critical mass, Intellectual capital, State-owned enterprises (SOEs), China

Introduction

Corporate governance (CG) and board gender diversity (BGD) are two of the most debated aspects of corporate board composition. They are considered a source of competitive advantage for the company's business (Midavaine et al. 2016; Radin and Stevenson 2006; Chiucchi et al. 2018), which has, in turn, triggered several regulatory interventions across the globe (Falconieri and Akter 2023). Over the last decade, the BGD has been crucial in studying firm performance. Many gender laws that impose female quotas in the firm have been introduced, enhancing female participation in corporate boards. The Critical Mass Theory (CMT) concept suggests that having more female directors on boards affects corporate performance.

Using the CMT, we investigate how the number of female directors impacts Intellectual Capital Performance (ICP) (Granovetter 1978; Kanter 1977). We consider the number of female directors (one, two, and three) to measure the Critical Mass Participation of females (CMPF). According to the CMT, a single female director represents a "token" and does not affect business decisions (Kanter 1977). In our study, we follow Granovetter (1978) and Liu et al. (2014), who believe that a critical mass (i.e., a specified number of women) is required to prove that gender diversity affects corporate practices.

CanÄibano et al. (2000) demonstrate that knowledge-oriented, fast-evolving, and tech-driven economies are replacing most manufacturing economies, in which IC has become the main driving force for the company's value creation process. A better understanding of the firm's future value creation prospects may translate into a higher share price generating higher market capitalization (Williams 2001). The utilization of unique values, expertise, experience, and strategies is usually grouped under the "Intellectual Capital (IC)" (Barney et al. 2001), which represents the competitive edge of the firm. Sullivan (2000) also pointed out that intangible resources play a crucial role in firm valuation, given the transition from a physical assets-based economy to a knowledge-driven economy. Bontis (2001) believes that intangible assets have become the main source of competitive edge, and an adequate measure of IC performance has to be identified.

A large part of the existing literature shows that leveraging and managing intellectual capital performance effectively improves business performance (Bayraktaroglu et al. 2019), while few scholars highlight that women-led boards are credited with leveraging IC efficiency (Nadeem et al. 2019, Smriti and Das 2018, Shahzad et al. 2019, Isola et al. 2020). Only a few studies have examined the influence of female representation from the standpoint of the CMT. They find that in the presence of a critical mass of female directors, the board becomes effective at its monitoring function (De Masi et al. 2021), corporate decisions (Rossi et al. 2017), corporate innovation practices (Torchia et al. 2011), and CSR activities (Yarram and Adapa 2021). These researches deal with well-established capital markets such as the US and the UK; therefore, understanding the role of female representation in emerging markets represents an important task. Our study is focused on the China market, which is characterized by an immature institutional system with a weak rule of law and regulations, poor policy transparency, a high level of government participation, and a lack of robust enforcement mechanisms (Jin et al. 2022; Wu et al. 2022). We investigate how the critical mass participation of women directors, as a measure of gender diversity, affects Intellectual Capital Performance (ICP), unlike most studies that analyze how gender diversity affects the firm performance or governance. The original contribution of this study stands in investigating how different minorities of women directors affect ICP in China, which has no quota for female directors but high ownership concentration, strong family ownership, and poor governance structure. This study aims to provide practical guidance to China's regulatory bodies on diversity practices.

China is the world's largest developing economy, the second largest by nominal Gross Domestic Product, and represents a global market due to its vast industry that largely contributes to China's economy (Jiang and Kim 2015; Bian and Yan 2022). However, the corporate governance codes in China are generally less established, and state ownership substantially influences company decision-making.

This study adds to the ongoing discourse on gender diversity's impact on corporate boards by examining the unique dynamics in China. To achieve this, the study employs intellectual capital performance metrics instead of conventional accounting-based firm performance measures and applies the Critical Mass and Agency theories (De Masi et al. 2021; Torchia et al. 2011; Rossi et al. 2017; Konrad et al. 2008; Ouni et al. 2022). Our study utilizes the number of female directors as the primary variable of interest to evaluate its influence on intellectual capital performance instead of relying on the percentage of female directors. Additionally, we adopt the MVAIC approach to measure the intellectual capital of Chinese listed companies. To comprehensively analyze, we investigate both state-owned enterprises (SOEs) and private-owned enterprises (POEs) across China's eastern, western, and central regions (He et al. 2022) to capture behaviors that different socioeconomic contexts and institutional features may cause. To our knowledge, no researchers have employed the aforementioned approaches to examine the Chinese market.

This study is organized as follows: in Section "Methodology", the theoretical framework is presented; Section "Empirical analysis" describes the data and the methodology; Section "Empirical results and discussions" illustrates the results; Section "Additional test" shows additional performance tests; Section "Robustness check" describes the robustness checks; and Section "Conclusions" provides some conclusions.

Methodology

Theoretical framework

The relevance of the number of women on boards of directors represents a crucial issue when discussing women's representation. A minimum level of representation is required to have a significant influence (Dahlerup 2006). The notion of "critical mass" on boards of directors is based on the premise that unless there is a certain number of females on the board of directors, the qualities and skills that female members can bring to the group will be ignored (Dahlerup 2006; Konrad et al. 2008). Females may be considered "tokens" without a critical mass, and their effect is restricted (Schwartz-Ziv 2017). The presence of at least three female directors (about one-third of boards) has been shown to improve the female experience on boards and their governance efforts (Konrad et al. 2008; Kramer et al. 2007; Torchia et al. 2011)). The CMT asserts that women who represent a marginal element inside a group or organization are viewed more as representations of their gender than as individuals. According to Kanter (1977), to enhance and even impact the decisions of an otherwise homogenous group, the proportion of women should be at least 35%; otherwise, there will be no effect. The CMT considers the involvement of one female as a token, the participation of two females as the presence, and the involvement of three females as the group's voice. When the percentage of female directors on the board of directors is high (larger than 35%), the company's performance improves, and information transparency increases (Gyapong et al. 2016; Liu et al. 2014; Ahmed and Ali 2017).

To test the validity of the CMT, we identify the minority group sizes of female directors (i.e., one female, two females, and at least three females) and investigate their influence on ICP to identify a possible relationship. The research model is shown in Fig. 1.

