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Submitted 06-20-2023. Approved 12-12-2023

Evaluated through a double-anonymized peer review. Associate Editor: Ebes Esho

Reviewers: Jorge Alcaraz, Universidad de Monterrey, Nuevo León, México. The other three reviewers did not authorize disclosure of their identity and peer review report.

The Peer Review Report is available at this link.

Original version | DOI: http://dx.doi.org/10.1590/S0034-759020240303

INNOVATION EFFICIENCY, OVERSEAS EXPERIENCE OF CHIEF EXECUTIVE OFFICER, AND FIRM VALUE IN CHINESE CHIP COMPANIES

Eficiência em inovação, experiência internacional do diretor executivo e valor da empresa em companhias de chips chinesas

Eficiencia en innovación, experiencia internacional del director ejecutivo y valor de la empresa en compañías chinas de chips

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ABSTRACT

This study examines the impact of CEO overseas experience and innovation efficiency on firm value. Using the propensity score matching technique with 645 observations from 129 Chinese chip companies listed from 2015 to 2019, we found that CEOs with overseas experience significantly increase firm value. Innovation efficiency has a significantly positive effect on firm value. Importantly, CEO overseas experience moderates the impact of innovation efficiency on firm value, indicating that these CEOs are better able to leverage innovation for value creation. The results underscore the importance of attracting and retaining CEOs with overseas experience and enhancing innovation efficiency to stay competitive. The study has theoretical and policy implications for companies, policymakers, and industry stakeholders.

Keywords: CEO overseas experience, innovation efficiency, firm value, propensity score matching method, Chinese chip companies.

RESUMO

Este estudo examina o impacto da experiência internacional do CEO e da eficiência da inovação no valor da empresa. Utilizando a técnica de pareamento por escore de propensão com 645 observações de 129 empresas chinesas de chips listadas na bolsa de valores de 2015 a 2019, descobrimos que CEOs com experiência internacional aumentam significativamente o valor da empresa. A eficiência da inovação tem um efeito positivo significativo no valor da empresa. Notavelmente, a experiência internacional do CEO tem efeito moderador em relação ao impacto da eficiência da inovação no valor da empresa, indicando que esses CEOs têm melhor capacidade de aproveitar a inovação para a criação de valor. Os resultados destacam a importância de atrair e reter CEOs com experiência internacional e aprimorar a eficiência da inovação para se manter competitivas. O estudo tem implicações teóricas e políticas para empresas, formuladores de políticas e partes interessadas na indústria.

Palavras-chave: *experiência internacional do CEO, eficiência da inovação, valor da empresa, método de pareamento por escores de propensão, empresas de chips chinesas.*

RESUMEN

Este estudio examina el impacto de la experiencia internacional del CEO en el valor de la empresa y la eficiencia de la innovación en el valor de la empresa. Utilizando la técnica de coincidencia de puntuación de propensión con 645 observaciones de 129 empresas de chips chinas que cotizan en bolsa durante el período de 2015 a 2019, encontramos que los CEO con experiencia en el extranjero aumentan significativamente el valor de la empresa. Es importante destacar que la experiencia internacional del CEO modera el impacto de la eficiencia de la innovación en el valor de la empresa, lo que indica que dichos CEO están en mejores condiciones de aprovechar la innovación para la creación de valor. Los resultados subrayan la importancia de atraer y retener CEO con experiencia en el extranjero y mejorar la eficiencia de la innovación para mantenerse competitivos. Este estudio tiene implicaciones teóricas y políticas para las empresas, los formuladores de políticas y las partes interesadas en la industria.

Palabras clave: *experiencia internacional del CEO, eficiencia de la innovación, valor de la empresa, método de emparejamiento de puntaje de propensión, empresas de chips chinas.*

INTRODUCTION

Previous literature suggested that both the implicit and explicit characteristics of top management teams (TMT) play a decisive role in a firm's strategic management process and performance. Researchers have attempted to explore CEO characteristics as critical factors for predicting firm performance from various perspectives (Shahab & Ye, 2018). For instance, studies have focused on CEOs' gender and educational background (Huang, 2013; Mazutis, 2013; McGuinness et al., 2017), age and tenure (Huang, 2013; Kang, 2017), CEOs' or senior managers' political connections (Marquis & Qian, 2014; Shahab et al., 2018), CEOs' confidence level (McCarthy et al., 2017), CEO duality (García-Sánchez et al., 2013), CEO's nationality (Huang, 2013), and reputation (Borghesi et al., 2014; García-Sánchez et al., 2013).

According to the upper echelons theory, top managers, especially CEOs, play a crucial role in strategic decision-making and implementation, which ultimately impacts the performance or growth of the firm (Abatecola & Cristofaro, 2020; Hambrick, 2007; Hambrick & Mason, 1984). From this perspective, the psychological characteristics of TMT, such as cognitive orientation and values, and their outward characteristics, such as age, work experience, and educational background, are essential determining factors in the firm's strategic management process and performance. Studies have indicated that the characteristics of top management (especially CEOs) can motivate a stronger commitment to execution in the face of environmental constraints and strategic challenges. This heightened commitment leads to improved innovation efficiency within the company, ultimately positively impacting its overall performance (Ntim & Soobaroyen, 2013; Shahab et al., 2018; Soobaroyen & Ntim, 2013). In other words, specific characteristics of CEOs can serve as significant antecedents for sustainable environmental management and performance within the firm.

However, these studies have some gaps. Firstly, these studies have primarily focused on developed markets, and there has been insufficient consideration given to the performance and management phenomena of enterprises in developing markets (e.g., McGuinness et al., 2017; Shahab et al., 2018). Therefore, this study's findings rely heavily on data from developed markets, which may not be easily applicable to developing countries such as China. This is because developed and developing countries exhibit significant differences in technological environments and implementation mechanisms. This could impact a comprehensive understanding of the driving factors behind technological innovation efficiency and firm value.

