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Impact of CEOs' Academic Work Experience on Firms' Innovation Output and Performance: Evidence from Chinese Listed Companies

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Abstract: To date, the effect of the specific type of prior work experience of chief executive officers (CEOs) on innovation and firm performance remains poorly understood. Using upper perspective theory, this study argues that CEOs' academic work experience affects firms' innovation output, which in turn determines how research and development (R&D) activities affect firm performance. Analyzing a sample of 1210 Chinese publicly traded firms from 2013–2017, we found that firms with CEOs who were previously associated with universities or research institutions had better innovation output and performance than firms led by CEOs without such background. In addition, we found that former academics spent more on R&D investment, resulting in lower firm performance compared to firms that were not led by CEOs with an academic background. Furthermore, the innovation output was even higher, and performance was inversely reduced for ventures where state ownership is significant.

Keywords: academic experience; corporate innovation; firm performance; incentives; state-owned enterprises

1. Introduction

Innovation is one of the most crucial ways for a company to survive and develop. How to promote innovative accomplishments and firm performance through research and development (R&D) activities has been a hot topic for academia and business lately. Both psychological motivation and value orientation affect the strategic decision-making of chief executive officers (CEOs), including innovation projects and, subsequently, firm performance [1]. Thus, as the CEO is the most robust decision-maker in a company, the role is significant. Previous studies on the upper echelons perspective have revealed that some characteristics of top managers influence innovation activities, such as functional background, education, tenure, age, and career horizon [2–4]. Despite comprehensive research, little has been done to investigate the correlation between CEOs' academic background or experience and innovation output and firm performance [5].

Technological innovation and firm performance are crucial to providing solutions for sustainable development regarding economic growth, environmental preservation, and social progress, as they are considered new means for using scarce resources optimally and efficiently [6]. Innovation progress, which is considered as a tool for developing human potential, can augment productivity and income, enhance health and education, and develop social welfare and equity [7]. The United Nations Industrial Development Organization (UNIDO) reports that innovation can integrate the three goals of sustainable development, economics, society, and environment; achieving these goals warrants significant R&D activities to explore and maximize the potential of technological innovation [8]. As the top leaders

at firms, CEOs play a significant role in the impact of firm innovation and performance on social welfare. From the managerial perspective, “the real gains will only be made by harnessing the innovative potential of entrepreneurs who will develop the innovative business solutions to deal with the environmental challenges” [9]. Furthermore, institutional quality and corporate governance can positively moderate the correlation between technological innovation and sustainable growth [10].

Hambrick and Mason [4] proposed the upper echelons perspective, considering organizational output as a result of top managers’ values and cognitive abilities in an organization. Meanwhile, scholars have mainly used agency theory to contend with the continuous conflict between the self-interest and risk averseness of CEOs and the long-term development of companies [11], and to resolve the issue of varying interests between CEOs and firms. Reportedly, firm property and managerial incentives are crucial factors in aggravating or alleviating the agency problem [12,13]. Moreover, the impact of innovation input and output on firm performance remains uncertain [14]. This study uses both upper echelons perspective and principal agent theory to investigate the effect of CEOs’ unique work experience on firm innovation output and performance among a sample of Chinese listed companies.

This study introduces the notion of academic CEOs with career experience that includes universities or research institutions and engagement in research work before becoming a CEO. To elucidate the influence of academic CEOs on innovation, we presume that such CEOs tend to select strategies that prioritize innovation and have a better and more precise understanding of how to implement R&D activities efficiently, in turn promoting firms’ innovation outcome [5,15,16]. We found that CEOs with an academic background are inclined to enhance innovation achievement. We also demonstrate that the relationship between academic CEOs and innovation output is more significant for state-owned enterprises (SOEs). While short-term incentives augment this relationship, long-term incentives do not. In addition, the impact of academic CEOs is weaker with increasing R&D investment. Then, we found that firms with academic CEOs that have more R&D spending exhibit weaker firm performance. On the contrary, firms with academic CEOs that have more innovation output are more likely to exhibit better firm performance, and it is more significant for non-SOEs. Although this result is not conclusive, it strongly indicates that specific CEO background or experience could, under the right circumstances, provide both R&D and economic benefits.

This study aims to promote both theory and management practice. We attempt to contribute to two areas in theory. First, we highlight the significant positive impact of top managers on innovation outcomes and firm performance. We claim an empirical explanation for why some top managers have more impact on firms’ innovation and performance than others. Based on their preference or cognition, CEOs’ choices represent the discretion they exercise in allotting their firms’ scarce resources. How this discretion is manifested has a long-term influence on a firm’s technological innovation [17]. This nexus between a manager’s unique work experience and innovation outcome, although significant both substantively and theoretically, remains seldom explored. This study also extends the research examining the impact of the interaction between executives’ characteristics and innovation input or output on firm outcomes. Second, regarding the agent perspective, some CEOs focus more on short-term interests, which highlights financial statements and benefits by suppressing long-term strategies. As the innovation process is typically risky, costly, and continuous, electing the right managers and providing them with suitable incentives to align their interests with the firm’s long-term objectives should help leading managers to put more effort into innovation activities [13]. We build on the nascent stream of thought resolving the agent issue through the complicated influence of CEO characteristics on firm strategies. This study complements the current literature by developing a theory to reconcile the interests of both firms and CEOs through CEOs’ individual preferences or occupational habits.

2. Theoretical Foundations and Hypothesis Development

2.1. Chief Executive Officer (CEO) Academic Work Experience and Corporate Innovation Output

The background and experience of CEOs are crucial in terms of their receptivity and attitude to innovative ideas and activities [18]. The executive career path markedly influences individual preferences, beliefs, values, goals, and skills, which determine motivation and ability in practical action [19–23]. CEOs operate their companies with a partially personalized perspective rooted in experiences, motives, and character, even when making strategic choices in a highly competitive environment with limited enterprise resources [3,4]. Some studies contend that executives bring specific and unique orientations to companies, affecting strategic decision-making and organizational outcomes [2,24]. CEOs' career experience in different functions affects corporate R&D decisions, as their perceptions of the latest technology are biased by prior functional experience. CEOs with output functional experience, such as research, engineering, marketing, or sales, which highlight enterprise development by launching new products and services, capture new markets and prefer innovative strategies and activities [25]. Reportedly, R&D activities positively correlate with executives' technical work experience [26]. In the Chinese context, CEOs with a professional background are more skillful in making innovation decisions and accelerating innovation activities [18].