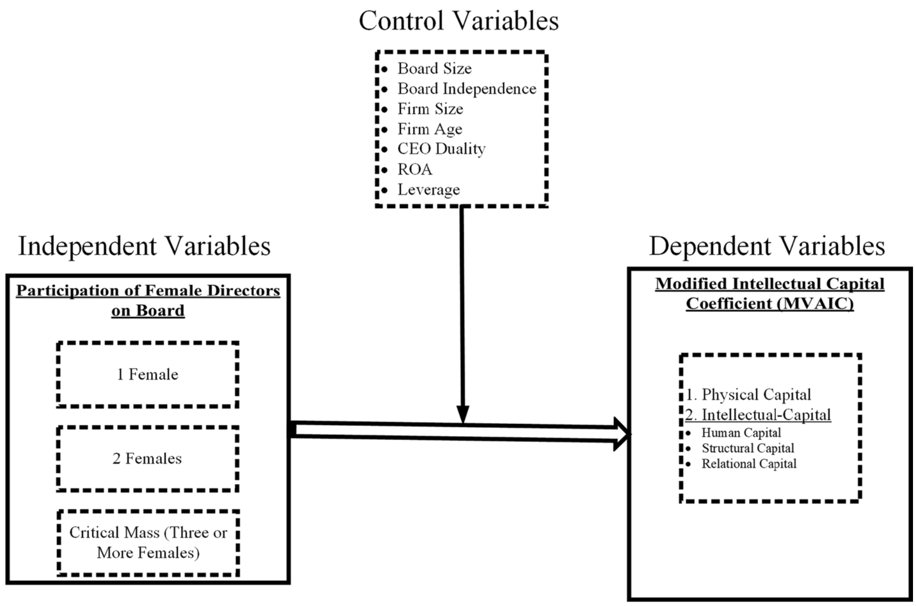

Fig. 1 Research framework

Measurement of intellectual capital

Galbraith coined the term "Intellectual Capital" in 1969, describing it as an individual's intellectual contribution. According to Bell (1997), IC is a firm's resource for creating a competitive edge. Stewart (1997) claims that IC combines information, knowledge, competence, practice, and learning capacity. IC was defined by Kaplan and Norton (1996) as investments in suppliers, customers, personnel, and technological innovation. Edvinsson and Malone (1997) suggest using the gap investors find in the balance sheet performance to measure IC. There has been a widespread effort to find an adequate model to measure IC. Academics suggest recognizing three categories in IC: human capital (HC), structural capital (SC), and relational capital (RC) (Xu and Li 2019; Stewart 1997; Sydler et al. 2014). Pulic (2000) introduces the Value-Added Intellectual Coefficient (VAIC) model, dividing IC into human capital and SC using data from financial statements.

According to Johnson (1999), "Human Capital" represents the combination of employees' skills, competencies, capabilities, and experiences. Chen et al. (2005) include "Structural Capital," culture, routines, databases, processes, patents, copyrights, and trademarks. Yang and Lin (2009) describe "Relational Capital" as formal business collaborations and all informal relationships with customers, suppliers, banks, and non-profit organizations. The VAIC is used to determine a firm's efficiency in creating both tangible and intangible value, and for Pulic (2004), it is the only valid method that provides comparability and scope. Crema and Verbano (2016) use VAIC to measure Intellectual Capital (IC) in small and medium-sized enterprises, including HC, internal SC, and RC.

VAIC takes into account Capital Employed Efficiency (CEE), Human Capital Efficiency (HCE), and Structural Capital Efficiency (SCE). Ståhle et al. (2011) criticize the VAIC, arguing that it measures the labor efficiency and the invested capital of a firm and not the IC. It cannot deal with the synergistic effects between various types of tangible and intangible assets (Dzenopoljac et al. 2017). In addition, it does not consider venture and innovation capital and assumes the beginning and ending inventories are zero.

To address the VAIC model's issues, we modify the VAIC model by including RC as an element of IC and using marketing, selling, and advertising costs as a proxy for the RC. The research framework is described in Fig. 1.

Female directors and intellectual capital performance

One of the directors' most critical tasks is monitoring the management (Adams et al. 2010). Gender diversity may improve the firm's human capital performance; as Low et al. (2015) argue, female directors are efficient in monitoring, increasing boards' human and structural efficiency, and enhancing internal and external collaboration. Williams (2003) finds that female-led boards tend to increase the financial performance of firms. Females also have a distinct cognitive style essential to producing harmony and are regarded as superior knowledge sources (Earley and Mosakowski 2000). Broadbridge et al. (2006) and Kravitz (2003) spotlight that the presence of female directors on boards is better able to address complex problems and interact with the external environment.

Further, Krishnan and Park (2005) claim that female directors work harder to retain their status since they encounter significant hurdles. The ability of a corporation to recruit and retain qualified employees is enhanced when its board of directors is gender diverse (Cox and Blake 1991), improving the IC of the firm. Furthermore, gender diversity leads to greater creativity and inventiveness in the firm's goods and services (Nadeem et al. 2017; Campbell and Mínguez-Vera 2008). The connections of the board of directors with key suppliers and partners are often a source of new experience and resources that adds value to the firm. Saruchi et al. (2019) find that female board members in Gulf-listed firms substantially influence relational capital efficiency (RCE).

Zhang et al. (2013) find that in U.S. public firms, board gender diversity substantially influences social performance. Faccio et al. (2016) show how women-led companies take more time to make investment choices than men-led companies causing less variable earnings. According to Reguera-Alvarado et al. (2017), having women on a firm's board of directors significantly positively impacts the company's financial performance. Consequently, it is expected that BGD would improve the efficiency of financial resources used by companies.

Studying the relationship between female directors' involvement and IC performance is promoted by Regulators who impose gender equality in corporate boards of directors, given the traditional patriarchal attitude observed in the business world. Early research by Swartz and Firer (2005) investigate the influence of board diversity on IC performance in 117 South African companies applying the VAIC model to gender and ethnicity diversity and found that board ethnicity influences the IC as a proxy for board diversity. The impact of female directors on the IC is found in several empirical studies, only to cite the most significant, Tejedo-Romero et al. (2017), using Spanish firms between 2007 and 2011; Smriti and Das (2018), with a sample of 272 Indian firms listed on the National Stock Exchange during 2007–2019; Shahzad et al. (2019) investigating U.S.-based firms and Nadeem et al. (2019), with a sample of 500 listed UK firms.

Nadeem et al. (2017), using panel data and an adjusted VAIC model for 906 Chinese listed companies from 2010–2014, found a positive relationship between gender diversity and IC efficiency. They do not use Critical Mass Theory, and their results are affected by endogeneity. Nadeem (2020), in a recent study, on 107 Chinese IPO prospectuses, finds an impact on the IC disclosure[1] only with three or more female directors.

In this study, we use the CMT to measure the influence of various minority group sizes (one female, two females, and at least three female directors) on IC performance and to assess the impact on the multiple components of the IC.

We test the following hypothesis:

H1*: Critical mass participation of female directors (with three or more female directors) positively influences IC performance.*

We choose the MVAIC approach, a composite measure of HCE, SCE, RCE, and CEE. In addition, we also examine the relationships that exist between the CMPF and the IC components.