Secondly, most of these studies have predominantly emphasized the more prominent characteristics of CEOs, such as age, educational background, gender, CEO duality, tenure, and political connections (Huang, 2013; Kang, 2017; Marquis & Qian, 2014; Mazutis, 2013; McGuinness et al., 2017). In contrast, existing studies have not sufficiently explored how and why CEO overseas experience influences a company's engagement in technological innovation practices, thereby positively impacting its value.

Thirdly, one of the primary issues in studying innovation efficiency and value of enterprises is the cross-sectional nature of data (Lau et al., 2016), and relevant studies (Haque & Ntim, 2018; Liao et al., 2015) often suggest that longitudinal analysis of a company's technological innovation strategy could lead to a better understanding. This study also aims to contribute to the existing literature by using panel data from 2015 to 2019, allowing for a unique examination of whether the potential impact of CEO's characteristics on innovation efficiency and firm value varies over time. Hence, this study empirically investigates the innovation efficiency and firm value of Chinese publicly-listed chip companies, adopting the theoretical perspectives of the upper echelons theory (Abatecola & Cristofaro, 2020; Hambrick, 2007; Hambrick & Mason, 1984).

China's expenditure exceeded USD 378 billion in research and development in 2020 alone, an increase of 10% compared to 2019 (Chen et al., 2022). This amount represents the level of innovation investment second only to the United States. However, innovation often carries risks. It requires flexibility and is considered expensive, time-consuming, and uncertain (Cao et al., 2015; Lee & Yang, 2014; Sariol & Abebe, 2017). Investing funds into innovative projects, considering their relative efficiency, may lead to resource abuse and reduce firm profitability. In order to solve this problem, improving innovation efficiency is of great significance for enhancing the firm value. Chinese publicly listed chip companies are the subjects of this study. Panel data from 2015 to 2019 was selected to investigate how the overseas experience of CEOs affects the management of technological innovation and the value of companies subject to overseas policies and regulations. Specifically, this study focuses on the overseas experience background of CEOs as a critical attribute and employs empirical analysis drawing on the theoretical perspectives of upper echelons theory.

Overall, this study seeks to contribute to the existing literature uniquely. Firstly, it investigates the influence of a new CEO characteristic - overseas experience - on the technological innovation management and value of Chinese enterprises. Specifically, in this study, CEO overseas experience is treated as a key factor, drawing on the theoretical insights of the upper echelons theory (Abatecola & Cristofaro, 2020; Hambrick, 2007; Hambrick & Mason, 1984). Our research findings demonstrate that CEO overseas experience plays a crucial role in determining the innovation efficiency and value of Chinese enterprises. Secondly, this study employs the propensity score matching (PSM) method for group regression tests to investigate the relationships between variables more accurately, avoiding errors caused by sample heterogeneity. Additionally, group regression helps us gain a better understanding of the relationships between variables, offering more targeted recommendations for practical applications (Koenker & Bassett, 1978). Thirdly, there is a scarcity of previous literature examining the specific relationship between CEO unique characteristics, innovation efficiency, and firm value in the context of the Chinese market or other developing countries' markets.

The research process involves reviewing existing literature to construct the relationship model between CEO overseas experience, innovation efficiency, and firm value. Next, a counterfactual inference model is proposed using the propensity score matching method,

followed by regression analysis. Finally, the study discusses the impact of CEO overseas experience and innovation efficiency on firm value, and the moderating effect of CEO overseas experience based on the empirical results.

LITERATURE REVIEW

According to the upper echelons theory, the psychological and observable characteristics of senior executives, such as past experiences, career trajectories, educational backgrounds, and age, are critical factors in the implementation of strategic policies. Therefore, this study draws upon the arguments of the upper echelons theory (Hambrick, 2007; Hambrick & Mason, 1984) to provide insights on innovation efficiency and CEO overseas experience on firm value.

Most studies have adopted external environmental and internal management perspectives to explore firm innovation performance. For instance, innovation openness can accelerate the flow of innovation resources and facilitate the effective circulation of internal and external resources, thereby enhancing firm innovation performance (Laursen & Salter, 2006; Miotti & Sachwald, 2003; Tsai, 2009). Environmental regulations also impact firm innovation performance through relevant mediators (Albertini, 2013). CEO overseas experience provides them with excellent international education, advanced management skills, and advanced technological experience from foreign countries (Gu, 2022). CEO overseas experience helps companies better understand international market information and overcome information asymmetry, thereby facilitating the development of international business on a global scale. These advantages enable them to make high-quality decisions (Xu & Hou, 2021). While scholars have studied the educational background, characteristics, and other factors of the board of directors or top management (e.g., Johnson et al., 1993; Nekhili & Gatfaoui, 2013; Papadimitri et al., 2020), limited research has been conducted from the perspective of upper echelons theory on how the CEO overseas experience moderates the relationship of innovation efficiency and firm value.

One of the main challenges in studying innovation efficiency and firm value is the cross-sectional data (Lau et al., 2016). Studies often suggest employing longitudinal analysis of a company's technological innovation strategy (Haque & Ntim, 2018; Liao et al., 2015). Furthermore, it is worth noting that previous studies have predominantly concentrated on developed markets, leading to inadequate attention given to the performance and management dynamics of enterprises in developing markets (e.g., McGuinness et al., 2017; Shahab et al., 2018). Many scholars typically use the product of the independent and moderator variables to test for moderation effects. However, this approach overlooks the possibility of employing the PSM method for conducting grouped regression, which allows for a precise examination of relationships between variables and avoids errors caused by sample heterogeneity (Koenker & Bassett, 1978).