CEOs' academic experience, such as research and science, provides them with an explorative cognitive pattern, which enables them to determine and comprehend new opportunities and advanced technologies earlier and better than their peers [27]. In addition, their greater cognitive complexity allows them to absorb new ideas and accept innovations quickly when facing unpredictable and unknown problems [25]. Thus, academic CEOs are better at applying new technologies and developing firms' innovation ability [28]. To date, several studies have demonstrated a positive correlation between CEOs with higher education and firms' R&D activities [25,29]. CEOs with higher education are more likely to take market innovation strategies and spend higher amounts on R&D [30,31]. Furthermore, there is a great need to select top managers with higher education for high-tech enterprises in which innovation is the core of competitiveness [32].

Academic CEOs can transfer firms' attention and resources to enhance innovation activities in various ways. They have management authority and the power to set the firm's direction [4]. They can influence strategy formulation by controlling and deciding what information members of the firm attend to and how the information is interpreted [33]. In addition, they transmit their preferences and cognition to organizational behaviors through communication and actions, driving the culture and activities of the firm [17,34]. Like research-oriented CEOs, who are inclined to build a supportive organizational environment to enable innovation outcomes [35], academic CEOs are more likely to endorse innovation activities through culture-building and talent management. Some studies on corporate culture and environment have supported that CEOs are more likely to change enterprise strategy by building a sociocultural context that caters to their personality and preferences [36,37]. For instance, CEOs with a research background prefer constructing a supportive innovation environment within the organization to spread their cognition, ideas, preferences, values, norms, and behaviors [38]. Academic CEOs can use a regulatory framework, management activities, operating procedures, evaluation systems, and reward and punishment mechanisms to establish and strengthen the corporate culture to lead, encourage, and supervise firm innovation [39]. Since human resources is a core factor of innovation, attracting and cultivating research personnel is a priority [28]. Based on firms' sociocultural environment of innovation, academic CEOs are more willing to hire and reward like-minded employees who are easier to recognize and accept their innovation vision and tendency, resulting in the development of innovation teams and stimulation of innovation activities [36,37].

Hence, we expect that academic career experience develops CEOs' working habit of focusing more on innovation activities, thereby increasing R&D outcomes. Formally:

Hypothesis 1 (H1). *In comparison with their counterparts, CEOs with academic work experience create more innovation output for firms.*

2.2. Enterprise Ownership and Innovation Output

As different enterprises in China have different operational objectives and governance efficiency, the willingness of CEOs to promote technical innovation and their input intensity are also different compared to private-owned enterprises (POEs) [1]. The objective function of SOEs is not necessarily profit maximization [40]; this alternates with attaining various sociopolitical goals such as innovation, employment generation, or social stability [41,42]. The assessment and promotion mechanisms for executives in SOEs are related to the accomplishment of sociopolitical goals. Occasionally, even the performance is not included [43]. To develop their own individual career path and political future, academic CEOs in SOEs are more willing to enhance innovation output than their peers in private enterprises.

Although some studies have demonstrated that R&D efficiency is higher in POEs than in SOEs, most essential resources for innovation are assigned to state-owned businesses [44,45]. The difference in the distribution of innovation resources is reflected in different ownership patterns. R&D funds and staff are more concentrated in SOEs than private enterprises [12]. Reportedly, SOEs can more easily obtain loans from China's banking system and investment companies [46]. A majority of national and local scientific research projects are implemented by SOEs [47]. The amount and technical added value of innovation achievements at POEs are usually lower compared to SOEs [45]. Besides, CEOs with an academic background have a better understanding of rules and processes in SOEs, as SOEs, universities, and research institutions are all government-controlled systems in China. Moreover, all employees of universities and research institutions and executives of SOEs are part of the bureaucratic command system [1]. Furthermore, academic CEOs have a far greater awareness of how to acquire more resources from the government and promote innovation outcomes within the same system. Formally:

Hypothesis 2 (H2). *Compared with CEOs at POEs, CEOs with academic experience at SOEs create more innovation output for firms.*

We tested Hypotheses 1 and 2 using the following equation:

$$\begin{aligned} \text{Patent}_{t+1} = & \alpha_0 + \alpha_1 \times \text{Academic CEO}_t + \alpha_2 \times \text{Male}_t + \alpha_3 \times \text{Age}_t + \alpha_4 \times \text{Duality}_t \\ & + \alpha_5 \times \text{Political Connection}_t + \alpha_6 \times \text{Board Size}_t \\ & + \alpha_7 \times \text{Independence}_t + \alpha_8 \times \text{Leverage}_t + \alpha_9 \times \text{Total Asset}_t \\ & + \alpha_{10} \times \text{Total Asset Turnover}_t + \alpha_{11} \times \text{Property}_t \\ & + \alpha_{12} \times \text{Compensation}_t + \alpha_{13} \times \text{CEO Holdings}_t + \sum \text{Year} \\ & + \sum \text{Industry} + \varepsilon \end{aligned} \quad (1)$$

2.3. Moderating Role of Managerial Incentives in the Correlation between Academic CEOs and Innovation Output

Managerial incentives play a vital role in influencing innovation output [13]. The individual interests and career reputation of executives directly and uniquely correlate with the success or failure of specific firm projects [18,41]. As innovation is one of the riskiest long-term strategies with asymmetric information, it is crucial to motivate executives to monitor their self-preserving or self-interest behaviors [13,48]. Research-intensive firms pay their executives more to be more in favor of innovation and tolerate early failure for long-term performance [49,50]. Thus, managerial incentives can mitigate the impact of the agency problem and executives' risk aversion so that CEOs are more willing to launch risky projects [51–53]. In addition, some studies have supported that both short- and long-term incentives contribute to the implementation of risky activities, implying that both CEO compensation and shareholdings promote innovation input and output [18,51,54]. Formally:

Hypothesis 3a (H3a). *Compensation positively moderates the correlation between academic CEOs and innovation output of firms.*

Hypothesis 3b (H3b). *CEOs' stock ownership positively moderates the correlation between academic CEOs and innovation output of firms.*

We tested Hypotheses 3a and 3b using the following equation:

$$\begin{aligned} \text{Patent}_{t+1} = & \alpha_0 + \alpha_1 \times \text{Academic CEO}_t + \alpha_2 \times \text{Compensation}_t \\ & + \alpha_3 \times \text{CEO Holdings}_t \\ & + \alpha_4 \times \text{RB CEO}_t \times \text{Compensation}_t (\text{or CEO Holdings}_t) \\ & + \alpha_5 \times \text{Male}_t + \alpha_6 \times \text{Age}_t + \alpha_7 \times \text{Duality}_t \\ & + \alpha_8 \times \text{Political Connection}_t + \alpha_9 \times \text{Board Size}_t \\ & + \alpha_{10} \times \text{Independence}_t + \alpha_{11} \times \text{Leverage}_t + \alpha_{12} \times \text{Total Asset}_t \\ & + \alpha_{13} \times \text{Total Asset Turnover}_t + \alpha_{14} \times \text{Property}_t + \sum \text{Year} \\ & + \sum \text{Industry} + \varepsilon \end{aligned} \quad (2)$$

2.4. Moderating Role of Innovation Input in the Correlation between Academic CEOs and Innovation Output

Resource allocation is a crucial factor influencing organizational processes, and eventually innovation outcome, playing a moderating role between CEO work experience and R&D output [35]. Notably, CEOs entirely control the formulation and implementation of strategy decisions, especially resource allocation for innovation projects [15]. Previous research demonstrated that CEOs with higher education and a technical background tend to spend more for R&D expenditures [25]. They often use science and technology as a universal response to the growth and development of the enterprise [55]. In addition, they are inclined to recruit more people with a high level of education and technical background to build an innovation culture and attain R&D goals [29], making it much easier for such CEOs to adopt an R&D-intensive investment strategy and pursue their technological vision for innovation [35]. Although previous studies have shown that R&D investment is the primary source of R&D outcomes [56], R&D intensity positively correlates with innovation output as measured by patents or new product revenue [57]. Furthermore, R&D intensity is used as a positive mediator between research-oriented CEOs and the innovation output of firms [35].

However, investment is not a guarantee of innovation success; it is one of the factors of innovation output, helping firms to obtain R&D resources that are needed to develop innovation capability [29]. In addition, R&D activities require massive investment, but the results are uncertain. Innovation investment might not lead to the desired outcome or to a good result by a given date because of technical or economic reasons [13]. Some Chinese scholars reported a nonsignificant or negative relationship between R&D intensity and innovation output in China's various industries [58]. Owing to the institutional and administrative particularity of university and research institutions in China, most of their R&D activities are funded by the government. Researchers prioritize innovation accomplishments over the amount or efficiency of expenditures; they also prefer long-term and high-tech projects. Thus, we argue that academic CEOs are not as sensitive to R&D investment efficiency as their counterparts. Formally:

Hypothesis 4 (H4). *Innovation input negatively moderates the correlation between academic CEOs and innovation output of firms.*

We tested Hypothesis 4 using the following equation:

$$\begin{aligned} \text{Patent}_{t+1/(t+2)/(t+3)} = & \alpha_0 + \alpha_1 \times \text{Academic CEO}_t + \alpha_2 \times \text{R\&D Intensity}_t \\ & + \alpha_3 \times \text{RB CEO}_t \times \text{R\&D Intensity}_t + \alpha_4 \times \text{Male}_t + \alpha_5 \times \text{Age}_t \\ & + \alpha_6 \times \text{Duality}_t + \alpha_7 \times \text{Political Connection}_t + \alpha_8 \times \text{Board Size}_t \\ & + \alpha_9 \times \text{Independence}_t + \alpha_{10} \times \text{Leverage}_t + \alpha_{11} \times \text{Total Asset}_t \\ & + \alpha_{12} \times \text{Total Asset Turnover}_t + \alpha_{13} \times \text{Property}_t \\ & + \alpha_{14} \times \text{Compensation}_t + \alpha_{15} \times \text{CEO Holdings}_t + \sum \text{Year} \\ & + \sum \text{Industry} + \varepsilon \end{aligned} \quad (3)$$

2.5. Moderating Role of Innovation Input in the Correlation between Academic CEOs and Firm Performance

Studies revealed a positive and significant correlation between innovation input and firm performance [59]. However, the evidence relies heavily on a specific area with a specific database and methodology [60]. R&D activities are risky and do not always lead to desired future performance, as the innovative accomplishments do not match the needs of the market and customers [61]. The current literature supports that the correlation between R&D investment and firm performance highly depends on other factors [14,62].

In addition, numerous companies have overinvested in R&D activities to avoid losing their competitive edge [63]. Hartmann et al. [64] argued that increasing R&D expenditures does not yield proportional rewards after passing the cutoff point. Chan et al. [65] used a portfolio approach to investigate the correlation between R&D input and stock returns over five years; they found no direct correlation between R&D expenditures and stock returns. Using cross-sectional data on the software industry in China, Lin et al. [66] established that the correlation between R&D input and firm performance is not significant. Goya et al. [60] analyzed 9985 firms during 2004–2009 and, unlike previous studies, suggested that innovation input does not directly affect firm performance.