H1a*: Critical mass participation of female directors (with three or more female directors) positively influences physical capital efficiency in Chinese manufacturing listed companies.*

H1b*: Critical mass participation of female directors (with three or more female directors) positively influences human capital efficiency in Chinese manufacturing listed companies.*

H1c*: Critical mass participation of female directors (with three or more female directors) positively influences structural capital performance in Chinese manufacturing listed companies.*

H1d*: Critical mass participation of female directors (with three or more female directors) positively influences relational capital efficiency in Chinese manufacturing listed companies.*

Female directors, ownership structure, and IC performance

The Chinese economy is based on state-owned enterprises (SOEs) and private enterprises (POEs) (Han et al. 2022, Wu 2017). As "*guanxi*" (social relationship) is deeply entrenched in Chinese culture, firms often use their social network ties to get support from the Chinese government. In the case of SOEs, the IC performance is affected by the following:

- The principal-agent dilemma: when ownership and management control are separated, managers (agents) might act in their interests rather than in the owner's ones (principal) (Berle and Means 1932). Inadequate corporate governance affects the company's performance and IC efficiency.

[1] This research focuses only on voluntary intellectual capital (IC) disclosure in Chinese IPO prospectuses, assessing the disclosure index through 78 dimensions across six main categories of IC. However, our research, which is based on critical mass theory, considers the influence of two or more female directors on IC performance in Chinese manufacturing companies (using MVAIC and its components).

- Free-rider problems. The ineffective corporate governance negatively influences the business's performance and the IC's efficiency. According to the state ownership theory, all citizens are co-owners. Still, they lack the authority and inclination to influence and monitor the administration of state-owned firms. The government is the only one with power (Huibers 2005) but generally has conflicting goals. Budgetary limitations are permissive, causing substantial difficulties and weak performance. For instance, due to social commitments, managers and other personnel are chosen for political reasons, not their talents (Wu 2017; Lihui 2001). Zulkifli et al. (2018) find that government ownership negatively influences the relationship between IC and firm performance. Their results favor the grabbing-hand approach (Jaffar and Abdul-Shukor 2016), showing that stakeholders do not like state ownership, where the owners' interests prevail over the IC performance.

We, therefore, expect to find that critical mass participation of female directors in SOEs may not increase IC performance, so we formulate Hypothesis 2:

H2: *The Critical mass participation of female directors (with three or more female directors) is more associated with high IC performance (MVAIC and its components) in non-SOEs than SOEs of Chinese manufacturing listed companies.*

Empirical analysis

The dataset

We collected data for all publicly listed manufacturing companies on the Shanghai and Shenzhen Stock Exchanges between 2004 and 2017. Firms that issue other shares and special treatment (ST) companies are removed. The entire dataset is comprised of 8,745 observations. The China Stock Market & Accounting Research (CSMAR) database has been used to compile the data of dependent, independent, and control variables.

Variables

Dependent variables

The MVAIC model measures IC efficiency. We include an extra IC component, RC, which is often overlooked in most extended research, unlike the VAIC used by Public (2000). So the MVAIC framework is described by:

$$VA = OUT - IN$$

$$CEE = VA/CE$$

$$HCE = VA/HC$$

$$SCE = SC/VA$$

$$RCE = RC/VA$$

$$ICE = HCE + SCE + RCE$$

$$MVAIC = ICE + CEE$$

where VA = a company's value-added; OUT = total revenues; IN = total expenses excluding employees' expenses; CEE = capital employed efficiency. HCE = human capital efficiency, HC = human capital measured by total employee spending. CE = total assets-liabilities. SCE = VA—HC measures the structural capital efficiency. RCE = relational capital efficiency is relational capital measured by advertising, marketing, and selling expenditures. $MVAIC$ = modified value-added intellectual coefficient; ICE = Intellectual Capital Efficiency: $HCE + SCE + RCE$.

$MVAIC$ is the total of the company's intangible and tangible assets.

Independent variables

The Dummy variables FEM1, FEM2, and FEM3 are used to quantify the number of female directors. The dummy variable (FEM1) takes the value 1 when the board has at least one female director; 0 otherwise. Similarly, (FEM2) equals 1 when the board has two female directors, and (FEM3) equals 1 when the board has three or more female directors; otherwise, both (FEM2) and (FEM3) take the value 0.

Control variables

Board size (*BS*), board independence (*BI*), firm size (*FS*), CEO duality (*CEOD*), firm age (*FA*), return on assets (*ROA*), and leverage (*LEV*) (Shahzad et al. 2019, Smriti and Das 2018, Tejedo-Romero et al. 2017).

The description of the variables is reported in Table 1.

Models

We follow the approach used by previous researchers adopting panel data (Dobija et al. 2022; Liu et al. 2014; Ain et al. 2021). We use a fixed effect method to analyze the link between the CMPF and ICP, which allows for controlling unobserved firm-specific individual characteristics. We can capture the firms' heterogeneity[2] when investigating the effect of critical mass participation of female directors on aggregate IC. The OLS is performed on the following equations:

$$\begin{aligned} MVAIC_{i,t} = {} & \alpha + \beta_1 FEM1_{i,t} + \beta_2 FEM2_{i,t} + \beta_3 FEM3_{i,t} + \beta_4 BS_{i,t} \\ & + \beta_5 BI_{i,t} + \beta_6 CEOD_{i,t} + \beta_7 ROA_{i,t} + \beta_8 FS_{i,t} + \beta_9 FA_{i,t} \\ & + \beta_{10} LEV_{i,t} + Industry_{i,t} + Year_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{1}$$

$$\begin{aligned} CEE_{i,t} = {} & \alpha + \beta_1 FEM1_{i,t} + \beta_2 FEM2_{i,t} + \beta_3 FEM3_{i,t} + \beta_4 BS_{i,t} \\ & + \beta_5 BI_{i,t} + \beta_6 CEOD_{i,t} + \beta_7 ROA_{i,t} + \beta_8 FS_{i,t} + \beta_9 FA_{i,t} \\ & + \beta_{10} LEV_{i,t} + Industry_{i.t} + Year_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{2}$$

[2] The link between critical mass participation of female directors (CMPF) and intellectual capital performance (ICP) may be influenced by unobservable characteristics of firms. These unobservable characteristics can be linked to both CMPF and ICP. The firm fixed-effect approach addresses this problem.