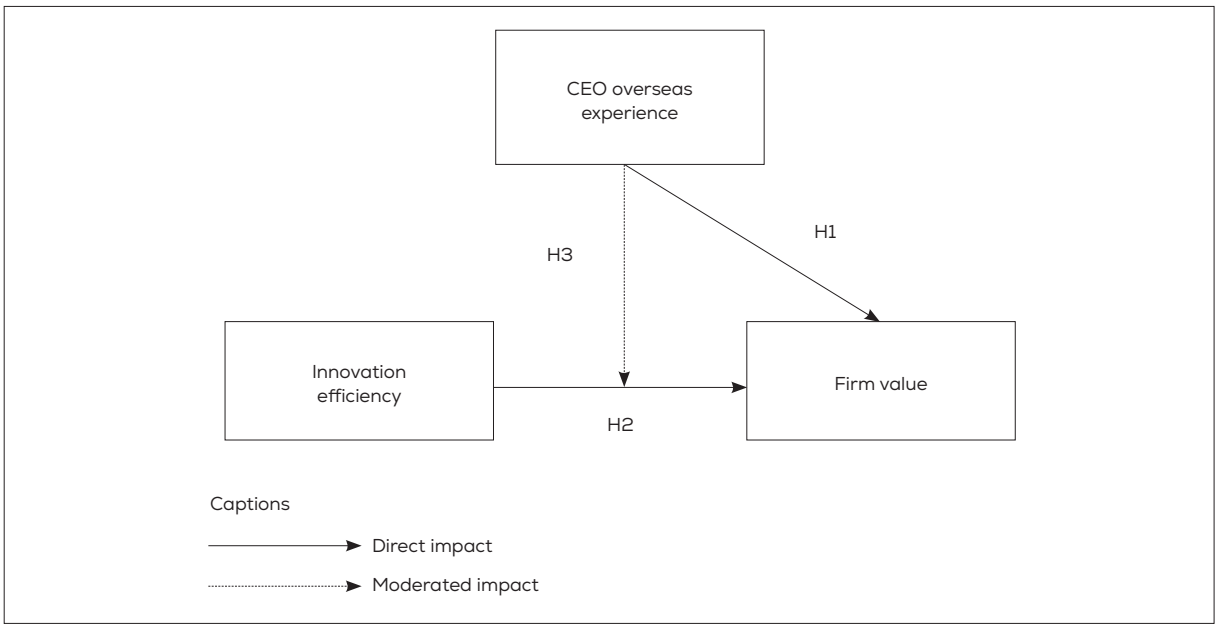
CEO overseas experience and firm value

Firm value is a representation of the company's achievements (Safitri et al., 2020), which indicates the level of trust the public has in the company based on its activities over the years (from its establishment until the present). There are various ways to measure firm value. In this study, Tobin's Q is used as a measure of firm value (Chung et al., 2019; Tseng & Goo, 2005; Wang, 2015). Overseas background is considered an essential component of human capital, representing a good educational background or professional knowledge (Quan et al., 2021). Upper echelons theory explains how overseas experience can influence an individual or team's cognitive ability and values (Nielsen & Nielsen, 2011). CEOs with overseas experience are better equipped to acquire broader knowledge and skills and utilize this pathway to enhance corporate governance and performance (Yuan & Wen, 2018).

CEOs with a good education or practical work experience abroad typically possess exceptional insight and information processing ability (Hsu et al., 2013). First, overseas capital markets are usually subject to strict regulations, and CEOs with overseas experience know the serious consequences of manipulating company information. In addition, to ensure the stable development of firms, CEOs with overseas experience can learn from the experiences of overseas capital markets and listed companies and carefully disclose information to avoid affecting the stock prices of listed companies (Bai et al., 2020). Secondly, CEOs with overseas experience can effectively obtain cutting-edge, dynamic information about their industry. Furthermore, overseas experience improves the CEO's ability to integrate knowledge, search and process information, and correctly evaluate the risks of strategic decisions. CEOs with overseas experience can provide more advanced management experience and technology, reduce the uncertainty of strategic decisions, promote the development of overseas markets and mergers and acquisitions, and contribute to expanding firm scale and improving firm performance (Xie et al., 2019). Finally, overseas experience strengthens the CEO's commitment to fulfilling their social responsibility. CEOs with overseas experience identify more strongly with the concept and principles of corporate social responsibility, better understand its importance, and become more familiar with the operational mode and practices of overseas corporate social responsibility. They can then apply this practical experience to domestic firms (Morsing & Spence, 2019; Parsa et al., 2021; Xu & Hou, 2021).

Empirically, existing literature has also demonstrated the relationship between CEO overseas experience and firm value or performance (Figure 1). For instance, based on upper echelons, resource dependence, and agency theory, research has found that CEO characteristics impact firm value (Polsiri & Sitthipongpanich, 2014). Drawing from upper echelons theory and behavioral theory, it has been revealed that CEO overseas experience influences corporate social responsibility (Xu & Hou, 2021). Additionally, some studies have shown a positive effect of CEO overseas experience on firm innovation performance (Cao et al., 2022).

Figure 1. Theoretical research model



Based on the above, this study proposes the following hypotheses:

H1: CEO overseas experience can significantly enhance the firm value.

Innovation efficiency and firm value

Innovation efficiency refers to the input-output ratio of technological innovation resources, indicating the efficiency of allocating technological innovation resources (Ghasemaghaei & Calic, 2020). In the face of global market competition, firms are increasingly focusing on innovation strategies to provide new products and services based on innovative technology, which in turn can improve firm value (Mehmood et al., 2019). Some studies show that technological innovation has a significant positive impact on firm value (Li et al., 2020; Simeth & Cincera, 2016). Through technological innovation, firms can create intangible resources that offer competitive advantages that are difficult for competitors to replicate. These intangible resources are crucial to maintaining sustainable competitive advantages and enhancing firm value (Donnellan & Rutledge, 2019; Khan et al., 2019).