If firms overinvest in R&D activities, they suffer the risk of experiencing innovation failure and consuming various resources and cash, thereby influencing firm performance [67]; this situation leads to innovation traps and a vicious circle, increasing costs and decreasing performance. Jose [68] and Lustgarten and Thomadakis [69] argued that R&D intensity significantly decreased firm performance as measured by Tobin's Q. In addition, Gou et al. [70] supported that R&D intensity negatively correlates with profitability and productivity. Using regression analysis, Han and Manry [71] established a negative correlation between R&D expenditures and stock prices in Korea. Feyzrakhmanova and Gurdgiev [72] investigated the nine largest pharmaceutical companies in the world during 1996–2013 and reported that R&D expenditures statistically and significantly negatively correlated with firm performance. Moreover, Yeh et al. [73] demonstrated an inverted-U correlation between R&D intensity and firm performance, suggesting that increasing R&D investment might not yield proportional rewards. Such divergent results imply that the correlation between R&D input and firm performance is complicated, and other factors could play significant roles in this link. Based on Hypothesis 4 mentioned above, academic CEOs prefer the innovation process and technological accomplishments rather than the efficiency of R&D investment. Hence, we argue that academic CEOs might decrease firm performance when they increase R&D expenditures. Formally:

Hypothesis 5 (H5). *Innovation input negatively moderates the correlation between academic CEOs and firm performance.*

We tested Hypothesis 5 using the following equation:

$$\begin{aligned} \text{Tobin's } Q_{t+1} = & \alpha_0 + \alpha_1 \times \text{Academic CEO}_t + \alpha_2 \times \text{R\&D Intensity}_t \\ & + \alpha_3 \times \text{RB CEO}_t \times \text{R\&D Intensity}_t + \alpha_4 \times \text{Male}_t + \alpha_5 \times \text{Age}_t \\ & + \alpha_6 \times \text{Board Size}_t + \alpha_7 \times \text{Independence}_t + \alpha_8 \times \text{Leverage}_t \\ & + \alpha_9 \times \text{Total Asset}_t + \alpha_{10} \times \text{Total Asset Turnover}_t \\ & + \alpha_{11} \times \text{Property}_t + \sum \text{Industry} + \varepsilon \end{aligned} \quad (4)$$

2.6. Moderating Role of Innovation Output in the Correlation between Academic CEOs and Firm Performance

Some studies reported no correlation between patents and returns, or even a negative relationship between them [74,75]. While these arguments support that patents have no influence or a negative impact on firm performance, there is also considerable evidence that, in many contexts, patents play a significant role. To date, some studies have established that the introduction of new products, which are direct sources of competitive advantage, positively affects business performance [67,74,76]. Camison and Villar [77] identified that both the innovation process and achievements enhance firm performance. Innovation activities and outputs have been established to be correlated and determinant factors of firm performance [78,79]. In addition, various empirical studies have demonstrated a positive impact of patents on firm performance, such as sales, market value, and stock returns [72,80,81]. Furthermore, firms can realize larger margins on innovative achievements, especially those with CEOs who have an academic background and a better understanding of new technology and products. Formally:

Hypothesis 6 (H6). *Innovation output positively moderates the correlation between academic CEOs and firm performance.*

2.7. Enterprise Ownership and Firm Performance

There is a serious formalism, agency, and policy burden problem in innovation activities of SOEs. Some scholars have investigated Chinese firms' innovation performance and proved that SOEs have lower innovation and productive efficiency than private sector companies [45]. For executives of SOEs, financial performance is only one part of their primary objectives. As they have both economic and political characteristics, their official nature requires them to undertake more governmental tasks and obtain sociopolitical objectives [41], which directly influences CEOs' promotion and determines their career prospects. Regulated by the central or local government, CEOs working at SOEs aim to fulfill government demands rather than maximize profit [45,82]. Such executives focus more on their political career path rather than the economic benefits. Even the level of SOE performance cannot affect CEOs' retention or demission. The pressure and demand to enhance financial performance for CEOs is less at SOEs than POEs [1]. Within such a management system, executives tend to develop innovation output as a vanity project, which plays a crucial role in their promotion mechanism. Besides, the innovation accomplishments at SOEs are highly likely to lack practical effects when CEOs are motivated by this promotion mechanism. Furthermore, CEOs promote specious and unpractical innovation output in order to acquire more government R&D subsidies or rewards and improve their individual political image. Formally:

Hypothesis 7 (H7). *Compared with CEOs at SOEs, academic CEOs at non-SOEs convert innovation output into economic benefits more efficiently.*

We tested Hypotheses 6 and 7 using the following equation:

$$\begin{aligned} \text{Tobin's } Q_{t+1} = & \alpha_0 + \alpha_1 \times \text{Academic CEO}_t + \alpha_2 \times \text{Patent}_t \\ & + \alpha_3 \times \text{RB CEO}_t \times \text{Patent}_t + \alpha_4 \times \text{Male}_t + \alpha_5 \times \text{Age}_t \\ & + \alpha_6 \times \text{Board Size}_t + \alpha_7 \times \text{Independence}_t + \alpha_8 \times \text{Leverage}_t \\ & + \alpha_9 \times \text{Total Asset}_t + \alpha_{10} \times \text{Total Asset Turnover}_t \\ & + \alpha_{11} \times \text{Property}_t + \sum \text{Industry} + \varepsilon \end{aligned} \quad (5)$$

Table 1 reported the summary of all hypotheses and models, including dependent variables, explanatory variables, expected regression relationship, and estimation methods.

Table 1. Introduction of hypotheses and models. CEO, chief executive officer; SOE, state-owned enterprise; R&D, research and development; OLS, ordinary least squares.

Hypothesis	Model	Dependent Variable	Key Explanatory Variable(s)	Expected Relationship	Estimation Method
1	1	Innovation Output (Patents)	CEO Academic Work Experience (0/1)	+	Tobit
2	2	Innovation Output (Patents) at SOEs	CEO Academic Work Experience (0/1)	+	Tobit
	3	Innovation Output (Patents) at non-SOEs	CEO Academic Work Experience (0/1)	−/Nonsignificant	Tobit
3a	4	Innovation Output (Patents)	CEO Academic Work Experience (0/1), CEO Compensation (moderating variable)	+	Tobit
3b	5	Innovation Output (Patents)	CEO Academic Work Experience (0/1), CEO Ownership (moderating variable)	+	Tobit
4	6	Innovation Output (Patents)	CEO Academic Work Experience (0/1), Innovation Input (R&D intensity, moderating variable)	−	Tobit
	7	Innovation Output (Patents)—2 Years Lagging	CEO Academic Work Experience (0/1), Innovation Input (R&D intensity, moderating variable)	−	Tobit
	8	Innovation Output (Patents)—3 Years Lagging	CEO Academic Work Experience (0/1), Innovation Input (R&D intensity, moderating variable)	−	Tobit
5	9	Firm Performance (Tobin's Q)	CEO Academic Work Experience (0/1), Innovation Input (R&D intensity, moderating variable)	−	OLS
6	10	Firm Performance (Tobin's Q)	CEO Academic Work Experience (0/1), Innovation Output (patents, moderating variable)	+	OLS
7	11	Firm Performance (Tobin's Q) at SOEs	CEO Academic Work Experience (0/1), Innovation Output (patents, moderating variable)	−/Nonsignificant	OLS
	12	Firm Performance (Tobin's Q) at non-SOEs	CEO Academic Work Experience (0/1), Innovation Output (patents, moderating variable)	+	OLS