Table 1 Variable definition and measurement

Acronym	Variable name	Definition	Literature
Dependent variables			
MVAIC	Modified value-added intellectual capital coefficient	Capital employed efficiency plus human capital efficiency plus structural capital efficiency plus relational capital efficiency	Nimtrakoon (2015), Xu and Wang (2018), Smriti and Das (2018), Xu and Li (2020), Chen et al. (2005)
CEE	Capital employed efficiency	Value-added/Capital employed	Nadeem et al. (2019), Nadeem et al. (2017), Dashtbayaz et al. (2020)
HCE	Human capital efficiency	Value-added/Human capital	Dashtbayaz et al. (2020), Nadeem et al. (2019), Nadeem et al. (2017), Smriti and Das (2018)
SCE	Structural capital efficiency	Structural capital/Value added	Nadeem et al. (2017), Dashtbayaz et al. (2020), Nadeem et al. (2019), Smriti and Das (2018)
RCE	Relational capital efficiency	Relational capital/value-added	Smriti and Das (2018), Xu and Li (2020), Xu and Wang (2018)
Independent variables			
FEM1	Female dummy 1	The dummy variable assumes the value 1 if the board has at least one female director; otherwise, it is 0	Torchia et al. (2011), Nadeem (2020), Liu et al. (2014), Yarram and Adapa (2021)
FEM2	Female dummy 2	The dummy variable assumes the value 1 if the board has two female directors; otherwise, it is 0	Yarram and Adapa (2021), Liu et al. (2014), Torchia et al. (2011), Joecks et al. (2013)
FEM3	Female dummy 3	The dummy variable assumes the value 1 if the board has three or more female directors; otherwise, it is 0	Yarram and Adapa (2021), Joecks et al. (2013), Liu et al. (2014), Nadeem (2020), Torchia et al. (2011)
Control variables			
BS	Board size	Total number of directors on the board	Vitolla et al. (2020), Nadeem (2020), Nicolò et al. (2021),Hidalgo et al. (2011), Shahzad et al. (2019)
BI	Board independence	The proportion of independent directors on the board,	Hidalgo et al. (2011), Hsu et al. (2019), Shahzad et al. (2019), Nadeem (2020), Vitolla et al. (2020)
CEOD	CEO duality	The indicator variable equals 1 if the same person holds both CEO and Chair positions and 0 otherwise	Dashtbayaz et al. (2020), Nadeem et al. (2019), Nadeem (2020), Nadeem et al. (2017)
ROA	Return on assets	Net profit scaled by total assets	Smriti and Das (2018), Nadeem et al. (2017),, Nadeem (2020)
FS	Firm size	Natural log of total assets	Asiaei et al. (2018), Vitolla et al. (2020), Nadeem (2020)
FA	Firm age	Listing years of the firm on the stock exchange	Vitolla et al. (2020), Shahzad et al. (2019)
LEV	Leverage	Total debt scaled by total assets	Shahzad et al. (2019), Nadeem (2020), Dashtbayaz et al. (2020)

$$\begin{aligned} HCE_{i,t} = {} & \alpha + \beta_1 FEM1_{i,t} + \beta_2 FEM2_{i,t} + \beta_3 FEM3_{i,t} + \beta_4 BS_{i,t} \\ & + \beta_5 BI_{i,t} + \beta_6 CEOD_{i,t} + \beta_7 ROA_{i,t} + \beta_8 FS_{i,t} + \beta_9 FA_{i,t} \\ & + \beta_{10} LEV_{i,t} + Industry_{i,t} + Year_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (3)$$

Table 2 Summary statistics

	Mean	Obs	SD	Min	Max
MVAIC	2.860	8335	2.778	− 22.3	21.110
CEE	0.319	8434	0.341	− 2.048	1.279
HCE	2.586	8343	1.111	− 14.297	23.34
SCE	0.471	8693	3.224	− 24.803	18.216
RCE	0.456	8426	0.717	− 13.054	27.982
FEM3	0.102	8745	0.303	0.000	1
BSI	8.489	8745	1.563	3	18
BI	0.373	8745	0.053	0.143	0.800
FS	21.464	8745	1.006	18.76	26.651
CEOD	0.274	8648	0.484	0.000	1
FA	3.555	8423	3.074	0.000	13
ROA	0.054	8745	0.050	− 0.237	0.206
LEV	0.334	8745	0.181	0.049	1.138

Table 3 ADF Unit Root

	Level		First difference	
	Coefficient	PV	Coefficient	PV
MVAIC	61.3	0.000	82.148	0.000
CEE	46.856	0.000	71.627	0.000
HCE	32.618	0.000	77.333	0.000
SCE	43.556	0.000	69.6	0.000
RCE	29.492	0.000	96.396	0.000
FS	27.777	0.000	29.401	0.000
CEOD	84.946	0.000	99.351	0.000
FA	36.834	0.000	57.867	0.000
ROA	68.316	0.000	74.473	0.000
LEV	44.244	0.000	68.4265	0.000

$$\begin{aligned} SCE_{i,t} = {} & \alpha + \beta_1 FEM1_{i,t} + \beta_2 FEM2_{i,t} + \beta_3 FEM3_{i,t} + \beta_4 BS_{i,t} \\ & + \beta_5 BI_{i,t} + \beta_6 CEOD_{i,t} + \beta_7 ROA_{i,t} + \beta_8 FS_{i,t} + \beta_9 FA_{i,t} \\ & + \beta_{10} LEV_{i,t} + Industry_{i,t} + Year_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{4}$$

$$\begin{aligned} RCE_{i,t} = {} & \alpha + \beta_1 FEM1_{i,t} + \beta_2 FEM2_{i,t} + \beta_3 FEM3_{i,t} + \beta_4 BS_{i,t} \\ & + \beta_5 BI_{i,t} + \beta_6 CEOD_{i,t} + \beta_7 ROA_{i,t} + \beta_8 FS_{i,t} + \beta_9 FA_{i,t} \\ & + \beta_{10} LEV_{i,t} + Industry_{i,t} + Year_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{5}$$

Table 4 Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	Vif
(1) MVAIC	1.000													
(2) CEE	0.007	1.000												
(3) HCE	0.425***	0.195***	1.000											
(4) SCE	− 0.329***	− 0.232***	− 0.331***	1.000										
(5) RCE	− 0.162***	− 0.577***	− 0.381***	0.367***	1.000									
(6) FEM3	0.046***	0.007*	0.049***	0.011	0.043	1.000								1.241
(7) BS	0.026**	0.103***	0.030***	− 0.004	− 0.017	0.077***	1.000							1.561
(8) BI	− 0.024**	− 0.041***	− 0.030***	0.011	0.040***	− 0.053***	− 0.518***	1.000						1.404
(9) FS	− 0.057***	0.114***	− 0.055***	0.026**	− 0.040***	− 0.022**	0.162***	0.013	1.000					1.302
(10) CEOD	− 0.005	− 0.005	− 0.001	0.008	− 0.002	0.000	− 0.160***	0.129***	− 0.082***	1.000				1.056
(11) FA	− 0.126***	− 0.057***	− 0.162***	0.062***	0.179***	0.001	0.000	0.010	0.420***	− 0.105***	1.000			1.516
(12) ROA	0.175***	0.423***	0.268***	− 0.013	− 0.481***	0.018*	0.008	− 0.027**	− 0.120***	0.067***	− 0.253***	1.000		1.190
(13) LEV	− 0.099***	0.223***	− 0.126***	0.024**	0.144***	− 0.032***	0.163***	− 0.019*	0.474***	− 0.084***	0.258***	− 0.369***	1.000	1.572