However, despite the extensive attention given to the importance of innovation, there is no consistent conclusion about the relationship between firm innovation and firm value in previous studies. Several studies have shown that there may be no relationship, negative correlation, or an inverted U-shaped relationship between firm innovation and firm value (Kim et al., 2018; Luo et al., 2022; Sun et al., 2019). The underlying reason for this is that while firm innovation can lead to excess profits, it also introduces high levels of uncertainty and unpredictability, increasing the

risk of R&D failure and, consequently, damaging firm value. Within a certain range, innovation can promote the improvement of firm value, but beyond this range, it may lead to problems such as high R&D costs, long R&D cycles, and increased risk, ultimately constraining the growth of firm value. Furthermore, the relationship between firm innovation and firm value may take time to materialize, with innovation having a negative impact on short-term performance but a positive impact on the long-term performance of the firm (García-Cabrera et al., 2021; Saether et al., 2021). However, this study argues that under the condition of excluding other confounding factors, innovation efficiency remains a crucial source for firms to develop unique competitive advantages and maintain core competitiveness, ultimately positively impacting the long-term value of firms. Therefore, this study proposes the following hypotheses:

H2: Innovation efficiency can significantly enhance firm value.

CEO overseas experience, innovation efficiency, and firm value

In clarifying the uncertain relationship between innovation efficiency and firm value in previous research (e.g., Kim et al., 2018; Luo et al., 2022; Sun et al., 2019), it is seen that certain factors might have interfered. This study specifically introduces CEO overseas experience to explore its moderating effect. As a special form of human capital, CEO overseas experience can compensate for the lack of innovation resources and capabilities and significantly improve the levels of applied and exploratory innovation (McKelvie & Davidsson, 2009; Verona & Ravasi, 2003). A CEO's diverse experiences and backgrounds can bring complementary knowledge and ideas, and CEOs with overseas experience are particularly well-suited to inspiring different perspectives and generating innovative thinking (Li, 2022; Zhang et al., 2022).

In fact, firm innovation is a long-term and high-risk investment decision with a high probability of R&D failure due to its high uncertainty and unpredictability, which can damage firm value. However, overseas study or work experience can increase the human and social capital of the senior management team, help firms establish connections with foreign social networks, access external information and resources, reduce the uncertainty of innovation, and improve the chance of innovation success (Xu & Hou, 2021).

The CEO's preferences can greatly influence the innovation input of firms, and more innovative CEOs tend to invest more in innovation (Wang et al., 2022; Zhang et al., 2021). On the one hand, a more innovative CEO can indirectly influence the innovation ability and willingness of the entire organization by influencing the organizational culture, thereby promoting the number of firm innovation projects. On the other hand, more innovative CEOs are more likely to attach importance to firm innovation in terms of strategy, thus improving the approval and investment rates of innovation projects (Wang et al., 2022).

Senior executives with overseas study experience often possess cutting-edge professional knowledge and a perfect knowledge structure, which can compensate for the firm's lack of

knowledge and technology and improve the utilization efficiency of existing knowledge and technology, leading to product optimization and improvement. CEOs with overseas working experience have rich work experience and a deeper understanding of product market positioning and customer demand (Vissak et al., 2020). They can better play their consulting function and provide constructive suggestions for product optimization and improvement, which is conducive to realizing the level of applied innovation and improving firms' ability. Thus, this study proposes the following hypothesis:

> H3: CEO overseas experience significantly moderates the relationship between innovation efficiency and firm value.

METHODS

Propensity score matching method (PSM)

PSM is employed in this study for group regression analysis to test the moderating effect of CEO overseas experience. PSM assists us in mitigating bias in observational data by approximating randomized experimental data through matched resampling. It effectively addresses selection bias and biased estimation issues caused by sample self-selection (Rosenbaum & Rubin, 1983). The purpose of propensity matching is to identify firms in the unprocessed group that share similar characteristics with those in the processed group, enabling the construction of counterfactual results. Specifically, during the matching process, the sample is divided into two groups: the treatment group (T), which comprises firms with CEOs possessing overseas experience, and the control group (C), which includes firms with CEOs lacking overseas experience. Let D={T, C} represent all the firm samples. To address the issue of selection bias, the matching method selects enterprises whose CEOs lack overseas experience and have a probability of possessing such experience that is very similar to that of the CEO in the control group. Using various covariates, the probability of firm i appearing in the treatment group, i.e., the probability of the CEO having overseas experience, is estimated, and the propensity score is calculated using Logit:

$$P(X_i) = P_r(D_i = 1|X_i) = F[h(X_i)] \quad (1)$$

Here, *Di* {0,1} represents whether the sample is in the treatment group, F(·) denotes the functional form of the Logistic model, and X_i represents the covariate vector comprising factors that affect the impact of CEO overseas experience on firm value. In this study, capital structure, profitability, and firm size are selected as matching variables. The estimated probability value of a CEO having overseas experience denoted as , can be obtained through calculations.

Propensity score matching is then employed to match firms with similar predicted probability values, resulting in the creation of a control group of firms with similar characteristics to the treatment group, denoted as C_p.

Econometric models

The primary objective of this study is to examine whether there is a noteworthy difference in firm value between companies whose CEOs possess overseas experience and those whose CEOs lack such experience after controlling for other factors. To test hypothesis H1, which suggests that CEOs with overseas experience facilitate an improvement in firm value, this study establishes the following fundamental regression equation:

$$\ln(FV) = \beta_0 + \beta_1 OE + \delta_1 IE + \delta_2 Cap + \delta_3 Pro + \delta_4 Size + \varepsilon \quad (2)$$

$\ln(FV)$ represents the natural logarithm of firm value. *OE* is a binary variable that indicates whether a company belongs to the treatment group, i.e., whether its CEO possesses overseas experience. If the CEO has such experience, the company is assigned to the treatment group, and *OE* is coded as 1; otherwise, it is assigned to the control group, and *OE* is coded as 0. *IE* (innovation efficiency), *Cap* (capital structure), *Pro* (profitability), and *Size* (firm size) are the control variables. These variables influence not only the firm value but also whether the firm is affected by the CEO's overseas experience. ε denotes the error term.