3. Materials and Methods

3.1. Sample

The study sample was drawn from China's listed companies on the Shanghai and Shenzhen Stock Exchanges during 2013–2017. Since 2017 is the latest year when we can obtain patent applications from database, for most firm and CEO variables, we relied on the China Stock Market and Accounting

Research (CSMAR) Database, databases of the Shanghai and Shenzhen Stock Exchanges, and corporate annual reports. We collected CEOs' resumes and personal profiles to trace their careers from annual reports, firm websites, social media, news reports, and search engines on the Internet. First, we excluded financial and insurance companies because of the particularity and complexity of financial indices and operational objectives. In addition, these types of companies are not sensitive to innovation activities. Second, firms with incomplete data and CEOs without a detailed resume or career introduction were omitted from the study. Then, we deleted samples where CEOs' tenure was <12 months, as a CEO would have exerted little influence over company strategies and operations, such as innovation activities, within such a short tenure. Finally, we omitted listed companies under special treatment. Our final sample comprised 1210 firm-years.

3.2. Measures

3.2.1. Dependent Variables

Tobin's Q is a standard method to measure firm performance. We used patent applications to measure innovation output, which is equal to the natural logarithm of 1 plus annual patent applications [73].

3.2.2. Independent Variables

We traced CEOs' career paths to determine whether they had worked at a university or research institution as a researcher or scholar. University and research institutions have been considered as innovative subjects in China for a long time. Employees at these organizations are more sensitive to innovation activities than others. We built a dummy variable (*Academic CEO*) to determine whether a CEO had academic work experience. If a CEO had done research at a university or research institution, we coded it as 1; otherwise, it was 0. In addition, innovation input was a moderating variable in this study. *R&D intensity* was extensively used to measure innovation input, which was defined as R&D expenditures divided by total assets [13]. CEO incentives were captured by two variables, compensation and CEO ownership [18]. *Compensation* was used to measure short-term incentives, which is equal to the natural logarithm of 1 plus total cash compensation comprising annual salary and bonus. The long-term incentive was a continuous measure of CEO ownership of the firm, which is equal to the natural logarithm of 1 plus the percentage of stock held by the CEO (*CEO holdings*).

3.2.3. Control Variables

We controlled several factors known to influence firm innovation output and performance. In addition, we included the demographic characteristics *male* and *age*. Of note, we controlled for *duality* regarding whether the CEO was the chairman of the company, suggesting power and discretion over the allocation of company resources. *Political connection* was controlled for individual networks and resources, as it is much easier for a CEO with government connections to acquire extra external resources and help with subsidy or patent applications. At the firm level, enterprise ownership (*property*) also suggests a similar function to CEO political connections. In addition, *SOEs* were allocated much more resources and privilege for innovation activities. We controlled *board size* and *board independence* to control the role of governance structure influencing CEOs' decisions. We included *firm leverage* to account for the asset and liability structure of the enterprise. Moreover, *firm size* was measured by the natural logarithm of end-of-year total assets, as more prominent firms can be predicted to have more resources and capacity. The total asset turnover was added to control the firm's operating capacity. Finally, we included *year* and *industry* dummies to control unknown heterogeneity from the environment. Notably, the industry dummies were referred from the two-digit industrial classification and code in China (GB/T 4754—2017).

3.3. Analysis

The models are presented in the Hypothesis section. Since the dependent variable, the logarithm of patents plus 1 is left censored at 0, we used tobit regression to test our hypotheses on innovation output. As innovation output is highly likely to lag strategic decisions, we incorporated a lag measure of 1 year to evaluate innovation outcome, same as prior research [57]. A lag would exist between a CEO's decision because of individual preference or occupational habit and patent applications reflecting innovation achievement. Model 1 was the basic tobit regression for the correlation between academic CEO and innovation output. In Models 2 and 3, we excluded property from control variables for grouping regression. In Model 2, dummy property was equal to 1, implying that all samples were SOEs; it was 0 in Model 3, implying that all firms were non-SOEs. Based on Model 1, we added moderating variables, CEO compensation, CEO holdings, R&D intensity, and their respective interactions in Models 4–6. Models 7 and 8 tested the two- and three-year lagging patent applications, since innovation is considered as a process that may need a period of time to translate R&D investment into innovation output.

To test the impact of academic CEOs and innovation activities on firm economic benefits, we included the ordinary least squares (OLS) regression model. In addition, we used a lag measure of 1 year to test firm performance, as performance lags CEO strategic decisions and firm innovation activities [35,83].

In Model 9, we tested the impact of the interaction between academic CEOs and R&D intensity on firm performance. Then, in Model 10, we replaced R&D intensity with patent applications to determine whether innovation output moderates the correlation between academic CEOs and firm performance. In Models 11 and 12, we ran grouping regressions with the SOE and non-SOE subsamples to see the moderating effect of innovation output on the relationship between academic CEOs and firm performance under different properties.