***, **, and * denotes significance at 1%, 5%, and 10%, respectively. Variable definitions are provided in Table 1

Table 5 Regression results for female director's critical mass perspective

Variables	(1) *MVAIC $_{i,t}$*	(2) *CEE $_{i,t}$*	(3) *HCE $_{i,t}$*	(4) *SCE $_{i,t}$*	(5) *RCE $_{i,t}$*
FEM1	0.011**	0.008	0.012	0.004	0.017
	(2.415)	(0.506)	(0.478)	(0.501)	(1.168)
FEM2	0.045*	0.017**	0.031*	0.013**	0.024***
	(1.726)	(2.375)	(2.040)	(2.255)	(3.231)
FEM3	0.078***	0.089***	0.040**	0.024***	0.062***
	(4.314)	(3.718)	(2.318)	(3.326)	(5.141)
BS	0.023***	0.021***	0.003**	0.003*	0.010*
	(3.104)	(3.227)	(2.309)	(1.792)	(1.659)
BI	− 0.313	− 0.069	− 0.284	− 0.097	0.143
	(− 1.325)	(− 0.414)	(− 1.053)	(− 1.062)	(0.906)
FS	0.165***	− 0.137	0.334***	− 0.011	0.337***
	(7.772)	(− 0.467)	(3.874)	(− 1.460)	(4.081)
CEOD	0.053**	0.019	0.079***	0.013	0.059***
	(2.262)	(1.187)	(2.993)	(1.445)	(3.800)
FA	− 0.043***	0.006	− 0.080***	0.006**	0.066***
	(− 6.401)	(1.309)	(− 10.547)	(2.425)	(4.913)
ROA	0.147***	0.624***	0.209***	0.208***	0.760***
	(5.402)	(3.760)	(5.238)	(3.618)	(3.962)
LEV	− 0.406***	0.042***	− 0.709***	0.021	0.665***
	(− 5.433)	(4.317)	(− 8.350)	(0.752)	(3.441)
N	7,920	8,018	7,928	8,276	8,011
R^2	27%	38.6%	27.7%	29.1%	47.3%
Year dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes

The t− values are given in parentheses. ***, **, and * denotes significance at 1%, 5%, and 10%, respectively. Variable definitions are provided in Table 1

Empirical results and discussions

Descriptive statistics

Detailed descriptive statistics of the variables are reported in Table 2. The average *HCE* is 2.586, the highest among the four components of *MVAIC*, showing that *HCE* accounts for a larger proportion of *MVAIC* than they do for *CEE* (0.319), *SCE* (0.471), and *RCE* (0.456). Firms in the sample have an *MVAIC* ranging from 12.312 to 21.116, an average value of 3.863 ($\sigma = 2.778$) which means that for every monetary unit invested, the manufacturing firm produces an average of 3.863. *FEM3* has an average value of 10.2%, so in the sample, out of 8,745 firms, only 892 have three or more female directors. The board of directors includes an average of 8.5 members, and 37.3% are independent; approximately 27.4% of board chairs hold the CEO position within the same company.

Diagnostic tests

Data are tested for stationarity, and they are all I(0), Integrated of order zero; the results of the ADF test are reported in Table 3. The presence of multicollinearity in the data is investigated using the Pearson correlation coefficient and a variance inflation factor test. Results are reported in Table 4. No multicollinearity is found in the variables, as shown by the low level of the correlation coefficients; none of the VIF values exceeds the threshold (1.57), and all variables result significantly below the accepted level of 10 (Gujrati 2003). We also employed the Breusch-Pagan/Cook-Weisberg test (Hettest) to detect heteroscedasticity, as described by White (1980). Our analysis revealed non-significant p-values from Breusch-Pagan's heteroscedasticity tests ($Chi^2 = 4.867$, p-value = 0.525), proving that heteroscedasticity issues were absent. Since the p-value is greater than the commonly used significance level of 0.05, we fail to reject the null hypothesis.

Regression results

Female director's critical mass and IC performance

The estimated parameters for Eqs. (2)-(5) are reported in Table 5. We find a statistically significant positive relationship for *FEM1 (β = 0.011, t-value* 2.415*), FEM2 (β = 0.045, t-value* 1.726), *and FEM3 (β = 0.078, t-value 2.314),* with *MVAIC.* These results, consistent with Nadeem (2020) and Liu et al. (2014), support *H1* and indicate that the participation of one, two, three, or more female directors on boards increases the IC performance of Chinese manufacturing firms by value creation.

The additional evidence of the impact of a critical mass of female directors is shown when we look at the effect on the components of IC (*CEE, HCE, SCE, and RCE*). We find that the number of female directors (FEM3) affects the Capital employed efficiency (*CEE) (β = 0.089, t-value 3.718),* supporting hypothesis H1a. Similarly, *BS (β = 0.021, t-value 3.227)* and *ROA (β = 0.624, t-value 3.760)* also positively contribute to the *CEE* of firms.

The critical mass of female directors (*FEM3*) positively affects the human capital efficiency (HCE) *(β = 0.040, t-value 2.318),* confirming Hypothesis *H1b*. We believe that three or more female directors on boards develop strategic policies that are more conducive to the effective use and leveraging of human resources. Table 5 further reveals that *FEM3* affects the efficiency of structural resources (SCE) *(β = 0.024, t-value 3.326)*. Our findings show that female directors considerably influence a company's product, service creativity, and innovation (Campbell and Mínguez-Vera 2008; Broadbridge et al. 2006) and confirm the critical mass theory's notation supporting Hypothesis *H1c*.

FEM3 is also impacting the relational capital efficiency (RCE) *(β = 0.062, t-value 5.141),* confirming *H1d* and CMT and showing that a company's intangible assets are affected by the higher participation of female directors (Nadeem 2020).

Turning to control variables, the board size, CEO duality, and ROA are significantly positively correlated with dependent variables, meaning that IC performance can be improved in companies with a larger board of directors and when the CEO serves as the chair of the board (Smriti and Das 2018; Srivastava et al. 2018). However, firm size, age, and leverage provide mixed findings. Overall, the results confirm the study's fundamental premise that increasing the number of women on corporate boards might improve the ICP of firms. Critical mass representation of female directors on corporate boards could enhance IC performance, leading to improved firm value and competitive advantage in the knowledge economy era. Similarly, Sardo and Serrasqueiro (2017) highlighted the relevance of IC investments in knowledge-based economies for generating value.