To test hypotheses H2 and H3, which suggest that higher innovation efficiency contributes to the improvement of firm value, and that CEO overseas experience positively moderates the relationship between innovation efficiency and firm value, this study extends the regression equation (2) by introducing CEO overseas experience as a grouping variable. The purpose is to investigate the difference in the impact of innovation efficiency on firm value between companies with and without CEO overseas experience.

$$\ln(FV_\tau) = \beta_{\tau 0} + \beta_{\tau 1} IE + \delta_{\tau 1} Cap + \delta_{\tau 2} Pro + \delta_{\tau 3} Size + \varepsilon_\tau, \; if \; OE\_\tau(\tau = 1,2,3) \quad (3)$$

In the regression equation (3), we define OE_τ as the measure of heterogeneity in CEO overseas experience. Specifically, *OE*_1 represents CEOs with overseas experience, *OE*_2 represents CEOs without overseas experience, and *OE*_3 encompasses the entire sample. Our focus in this study is on $\beta\tau 1$ (τ=1,2,3), as it allows us to assess the heterogeneous impact of innovation efficiency on firm value based on whether the CEO has overseas experience or not.

Procedure and sample

This study examines a sample of chip companies listed on the main board in China, the GEM Board, and the Science and Technology Innovation Board from 2015 to 2019. The data used in this study is primarily sourced from the financial statements, financial indicators, shareholder information, executive information, notes on financial statements, and CEO's resumes disclosed by the listed companies of Eastern Wealth Choice Financial Terminal and China Stock Market & Accounting Research database (CSMAR). We excluded ST and *ST companies, companies with discontinuous or missing market value data from 2015 to 2019, and companies with missing R&D expense data from the exported data. Finally, we obtained valid data from 129 Chinese listed chip companies for the period from 2015 to 2019, which resulted in a panel dataset comprising 645 observations. Table 1 presents the definition and descriptive analysis of each variable.

Table 1. Variable definition and descriptive statistical analysis

Variable	Symbol	Definition	OE=1			OE=0		
			Sample	Mean	SE	Sample	Mean	SE
Firm value	FV	Tobin'Q = market value/ book value of total assets	155	3.38	2.81	490	2.38	2.05
Firm value_ Sub	FV_sub	Market value + debt - cash	155	154.47	230.14	490	227.53	435.57
Innovation efficiency	IE	Intangible assets/total R&D expenditure	155	1.57	2.60	490	1.89	3.89
Innovation efficiency_ Sub	IE_sub	R&d expenditure/ operating income	155	2.39	5.00	490	6.01	16.37
Capital structure	Cap	Total debt/total assets (%)	155	34.79	17.02	490	38.87	20.22
Profitability	Pro	Net profit/operating income (%)	155	7.23	13.66	490	7.03	22.01
Firm size	Size	Ending total assets	155	70.99	131.19	490	169.28	403.60

Measure of firm value

Firm value refers to a firm's overall value, which is typically measured as the fair market value of its assets. The most common approach to measuring firm value is the income method (e.g., Almabekova et al., 2018; Plenborg, 2002; Hastuty et al., 2023), which expresses it in terms of return on equity, or the assets method, which uses total or net assets. Another popular method is the market method, which relies on Tobin's Q value or the market value of the firm's stock. Among these, Tobin's Q value is widely used by scholars. For instance, it has been employed to investigate the links between CEO R&D experience, technological innovation, and firm value (Tseng & Goo, 2005; Wang, 2015), and the relationship between environmental uncertainty, firm innovation, and firm value (Chung et al., 2019). Tobin's Q reflects the current performance of firms and provides a better reflection of their value, expressed as the market value divided by the book value of total assets.

Measure of CEO overseas experience

CEO overseas experience is analyzed as a binary variable, where a value of 1 indicates that the CEO has overseas experience, and 0 indicates that the CEO has no such experience. CEO Overseas experience includes educational, training, work, and life experiences gained abroad, which may bring additional value to the CEO and potentially impact the firm. Information on CEO overseas experience is obtained from the executive characteristics disclosed in the executive information of listed companies.

Measure of innovation efficiency

The focus of this study is on measuring the efficiency of technology innovation, also known as innovation efficiency, which is of utmost importance in the chip manufacturing industry where technology replacement is frequent. Various indicators have been used by scholars to measure technological innovation, such as the ratio of R&D expenses to revenue, the number of patent applications, and the ratio of R&D personnel to the total number of employees. In this study, intangible assets are used to represent technological output. This approach is adopted because new projects developed by firms undergo R&D and development stages. The expenditure during the R&D stage is included in the R&D expense in accounting, while the cost during the development stage is capitalized as intangible assets. Land use rights and copyrights are excluded from intangible assets since they have a relatively minor impact on firms' technological innovation, making the innovation output more accurate.

Measure of control variables

This study includes three control variables: capital structure, profitability, and firm size. Capital structure refers to the composition and proportion of the various long-term capital sources of an enterprise, which is crucial for its capital management. Optimal capital structure can help the enterprise raise required funds with the lowest weighted average cost of capital, thereby maximizing enterprise value. Profitability significantly impacts firm value since an enterprise's goal is to make profits and pursue profit maximization. Profits can add value to shareholders' rights and interests, increase internal retention, and enhance enterprise development. Firm size also affects firm value. As per the scale economy effect, the larger the firm, the lower the production cost, leading to increased firm value due to cost reduction.