4. Results

4.1. Descriptive Statistics and Correlations

Table 2 presents descriptive statistics for the dependent and independent variables. On average, 9% of CEOs had academic work experience during 2013–2017. Firms' mean R&D expenditure was RMB 146 million, amounting to USD 21.3 million. The mean R&D intensity was 0.013, and each firm applied for 137 patents every year. Table 3 presents average data in subsamples, including R&D expenditure, R&D intensity, patent applications, and Tobin's Q. Firms with academic CEOs tended to invest more in R&D activities and have more innovation output and better performance. Grouped by ownership, SOEs invested more in innovation than private companies. However, the gap of R&D intensity between SOEs and non-SOEs is narrow, implying that although SOEs have more resources to push R&D projects, POEs do not lack the willingness to invest in innovation. Based on patent applications, SOEs supersede non-SOEs in innovation output, but SOEs lag behind in firm performance.

Table 4 presents the correlations for the study variables. The correlation coefficient between all variables is <0.5 , which makes it suitable to use all variables in our models simultaneously. Also, we estimated the mean variance inflation factor (VIF) for regression analysis. The VIF of each variable is between 1 and 2, far below 10, indicating very limited multicollinearity. We do not report the VIF of our regression analysis, but these figures are available upon request.

4.2. Academic CEOs and Innovation Output

Table 5 presents the tobit regressions results of the correlation between academic CEOs and lagging innovation output. In Model 1, the coefficient of academic CEOs and patent applications is positive and statistically significant at the 1% level. The empirical results strongly support Hypothesis 1, suggesting that academic CEOs strongly tend to promote innovation output. Detailed analysis of other variables revealed that CEO age is a negative factor for innovation performance, which is consistent

with previous studies. Firm size measured by total assets is positive correlated with innovation output. Moreover, firm ownership is positively correlated with innovation output, suggesting that SOEs create more patents than POEs. Furthermore, the presence of CEO incentives enhances corporate innovation performance, regardless of short-term motivation, compensation, or long-term incentive and CEO share.

Table 2. Descriptive statistics.

		Obs.	Mean	Median	S.D.	Min	Max
1	Academic CEO	1209	0.090	0.000	0.286	0.000	1.000
2	R&D Expenditure (Million)	1209	146.000	29.800	615.000	0.000	9410.000
2	R&D Intensity	1209	0.013	0.007	0.017	0.000	0.162
3	Patent	1209	136.836	28.000	431.780	0.000	5625.000
4	Tobin's Q	1162	2.485	2.056	1.750	0.153	20.363
5	Male	1209	0.946	1.000	0.226	0.000	1.000
6	Age	1209	49.532	50.000	5.625	30.000	68.000
7	Compensation (thousand)	1209	892.170	648.900	899.209	0.000	7359.600
8	Holdings	1209	0.048	0.000055	0.113	0.000	0.595
9	Duality	1209	0.232	0.000	0.422	0.000	1.000
10	Political Connections	1209	0.164	0.000	0.370	0.000	1.000
11	Property	1209	0.414	0.000	0.493	0.000	1.000
12	Board Size	1209	8.778	9.000	1.750	5.000	17.000
13	Independence	1209	0.374	0.333	0.055	0.250	0.714
14	Leverage	1209	0.443	0.434	0.197	0.019	1.352
15	Total Asset (billion)	1209	15.200	4.340	51.700	0.218	801.000
16	Total Asset Turnover	1209	0.635	0.537	0.448	0.008	5.413

Table 3. Average data of subsamples.

	R&D Expenditure (million)	R&D Intensity	Patent	Tobin's Q
Full Sample	146.00	0.01	137	2.485
Firms with Academic CEOs	155.00	0.017	170	2.676
Firms with Non-Academic CEOs	144.00	0.012	129	2.44
SOEs	226.00	0.014	166	2.20
Non-SOEs	89.20	0.013	117	2.68

Models 2 and 3 tested the effect of firm property on the correlation between academic CEOs and patent applications. For SOEs, academic CEOs remained positively and statistically significant at the 1% level. However, for non-SOEs, we found a nonsignificant result. With support from China's institutional system and the State-Owned Assets Supervision and Administration Commission (SASAC), academic CEOs at SOEs have more resources and social relationships than CEOs at private enterprises. Thus, it is much easier for them to increase the level of firm innovation, confirming Hypothesis 2. Also, we found there was no relationship between CEO compensation or CEO ownership and patent applications in SOEs' subgroup, supporting that the incentives mechanism and agency problems were distinctive in SOE. In non-SOEs, both CEO compensation and ownership promoted innovation output.

Table 4. Correlation of all variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 Academic CEO	1															
2 R&D Intensity	0.13 ***	1														
3 Patents	0.07 ***	0.12 ***	1													
4 Tobin's Q	0.06 **	0.17 ***	−0.23 ***	1												
5 Male	0.02	−0.04 **	−0.05 **	0.00	1											
6 Age	0.10 ***	−0.07 ***	0.02	−0.00	−0.04 *	1										
7 Compensation	0.03	0.01	0.07 ***	0.01	0.01	0.03	1									
8 Holdings	0.03	0.06 **	−0.01	−0.01	0.05 **	0.02	−0.06 ***	1								
9 Duality	0.04 **	0.00	−0.03	−0.01	−0.00	0.16 ***	−0.04 **	0.54 ***	1							
10 Political Connections	−0.08 ***	−0.04 **	0.03	−0.01	0.05 **	0.12 ***	−0.03	0.12 ***	0.34 ***	1						
11 Property	0.05 **	0.02	0.18 ***	−0.14 ***	−0.07 ***	0.13 ***	−0.07 ***	−0.34 ***	−0.34 ***	−0.14 ***	1					
12 Board Size	−0.00	0.01	0.16 ***	−0.14 ***	−0.10 ***	0.05 **	−0.03	−0.17 ***	−0.21 ***	−0.03	0.29 ***	1				
13 Independence	0.05 **	−0.02	0.01	0.01	0.10 ***	0.01	−0.03	0.02	0.08 ***	0.06 ***	−0.04 **	−0.43 ***	1			
14 Leverage	−0.10 ***	−0.14 ***	0.24 ***	−0.32 ***	−0.07 ***	0.02	−0.06 ***	−0.19 ***	−0.13 ***	−0.02	0.29 ***	0.20 ***	0.01	1		
15 Total Assets	−0.02	−0.15 ***	0.50 ***	−0.44 ***	−0.10 ***	0.11 ***	0.06 **	−0.18 ***	−0.16 ***	0.04 *	0.28 ***	0.27 ***	0.08 ***	0.52 ***	1	
16 Total Asset Turnover	−0.04 **	0.03	−0.01	−0.08 ***	−0.00	−0.02	0.05 **	−0.08 ***	−0.08 ***	−0.03	0.12 ***	0.03	−0.01	0.19 ***	0.08 ***	1

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.**Table 5.** Tobit regressions of academic CEOs on lagging firm innovation output.