Table 6 Regression results with a lag of dependent variables

Variables	(1) $MVAIC_{i,t}$	(2) $CEE_{i,t}$	(3) $HCE_{i,t}$	(4) $SCE_{i,t}$	(5) $RCE_{i,t}$
$MVAIC_{i,t-1}$	0.366***				
	(3.573)				
$CEE_{i,t-1}$		0.075***			
		(7.789)			
$HCE_{i,t-1}$			0.316***		
			(7.144)		
$SCE_{i,t-1}$				0.114***	
				(8.586)	
$RCE_{i,t-1}$					0.646***
					(4.815)
FEM1	0.021	0.003	0.005	− 0.001	− 0.014
	(0.978)	(0.178)	(0.198)	(− 0.113)	(− 1.037)
FEM2	0.043*	0.012**	0.028	0.006	0.009
	(1.698)	(2.553)	(0.932)	(0.484)	(0.595)
FEM3	0.055***	0.058***	0.039***	0.025**	0.015*
	(3.710)	(5.773)	(4.549)	(2.505)	(1.754)
N	6,450	6,556	6,459	6,970	6,549
R^2	28%	32.1%	35.7%	23.3%	26.1%
Control variables	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes

The t-values are given in parentheses. ***, **, and * denotes significance at 1%, 5%, and 10%, respectively. Variable definitions are provided in Table 1

Due to simultaneity and unobserved heterogeneity, all previous research on the relationship between CG and firm performance is dynamic and possesses the problem of endogeneity (Wintoki et al. 2012).[3] For instance, it may be not just the gender that has an impact on the company's performance (in our case, we consider the gender's intellectual capital performance), but past IC performance may also affect the current IC performance; the dependent variables' lagged values might also operate as regressors. Furthermore, company culture and CEO management competence characteristics may have a combined effect on gender composition and IC performance; hence, we must introduce such variables (Nadeem et al. 2017). To check this argument empirically, we follow Wintoki et al. (2012) and run our regression of current performance on one lag of past performance, including all control variables. Our analysis shows that the coefficient for a one-year lag of the dependent variable is significant at the 5% level, indicating that a single lag is sufficient to capture the dynamic nature of the CG-ICP relationship. This finding aligns with previous studies by Adams and Ferreira (2009) and Dezso and Ross (2012). Results in Table 6 confirm that a certain threshold of female directors on boards positively impacts the IC performance of manufacturing firms.

[3] Wintoki et al. (2012) provide a comprehensive explanation of how organizations choose alternative governance structures to best suit their operation activities and information environment. Moreover, they point out that a firm's present performance may have a substantial impact on future governance decisions, as well as the other way around. As a result, endogeneity is unavoidable in this kind of research.

Table 7 Regression result with ownership structure perspective (POEs sub-sample)

Variables	(1) *MVAIC $_{i,t}$*	(2) *CEE$_{i,t}$*	(3) *HCE$_{i,t}$*	(4) *SCE$_{i,t}$*	(5) *RCE$_{i,t}$*
FEM1	0.032	− 0.002	0.011	0.012	− 0.003
	(1.306)	(− 0.098)	(0.414)	(1.430)	(− 0.617)
FEM2	0.048*	0.008*	0.032	0.013	0.008
	(1.690)	(1.523)	(1.004)	(1.406)	(0.436)
FEM3	0.096***	0.103***	0.045**	0.036***	0.011**
	(2.697)	(2.857)	(2.543)	(3.537)	(2.476)
BS	0.006	0.023***	0.001	0.003	− 0.014**
	(0.570)	(3.168)	(0.081)	(0.757)	(− 2.026)
BI	− 0.490*	0.120	− 0.499*	− 0.045	− 0.097
	(− 1.862)	(0.661)	(− 1.666)	(− 0.517)	(− 0.553)
FS	0.183***	− 0.139***	0.337***	− 0.012*	− 0.374***
	(7.767)	(− 8.830)	(2.699)	(− 1.666)	(− 4.153)
CEOD	0.056**	0.017	0.090***	0.009	− 0.060***
	(2.291)	(0.982)	(3.225)	(1.105)	(− 3.686)
FA	− 0.050***	0.009	− 0.085***	0.006*	0.077***
	(− 5.827)	(1.497)	(− 8.712)	(1.910)	(13.429)
ROA	0.279***	0.384***	0.033***	0.131**	− 0.436***
	(2.608)	(5.508)	(3.557)	(2.517)	(− 8.338)
LEV	− 0.387***	2.021***	− 0.723***	0.032	0.689***
	(− 4.800)	(7.634)	(− 7.907)	(1.209)	(2.943)
N	6,647	6,729	6,653	6,907	6,725
R^2	28.9%	39.9%	29%	22.2%	37.7%
Year dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes

The t-values are given in parentheses. ***, **, and * denotes significance at 1%, 5%, and 10%, respectively. Variable definitions are provided in Table 1

Female director's critical mass, ownership structure, and IC performance

We test the second Hypothesis, *H2,* by dividing our sample into state-owned enterprises (SOEs) and private-enterprises (POEs). The results are shown in Table 7 and Table 8. We find that FEM3 positively and significantly influences ICP (using MVAIC as a dependent variable) of privately owned manufacturing companies, unlike the SOEs ones *(β = 0.096, t-value 2.697).* These findings suggest that to compete with SOEs, POEs produce technologically enhanced products (Cao et al. 2019) due to a difference between the performance of SOEs and POEs. When we replace *MVAIC* with its components, the results also show a significant positive relationship between *FEM3* and *CEE (β = 0.103, t-value 2.857), HCE (β = 0.045, t-value 2.543), SCE (β = 0.036, t-value 3.537)*, and *RCE (β = 0.011, t-value 2.476)*, supporting *H2* and the CMT.