RESULTS

PSM test

The fundamental concept of PSM is to identify an appropriate control group (companies without CEO overseas experience) for the treatment group (companies with CEO overseas experience). Common matching methods include minimum radius matching, nearest neighbor sample matching, and kernel estimation matching, among others. Regardless of the matching method, the final results should ideally be similar. For this study, the kernel density function matching method was selected. By utilizing the measurement equation (1) and observable matching variables, the predicted probability value of each firm's CEO having overseas experience can be computed. Subsequently, similar firms without CEO overseas experience can be identified for each firm with CEO overseas experience. Following the model matching process, the estimated value of the average treatment effect (ATT) was 0.7799, with a corresponding T-value of 3.15. The T-value exceeded the critical value of 2.58, indicating a significant treatment effect at a 1% significance level.

After obtaining propensity scores, it is crucial to ensure the accuracy of the propensity score matching results by testing for significant differences in covariates between the treatment group and the control group, also known as a balance test. As shown in Table 2, prior to matching, some variables exhibited significant differences between the control and treatment groups. However, after matching, all variables in both groups showed no significant differences. Table 2 also demonstrates that the absolute standard deviation value for each matching variable is below 5%. Additionally, the P-values of all variables in the t-test are greater than 10% and pass the joint test. These results indicate that the selected matching variables and methods are reasonable, ensuring the reliability of the estimation results in this study. Moreover, the obtained samples guarantee the randomness of the sample processing.

Table 2. PSM balance test results

Variable	Before the match (U) After the match (M)	Mean		Deviation rate	Deviation rate reduction ratio (%)	T-test	
		Treatment group	Control group			t值	p>|t|
IE	U	1.57	1.89	-9.6		-0.96	0.34
	M	1.58	1.44	4.1	57.2	0.49	0.62
IE_sub	U	2.39	6.01	-29.9		-2.71	0.01
	M	2.40	1.98	3.5	88.3	0.87	0.39
Cap	U	7.23	7.03	1.1		0.11	0.91
	M	7.82	9.85	-11.1	-902.1	-1.23	0.22
Pro	U	34.79	38.87	-21.8		-2.27	0.02
	M	34.86	34.91	-0.3	98.8	-0.02	0.98
Size	U	70.99	169.28	-32.8		-2.98	0.00
	M	71.40	73.09	-0.6	98.3	-0.12	0.91
Sample (Joint test)		Pseudo R2		LR chi2		p>chi2	
Before the match (U)		0.02		16.81		0.01	
After the match (M)		0.01		4.62		0.46	

Multicollinearity test

To ensure the precision and accuracy of the regression model, a multicollinearity test will be conducted on the independent variables and control variables of the model presented below. This study employed tolerance and Variance Inflation Factor (VIF) to diagnose the issue of multicollinearity. Severe multicollinearity is defined when the tolerance is less than 0.1 or when the VIF exceeds 10. As indicated in Table 3, all variables in this study exhibit tolerance values greater than 0.1, and the VIF values are below 10. These findings suggest that the established regression model does not suffer from severe multicollinearity, and the results are relatively accurate, providing valuable insights for reference.

Table 3. Correlation matrix and collinearity diagnosis

Variable	Tolerance	VIF	OE	IE	Cap	Pro	Size
OE	0.96	1.04					
IE	0.97	1.04	-0.038				
Cap	0.79	1.26	-0.089*	-0.004			
Pro	0.90	1.12	0.004	-0.172***	-0.244***		
Size	0.84	1.19	-0.117**	-0.038	0.382***	-0.15	
FV	-	-	0.185***	0.086*	-0.489***	0.107***	-0.259***

Note. * p < 0.05; ** p < 0.01; ***p < 0.001; the matrix exhibits Pearson correlation coefficients.

Group regression analysis

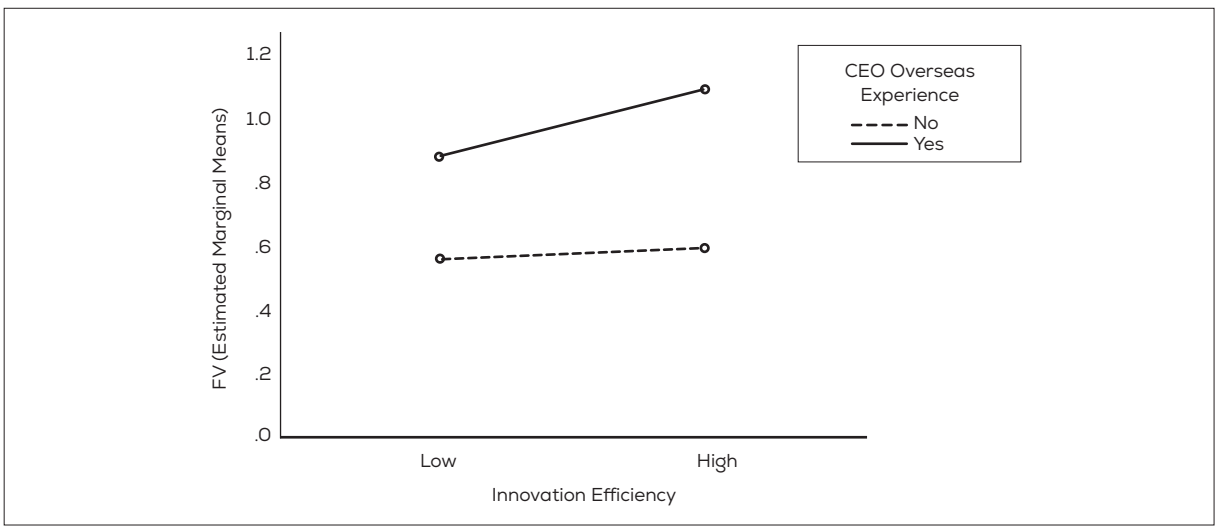
The results are presented in Table 4, where Model (1) examines the individual effects of CEO overseas experience and innovation efficiency on firm value. Additionally, to investigate the moderating effect of CEO overseas experience, Model (3) and Model (4) illustrate the impact of innovation efficiency on firm value for companies with and without CEO overseas experience, respectively. According to the results of Model (1), CEO overseas experience (β=0.229, p<0.001) exhibits a significant positive impact on firm value. This empirical result supports hypothesis 1. Based on the findings from Model (5), innovation efficiency (β=0.014, p<0.05) demonstrates a significant positive influence on firm value. This empirical result provides support for hypothesis 2. Based on the findings from Models (3) and (4), the inclusion of CEO overseas experience significantly enhances the model's explanatory power. In the sample group of CEOs with overseas experience, innovation efficiency (β=0.060, p<0.001) demonstrates a significant positive impact on firm value. However, in the sample group of CEOs without overseas experience, innovation efficiency does not significantly influence firm value. Model 2 further clarifies that innovation efficiency is influenced by the level of CEO experience. Innovation efficiency (β=0.008, p>0.05) becomes insignificant, while the interaction between CEO overseas experience and innovation efficiency exercises a positive and significant effect on firm value (β=0.055, p<0.01). This empirical result supports hypothesis 3. The interaction plot in Figure 2 indicates that when the CEO possesses overseas experience, the positive impact of innovation efficiency on firm value is greater compared to cases where the CEO lacks overseas experience.