	Model-1	Model-2 SOE	Model-3 Non-SOE	Model-4	Model-5	Model-6	Model-7 2-Year Lagging	Model-8 3-Year Lagging
Property	0.217 ** (0.087)	−	−	0.227 *** (0.085)	0.216 ** (0.087)	0.180 *** (0.014)	0.199 *** (0.031)	0.112 ** (0.054)
Compensation	0.085 ** (0.034)	0.043 (0.031)	0.187 *** (0.051)	0.065 ** (0.032)	0.085 ** (0.035)	0.080 *** (0.020)	0.062 *** (0.012)	0.075 *** (0.021)
Holdings	0.111 *** (0.036)	0.675 (0.428)	0.077 ** (0.034)	0.110 *** (0.036)	0.127 *** (0.038)	0.095 *** (0.017)	0.114 *** (0.037)	0.138 *** (0.001)
CEO with Research Background	0.241 *** (0.085)	0.328 *** (0.107)	0.058 (0.123)	0.158 * (0.085)	0.252 *** (0.086)	0.225 *** (0.048)	0.250 *** (0.050)	0.287 *** (0.017)
CEO with Research Background × Compensation				0.438 ** (0.198)				
CEO with Research Background × Holdings					−0.092 (0.063)			
R&D Intensity						0.148 *** (0.048)	0.167 *** (0.019)	0.204 *** (0.031)
CEO with Research Background × R&D Intensity						−0.084 *** (0.022)	−0.127 *** (0.029)	−0.158 *** (0.037)
Controlled Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−0.293 (0.334)	−0.195 (0.405)	0.397 (0.421)	−0.231 (0.322)	−0.319 (0.326)	−0.190 (0.239)	−0.121 (0.277)	−2.832 *** (0.136)
R ²	0.239	0.248	0.281	0.243	0.240	0.251	0.250	0.284
Observations	1210	501	709	1210	1210	1210	651	324

Robust standard errors in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

In Models 4 and 5, we used the interaction of CEO compensation and CEO holdings with academic CEOs to test the impact of managerial incentives on the correlation between such CEOs and innovation performance. The coefficient of compensation with academic CEOs is positive and significant at the 5% level, supporting Hypothesis 3a. In addition, academic CEOs with higher compensation develop more firm innovation output. Nevertheless, CEO holdings has no influence on the correlation between academic CEOs and patent applications, suggesting that the efforts of academic CEOs for R&D outcomes cannot be stimulated by their ownership, rejecting hypothesis 3b.

Models 6 to 9 showed that R&D intensity and its interaction with academic CEOs are added in regression analysis. R&D intensity positively and significantly correlated with academic CEOs at the 1% level. However, a negative correlation was found between the interaction and lagging patent applications of one to three years, bolstering Hypothesis 4 and suggesting that the R&D expenditure suppresses the positive correlation between academic CEOs and innovation output.

Considering the median of patents was far below the mean value in Table 2, the distribution showed that fewer listed companies contributed most innovation output. And there were 83 firm-year, 6.86% in our samples creating no patent. We ran additional tobit regressions from Models 1 to 6 for robustness tests using different samples in which firms generated at least one patent. We found that the results remain robust to this additional analysis. We do not report the additional regression analysis, but these figures are available upon request.

4.3. Academic CEOs, Innovation Activities, and Firm Performance

Table 6 presents the impact of academic CEOs and firm innovation activities on lagging firm performance by OLS regression. In Model 9, R&D intensity negatively and significantly correlated with the correlation between academic CEOs and firm performance at the 10% level, supporting Hypothesis 5 and implying that if academic CEOs tend to invest more in firm innovation, firm innovation output will be restrained.

Table 6. Ordinary least squares (OLS) regression of academic CEOs and innovation on lagging firm performance.

	Model-9	Model-10	Model-11 SOE	Model-12 Non-SOE
Property	0.031 (0.047)	0.042 (0.046)	- -	- -
CEO with Research Background	-0.061 (0.068)	-0.101 (0.075)	-0.123 (0.135)	-0.099 (0.093)
R&D Intensity	0.083 * (0.047)			
CEO with Research Background × R&D Intensity	-0.111 * (0.066)			
Patent		-0.048 (0.046)	0.080 ** (0.038)	-0.124 * (0.073)
CEO with Research Background × Patent		0.216 *** (0.081)	0.130 (0.095)	0.292 ** (0.124)
Controlled Variables	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Constant	-0.736 *** (0.178)	-0.716 (0.203)	-0.446 (0.182)	-0.726 (0.361)
R ²	0.288	0.290	0.415	0.252
Observations	1162	1162	481	681

Robust standard errors in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

Model 10 demonstrated that the coefficient corresponding to the interaction term of academic CEOs and firm patent applications is strongly positive and significant at the 1% level, supporting

that academic CEOs can promote firm performance by increasing firm innovation achievements. For Hypothesis 7, we found a positive and significant impact of academic CEOs and firm patent applications in non-SOEs by Model 11 and an insignificant result in SOE subsamples by Model 12, suggesting that the private sector is better at transforming innovation products into economic benefits than SOEs. Combined with the significance of property for patents in Model 1, we found that there was no relationship between property and firm performance in Model 9. These results support that the high level of innovation input and output of SOEs cannot bring higher performance than non-SOEs.