Additional test

Female director's critical mass, regional differences, and IC performance

China's development pace varied between regions and provinces (Fan et al. 2011). Eastern provinces progress more than Western and Central areas concerning GDP per

Table 8 Regression result with ownership structure perspective (SOEs sub-sample)

Variables	(1) $MVAIC_{i,t}$	(2) $CEE_{i,t}$	(3) $HCE_{i,t}$	(4) $SCE_{i,t}$	(5) $RCE_{i,t}$
FEM1	−0.042	−0.012	0.058	−0.030	−0.051
	(−0.748)	(−0.280)	(0.894)	(−0.957)	(−1.390)
FEM2	0.087	0.029	0.054	0.029	−0.013
	(1.148)	(0.521)	(0.630)	(0.692)	(−0.265)
FEM3	0.037	0.058	0.058	0.008	0.057**
	(0.339)	(0.727)	(0.470)	(0.141)	(2.213)
BS	0.018	0.007	0.012	0.009	0.010
	(0.809)	(0.460)	(0.495)	(0.726)	(0.723)
BI	0.052	−0.554	0.401	0.030	1.390***
	(0.081)	(−1.192)	(0.547)	(0.088)	(3.379)
FS	0.120**	−0.097**	0.372***	−0.038	−0.239***
	(2.098)	(−2.398)	(5.732)	(−1.269)	(−6.602)
CEOD	0.005	0.028	−0.054	0.030	−0.030
	(0.068)	(0.475)	(−0.587)	(0.690)	(−0.569)
FA	−0.019	0.003	−0.068***	0.011	0.044***
	(−1.425)	(0.278)	(−4.458)	(1.559)	(5.096)
ROA	0.491***	0.635***	0.326***	0.774***	−1.541***
	(6.004)	(7.917)	(6.126)	(2.716)	(−3.804)
LEV	−0.391*	2.071***	−0.562**	0.116	0.509***
	(−1.737)	(2.916)	(−2.197)	(0.961)	(3.515)
N	1,172	1,188	1,174	1,260	1,185
R^2	21%	35.1%	24.1%	23.3%	38.6%
Year dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes

The t-values are given in parentheses. ***, **, and * denotes significance at 1%, 5%, and 10%, respectively. Variable definitions are provided in Table 1

capita, investment, etc. (Cordeiro et al. 2013). China's Eastern area has reported greater IC levels than the Western region in recent years resulting in imbalanced economic growth (Xu and Li 2020). The faster economic growth of the Eastern region is due to its advantageous geographic location (Liu et al. 2018). Chao et al. (2015) analysed intellectual capital regionally using a sample of seventeen cities in Shandong Province in 2012. They found some disparities in how IC contributes to economic growth across the seventeen cities (Zhang and Jie 2017). The influence of IC components such as human capital, market capital, and renewal capital is smaller in the Western area than in the Eastern and Central regions. Recent researches show that manufacturing company performance differs in the various regions (Jin et al. 2018).

We estimate our models by dividing the sample into western, eastern, and central regions[4] (Table 9). The coefficient of *MVAIC* in the Eastern region shows the highest significant positive impact of *FEM3,* followed by Western and Central areas. *FEM3* has

[4] By following Xu and Li (2020), we considers Guangdong, Liaoning, Tianjin, Jiangsu, Beijing, Shanghai, Hebei, Guangdong, Hainan, Fujian, Shandong, and Zhejiang as eastern regions. The central regions includes is Hunan, Shanxi, Henan, Jiangxi, Jilin, Heilongjiang, Hubei, and Anhui. Finally, the western regions incudes Tibet, Inner Mongolia, Chongqing, Xinjiang, Yunnan, Ningxia, Guangxi, Qinghai, Gansu, Sichuan, Shaanxi, and Guizhou.

Table 9 Regression results with region perspective

Variables	(1) $MVAIC_{i,t}$	(2) $CEE_{i,t}$	(3) $HCE_{i,t}$	(4) $SCE_{i,t}$	(5) $RCE_{i,t}$
Panel A: eastern region					
FEM1	0.016	0.004	0.003	0.004	− 0.007
	(0.689)	(0.205)	(0.113)	(0.386)	(− 0.347)
FEM2	0.071**	0.014*	0.009*	0.006	0.013
	(2.502)	(1.655)	(1.819)	(0.538)	(0.567)
FEM3	0.102***	0.089**	0.054**	0.056***	0.039***
	(2.767)	(1.976)	(2.141)	(4.247)	(6.653)
N	5,921	6,000	5,923	6,159	4,875
R^2	0.191	0.372	0.302	0.231	0.479
Control variables	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes
Panel B: western region					
FEM1	0.015*	− 0.002	0.001*	− 0.003	− 0.010
	(1.803)	(− 0.813)	(1.651)	(− 0.876)	(− 0.222)
FEM2	0.017	0.015	0.014*	0.011	0.015**
	(1.493)	(1.255)	(1.818)	(0.333)	(2.084)
FEM3	0.026**	0.034***	0.032**	0.012**	0.033***
	(1.975)	(3.490)	(2.154)	(1.837)	(2.944)
N	858	1,043	862	1,105	1,040
R^2	0.154	0.503	0.218	0.037	0.311
Control variables	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes
Panel C: central region					
FEM1	− 0.047	0.025	0.014	0.033	− 0.054
	(− 0.553)	(0.634)	(0.157)	(1.332)	(− 1.359)
FEM2	0.078	0.026	0.134	0.056**	0.040
	(0.809)	(0.592)	(1.287)	(1.968)	(0.883)
FEM3	0.024*	0.098*	0.051**	0.016***	0.004*
	(1.919)	(1.842)	(2.000)	(3.462)	(1.877)
N	807	975	967	1,012	974
R2	0.128	0.587	0.238	0.035	0.530
Control variables	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes

The t-values are given in parentheses. ***, **, and *denotes significance at 1%, 5%, and 10%, respectively. Variable definitions are provided in Table 1

a stronger influence on a firm's CEE in the Central area compared to Eastern and Western regions in terms of IC components. Meanwhile, the impact of *FEM3* on a firm's *HCE* is more substantial in the Eastern than in Western or Central areas. This suggests that manufacturing firms in the East prioritized strengthening staff skills, capacities, and knowledge via training. The significant effect of female directors' critical mass on *SCE* and *RCE* is more substantial in Eastern areas, suggesting that these firms rely more on intangible assets like corporate culture, practices and systems, and solid connections

Table 10 Robustness check with alternative method—two-step system GMM estimation

Variables	(1) *MVAIC $_{i,t}$*	(2) *$CEE_{i,t}$*	(3) *$HCE_{i,t}$*	(4) *$SCE_{i,t}$*	(5) *$RCE_{i,t}$*
$MVAIC_{i,t-1}$	0.182***				
	(0.001)				
$CEE_{i,t-1}$		0.511***			
		(0.000)			
$HCE_{i,t-1}$			0.078**		
			(0.010)		
$SCE_{i,t-1}$				0.218***	
				(0.000)	
$RCE_{i,t-1}$					0.430***
					(0.001)
FEM1	0.032*	0.026	0.026	0.003	0.039
	(0.069)	(0.354)	(0.128)	(0.370)	(0.378)
FEM2	0.035**	0.032*	0.041**	0.068*	0.064
	(0.007)	(0.067)	(0.015)	(0.026)	(0.444)
FEM3	0.096**	0.076***	0.052*	0.087**	0.071***
	(0.004)	(0.000)	(0.067)	(0.005)	(0.000)
Control variables	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes
Observations	6,145	6,143	6,144	6,153	6,137
AR1 (p-value)	0.001	0.004	0.019	0.005	0.000
AR2 (p-value)	0.441	0.815	0.373	0.410	0.642
Hansen (p-value)	0.245	0.671	0.563	0.739	0.312
Difference-in-Hansen test (p-values)	0.358	0.426	0.539	0.222	0.409
Number of instruments	120	120	120	120	120

The p-values are given in parentheses. ***, **, and * denotes significance at 1%, 5%, and 10%, respectively. Variable definitions are provided in Table 1

with suppliers and customers. Moreover, manufacturing firms in economically distressed regions ignore SC and RC's importance.