Table 4. The Influence of CEO Overseas experience and innovation efficiency on firm value: Group regression analysis

			The heterogeneity of the CEO		
			OE_1	*OE_2*	*OE_3*
Model	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Variable	**ln(FV)**	**ln(FV)**	**ln(FV)**	**ln(FV)**	**ln(FV)**
OE	0.229*** (0.061)	0.140* (0.070)			
IE	0.015* (0.007)	0.008 (0.008)	0.008 (0.008)	0.060*** (0.019)	0.014* (0.007)
IE*OE		0.055** (0.022)			
Cap	-0.022*** (0.001)	-0.022*** (0.001)	-0.021*** (0.002)	-0.023*** (0.003)	-0.022*** (0.001)
Pro	0.002 (0.001)	0.002 (0.001)	0.001 (0.001)	0.004 (0.004)	0.002 (0.001)
Size	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	-0.001** (0.000)	0.000*** (0.000)
Constant	1.429*** (0.067)	1.444*** (0.067)	1.407*** (0.074)	1.685*** (0.129)	1.502*** (0.064)
R2	0.395	0.401	0.370	0.444	0.381
Observations	645	645	490	155	645

Note. * p < 0.05; ** p < 0.01; ***p < 0.001; the values in parentheses are standard errors.

Figure 2. Interaction effect of innovation efficiency with CEO overseas experience on firm value



Robustness test

To bolster the robustness of the regression analysis, this study introduces a refinement by replacing the variable FV_sub (comprising market capitalization, debt, and cash) with Tobin's Q value as a measure of firm value. Additionally, the variable for innovation efficiency (total intangible assets divided by R&D expenditure) is transformed into IE_sub (R&D expenditure divided by operating income). The regression analysis is then conducted once more using these replaced variables. The results demonstrate consistent findings across the models, as illustrated in Table 5.

Table 5. The influence of CEO overseas experience and innovation efficiency on firm value: robustness test

Model	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variable	ln(FV)	ln(FV)	ln(FV)	ln(FV)	FV_sub	FV_sub	FV_sub	FV_sub
OE	0.223*** (0.061)				27.678* (12.992)			
IE_sub					3.102*** (0.683)	2.159** (0.695)	32.771*** (2.752)	3.080*** (0.685)
Cap	-0.022*** (0.001)	-0.021*** (0.002)	-0.024*** (0.003)	-0.022*** (0.001)	-0.788* (0.316)	-0.704* (0.351)	-0.181 (0.555)	-0.821** (0.316)
Pro	0.001 (0.001)	0.001 (0.001)	0.004 (0.004)	0.001 (0.001)	0.756** (0.281)	0.558* (0.297)	1.696** (0.597)	0.750** (0.282)
Size	0.000*** (0.000)	0.000*** (0.000)	-0.001** (0.000)	0.000*** (0.000)	0.945*** (0.028)	0.962*** (0.029)	0.392*** (0.114)	0.942*** (0.028)
Constant	1.466*** (0.064)	1.426*** (0.071)	1.790*** (0.128)	1.533*** (0.062)	74.249*** (13.687)	75.136*** (14.841)	42.445* (20.869)	82.654*** (13.143)
R2	0.391	0.368	0.405	0.378	0.877	0.898	0.829	0.876
Observations	645	490	155	645	645	490	155	645

Note. * p < 0.05; ** p < 0.01; ***p < 0.001; the values in parentheses are standard errors.

DISCUSSION

The impact of CEO overseas experience on firm value

This finding suggests that CEOs with overseas experience can leverage their international work and study experiences, effectively utilize their management skills, and efficiently search and

process information. Consequently, they are better equipped to make decisions that contribute to maximizing firm value. Theoretically, the findings of this study are consistent with the predictions of the upper echelons theory, indicating that specific attributes of CEOs have an impact on the effective implementation of strategies and policies, leading to improved firm performance (Abatecola & Cristofaro, 2020; Hambrick, 2007; Hambrick & Mason, 1984).

The impact of innovation efficiency on firm value

This suggests that companies gain distinctive competitive advantages by enhancing their innovation efficiency, leading to a positive impact on firm value. Furthermore, this study delves into the moderating effect of CEO overseas experience on the relationship between innovation efficiency and firm value. There are similarities between previous research and the findings of this study, suggesting that there is a certain relationship between innovation efficiency and firm value or performance (Kim et al., 2018; Luo et al., 2022; Sun et al., 2019). There is even a consensus between research and the findings of this study that innovation efficiency can significantly enhance firm value (Li et al., 2020; Ouyang et al., 2020; Simeth & Cincera, 2016).

Moderating effect of CEO overseas experience

These results indicate that there may not be a single relationship between innovation efficiency and firm value, which aligns with previous studies (Kim et al., 2018; Luo et al., 2022; Sun et al., 2019). Before subgrouping, innovation efficiency had a significant positive impact on firm value. However, when this study differentiated the sample into CEOs with overseas experience and CEOs without overseas experience, an interesting finding emerged: in the subgroup of CEOs without overseas experience, the relationship between innovation efficiency and firm value did not reach statistical significance. This suggests that CEO overseas experience acts as a moderator in the relationship between innovation efficiency and firm value. Past studies have also found that companies with CEOs possessing special backgrounds can achieve better innovation efficiency (e.g., Li, 2022; McKelvie & Davidsson, 2009; Verona & Ravasi, 2003; Xu & Hou, 2021; Zhang et al., 2022), which contributes to the improvement of firm value or performance.

CONCLUSIONS

This study aimed to address the key question of how and why technological innovation of Chinese listed chip companies can enhance their firm value, specifically focusing on the attributes of their CEO overseas experience. We employed the arguments of the upper echelons theory (Hambrick & Mason, 1984), thereby extending and making new contributions to the existing literature.

Firstly, CEO overseas experience significantly enhances firm value. Companies with CEOs who possess overseas experience exhibit higher firm values compared to those without such experience. This can be attributed to the belief that foreign management concepts are more advanced, leading to more refined company management practices. CEOs with overseas experience tend to apply the operational and managerial concepts acquired abroad to their company's management, resulting in more efficient decision-making and value creation.

Secondly, innovation efficiency significantly improves firm value. Technological innovations within firms often translate into intangible assets, such as patents and trademarks, which are key measures of innovation performance. This study measures innovation efficiency by calculating the ratio of total intangible assets to R&D expenditure, providing an output-input perspective. The findings demonstrate that higher ratios of intangible assets to R&D expenditure correspond to greater innovation efficiency and, subsequently, higher firm values.

Finally, when CEOs possess overseas experience, innovation efficiency plays a significant role in improving firm value. The chip industry's most rapid growth occurs in countries like the United States, where companies such as Intel, Samsung, and TSMC lead the field. In contrast, the Chinese chip manufacturing sector is relatively limited. However, if CEOs of Chinese chip companies have studied or worked abroad, they have acquired advanced technological knowledge and can introduce it to domestic firms. Breakthroughs in key technologies resulting from the CEO's overseas experience contribute substantial value to firms, helping them maintain a competitive edge in the domestic chip industry. This leading competitive position brings numerous advantages, further enhancing firm value.

Furthermore, this study provides several policy and regulatory implications. One implication of these findings is that Chinese firms may need to augment the competencies and expertise of top management (especially of CEOs) to ensure the effective implementation of technological innovation policies. Especially for chip companies, it is crucial to increase R&D investment, enhance innovation efficiency, and strengthen intellectual property rights protection. Insufficient R&D investment is a common challenge for chip companies in developing countries like China. Only through independent innovation can they establish a competitive position in the market and avoid dependency on others. Actively attracting scientific research talents, establishing research centers, and allocating adequate funds to technology R&D are necessary steps. Investing in the development of R&D personnel's theoretical foundations will enhance the efficiency of their work and increase the chances of achieving breakthrough technologies beyond expectations.

Using foreign R&D personnel can leverage their overseas experience and technical expertise, enhancing the capabilities of Chinese chip companies. Foreign R&D personnel, influenced by their experience in overseas firms, generally possess strong technological R&D skills, as well as management insights that have been subtly shaped by their overseas exposure. The combined advantages of overseas experience and technical innovation make introducing foreign R&D personnel a valuable development opportunity. Although overseas R&D personnel may lack management experience, their exposure to foreign management practices over an extended

period enables them to acquire valuable insights. When integrated into the R&D department of an enterprise, such talent can provide unique contributions. However, the integration of overseas R&D personnel may face communication challenges. Therefore, firms need to establish effective communication mechanisms or language training programs. It is recommended that key R&D personnel in Chinese firms possess a certain level of proficiency in foreign languages, and they should be encouraged to learn additional languages. By introducing overseas R&D personnel, firms can improve the utilization of innovation resources, optimize project evaluation systems, and collaboratively establish an innovative framework that maximizes the transformation of R&D outcomes.

Finally, despite new contributions and research findings, this study also has some limitations that need to be understood and can potentially guide future research. Firstly, although this study has included capital structure, profitability, and firm size as control variables, further studies can consider including additional control variables, such as country variables, to ensure more accurate research results. Secondly, this study only focused on the CEO overseas experience and overlooked the different background characteristics of other top executives (e.g., chairpersons, chief technology officers, and chief financial officers) and management teams, which may also impact the research model. Also, the multifaceted nature of overseas experience, encompassing educational, training, and work experience, could potentially yield distinct implications for firm value. Consequently, a comprehensive investigation into this aspect remains a valuable prospect for future research. Lastly, this study suggests that further studies could provide new insights into the research model by comparing emerging and developed markets.

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ACKNOWLEDGEMENTS

This work received support from the Ministry of Education's Humanities and Social Science Project (21YJC630022) and the Young Innovative Research Team of Dongguan University of Technology (TDQN2019013), China.

CONFLICT OF INTEREST

The author declare no conflicts of interest.

AUTHORS' CONTRIBUTION

Yung-Shuan Chen: Conceptualization, data curation, formal analysis, funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Writing – original draft; Writing – proofreading and editing.