Robustness check

Two-step system GMM estimation

To address the issue of endogeneity, Two-stage least squares and Three-stage least squares may be used to evaluate dynamic models; however, these methods need external tools challenging to get in finance (Wintoki et al. 2012), and only account for the dynamic aspect of endogeneity, that's always inherent in the relationship between BGD and organizational performance (Nadeem et al. 2017). The two-step system GMM is the best estimate approach in this case because it integrates internal instruments to cope with the endogeneity issue (Wintoki et al. 2012). We estimate all the equations using the two-step system GMM method, replacing the dependent variable of MVAIC with its four components (CEE, HCE, SCE, RCE) to study the influence of a critical mass of female directors:

$$\begin{aligned} MVAIC_{i,t} = & \alpha + \gamma MVAIC_{i,t-1} + \beta_1 FEM1_{i,t} + \beta_2 FEM2_{i,t} + \beta_3 FEM3_{i,t} \\ & + \beta_4 BS_{i,t} + \beta_5 BI_{i,t} + \beta_6 CEOD_{i,t} + \beta_7 ROA_{i,t} + \beta_8 FS_{i,t} \\ & + \beta_9 FA_{i,t} + \beta_{10} LEV_{i,t} + Industry_{i,t} + Year_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{6}$$

The results in Table 10 demonstrate that FEM3 has a statistically significant positive impact on IC performance when MVAIC is used as the dependent variable. Similar results are also obtained for the IC components such as *CEE, HCE,* and *RCE.* These findings are in line with our main conclusions. They indicate that three or more female directors in Chinese manufacturing firms enhance IC performance through their effective monitoring role (Ain et al. 2020). For brevity, we have reported the outcomes of the key variables.

Conclusions

IC is well-known as a source of wealth for improving a company's performance and retaining a competitive edge. Using the data from Chinese manufacturing companies from 2004–2017, our study investigates the effect of female directors' critical mass on IC performance using the CMT. We assess the impact of female directors segregating the data according to i) ownership structure (SOEs and POEs) and ii) regional differences (eastern, western, and central regions). As the dependent variable, we use the MVAIC model and its components. We find that three or more females on the board of directors significantly impact the MVAIC and its components. Secondly, FEM3 shows a more pronounced impact on the IC performance in the POEs concerning the SOEs and the IC performance of manufacturing firms in the Eastern region with respect to the Western and Central areas. Finally, in line with Kanter (1977), the results show a greater influence of women concerning corporate decisions, moving from "tokenism" to a "critical mass" scenario.

Implications

This study provides valuable tools for management policies, policymakers, regulators, and academicians. Critical Mass Theory allows us to measure the effect of three or more female directors' participation in the board of directors. The involvement of only one female director on the board will be labeled, stereotyped, and dismissed by the majority group, so the minority group size of female directors must be considered. If two female directors are appointed, the issue remains unsolved. 'Three' seems to be the cut-off point. Boards of directors should include "at least three women" to interact and influence board working styles, methods, and duties, which will better impact firms' intellectual capital performance. From a practical standpoint, this study closes the gap between theory and practice by giving policymakers and Chinese regulatory bodies a deeper understanding of the significance of having female board members as a key component of leveraging a firm's intangible performance. This is crucial in generating value and gaining a competitive edge in a knowledge economy. This study may also serve as a foundation for future research on female directors' critical mass participation in the IC performance in other developing markets.

For regulatory authorities

Recently, policymakers and regulatory bodies have instituted quotas to enhance the gender diversity of the board (Pothisarn et al. 2023). Countries have different minimum mandated percentages of women that should be included on company boards of directors. These countries also have different rules. On the one hand, the findings of our study demonstrate the significance of enacting legislation that pushes Chinese companies to raise the proportion of female board members. On the other hand, it offers light on the minimum threshold a board should attain to enjoy the advantages of having gender diversity.

For academician

This study examines several academic papers published between 1977 and 2017. Gender diversity on corporate boards has generally received support and recognition. Female representation on the board, as defined by the percentage of female directors on the board, has been the main focus of the majority of the research conducted (Nadeem et al. 2017; Shahzad et al. 2019; Sanyaolu et al. 2022) and have overlooked how CMPF, in particular, affect the knowledge-based economy's ability to create value. Additionally, by incorporating RC, this research accounts for the MVAIC model's multi-dimensional nature. As a result, this research adds to the existing literature by pinpointing the factors influencing IC efficiency in companies in emerging countries. The empirical results of this research reveal that in a knowledge-based economy, a gender-diverse board may develop favorable policies for leveraging intellectual resources—which is a fundamental cause of value creation and competitive advantage for companies. The findings of this study may help theorists define the correct proportion of women on corporate boards in emerging economies like China.

The research reported in this paper has some limitations, which may affect the interpretation and generalizability of the results. These limitations can serve as directions for future investigation. First, our research sample is limited by the unique structure of the Chinese market, with most companies owned by the government, unlike in the developed economies. Further research can verify the same arguments in developed countries and examine the role of female directors in improving IC performance by considering sub-national institutional contingencies such as concentrated ownership and family firms. This might be interesting since Chinese companies operate under a two-tier governance framework. Second, the MVAIC model is used to quantify IC performance, a quantitative metric that may not incorporate the firm's innovation, research, and development costs. Because investments in innovation capital are regarded as the fundamental criterion of SC in the literature, future researchers might include it in the MVAIC model and increase IC latitude. Future studies may further be classified and measure IC in terms of different components, e.g., the balanced scored card approach, market capitalization method, the intangible asset monitor, and the Skandia.[5]

[5] For detail of these components, see the study of Xu and Wang (2018).

Abbreviations

ICP	Intellectual capital performance
MVAIC	Modified value-added intellectual coefficient
CG	Corporate governance
BGD	Board gender diversity
CMT	Critical mass theory
CMPF	Critical mass participation of females

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Declarations

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