5. Discussion

Most scholars and executives would agree that innovation output and the impact of R&D on firm performance are crucial aspects in the survival and development of enterprises, especially because firms have to manage rapid changes and fierce competition [59,61]. In this study, we argue that CEOs with academic work experience can enhance firms' innovation output. We present this correlation from three aspects. First, academic working experience nurtures a stronger spirit of exploring new ideas and new technologies, which encourages these CEOs to form innovation strategies, develop R&D activities, and pursue more fruits of innovation [5]. In addition, academic organizations often establish the belief that science and technology are the only ways to resolve issues, develop organizations, and achieve individual fulfilment. Thus, academic CEOs tend to augment the competitive advantage of firms or move out of predicaments by using innovation activities. Moreover, academic CEOs, with better perception of and sensitivity to new technologies acquired by their previous career experience, are more adept at discovering new opportunities and applying new technologies for products and services [27].

Second, academic CEOs have more innovative and intellectual resources and expanded relationship networks than other CEOs; they have better connections with scientific researchers and are more likely to initiate R&D in cooperation with universities or research institutions. In some cases, their original work units are pleased with and take profit from collaborating with the CEOs and offer supernumerary research capacity and resources; such connections and cooperation markedly decrease R&D cost and promote innovation output for firms. Third, academic CEOs tend to build an organization and culture that supports innovation within firms, showing their willingness and preference for innovation, attracting and rewarding a scientific workforce, and promoting an innovation atmosphere [37]. In addition, the internal environment of firms is transformed to make it conducive to the development of innovative activities, which is similar to universities and research institutions and familiar to academic CEOs. Accordingly, we support that academic executives of SOEs are more skilled at enhancing R&D performance because of the assessment and promotion mechanism of SOEs, more capital, and related resources.

In this study, we also tested the moderating effect of managerial incentives and R&D input intensity on the correlation between academic CEOs and firms' innovation performance. Unlike previous studies, our analysis shows that compensation stimulates innovation performance of enterprises under academic CEOs, but shareholdings do not. Our analysis results of managerial incentives show academic CEOs' insensitivity to finance for the first time. Such CEOs consider innovation activities as duties and responsibilities that no longer require long-term incentives, just as they did at their universities and research institutions, where they were paid to conduct R&D projects. Our approach to academic CEOs and innovation efficiency draws upon and integrates innovation input, which again proves that such CEOs are not skilled at utilizing R&D investments and not sensitive to financial indices. Consistent with our hypothesis, academic CEOs cannot convert capital into innovation accomplishments well when they are given an excess of investment. As at universities and research institutions, researchers focus more on advanced and technical levels of innovation rather than the financial efficiency of research expenditure.

5.1. Implications for Management Research and Practice

This study has several crucial implications for management research and theory. First, we demonstrated that academic CEOs are related to higher innovation outcomes for firms, which contributes to the development of upper echelons theory. There is a growing body of evidence showing that CEOs are essential to the R&D activities and financial performance of firms [77–79]. This study extends the impact of CEOs' specific work experience on firms' strategy and innovation performance. Moreover, we determined the mechanism of how CEOs influence firm performance through R&D activities.

Second, we built a bridge between upper echelons theory and principal agent theory. Based on the upper echelons perspective, the discrepancy between a firm's long-term interests and an executive's current benefits or aversion to risk can be resolved by the executive's specific cognitive structure, individual preferences, and occupational habits. In addition, CEOs with academic work experience tend to promote the long-term interests of firms by developing innovation capacity, which is more likely to damage their own benefits or even career reputation.

Third, our findings of managerial incentives depict academic CEOs' distinctive agency problem and reveal the mismatch of present executive incentive design. The current literature supports that both short- and long-term incentives promote CEOs' efforts on R&D activities, and long-term incentives work better [51,54]. This study reveals academic CEOs' unique demand for compensation and shareholdings, implying that not all executives are sensitive to stock option incentives. Although most studies support that ownership is an effective method to alleviate CEOs' short-sighted behaviors and agency issues, academic CEOs' efforts toward innovation output are only promoted by compensation. Thus, we identified and filled the gap between CEO incentives and the agency problem.

Finally, this study contributes to the literature on innovation activities and firm performance. The correlation between innovation input or output and firm performance is uncertain and has been debatable for quite some time [62,64]. We did not test the correlation independently but introduced executives' characteristics into the analysis. The analysis results indicate that CEOs' academic work experience does not influence firm performance directly, and we should consider innovation activities and their interaction. Hence, we developed a framework that combines CEOs' unique background and innovation input or output to explore their integrated effect on firm performance, revealing academic CEOs' insensitivity to capital funds and an outstanding ability to identify technical opportunities. We suggest that academic CEOs reduce the correlation between R&D investment and firm performance, and develop the efficiency to translate innovation achievements into financial profits. Thus, this study provides empirical evidence for the debate on the impact of innovation on firm performance.

Our findings have some practical implications for boards of directors making decisions on executive selection and incentives. With a growing number of scholars leaving universities and research institutions to join the corporate sector, academic executives play a vital role in listed companies [5]. Such CEOs are indispensable for firms' development of innovation achievements, long-term technological advantage, and sustainable competitiveness. In addition, recruitment and selection of academic CEOs mitigate the agency issue and promote an innovation-oriented culture and strategy, resulting in the alignment of the organization and managers' interests. An academic CEO is the right choice for an ambitious enterprise. Moreover, it is imperative that boards of directors consider CEOs' academic work experience when setting their pay. Some previous studies have demonstrated that it is crucial for firms to reward executives for supporting R&D activities to develop innovation output by both long- and short-term managerial incentives [18,54]. However, for academic CEOs, only compensation can encourage their effort in innovation performance. Future research can further investigate the correlation between academic CEOs and other long-term projects of firms. Finally, this study contributes to the self-knowledge and self-evaluation of academic CEOs. They can notice their defects in the inefficiency of investment and improve the capital conversion rate to create more innovation achievements and improve firm performance with limited funds.

In addition, this study sounds an alarm to executives at SOEs and government officials who regulate China's SOEs. At SOEs, academic CEOs promote more innovation output, but cannot produce corresponding firm performance, suggesting a more serious agency problem and a mismatch between innovation output and financial performance. Compared with the private sector, SOEs are usually considered to be less efficient and less profitable in innovation and productivity [45]. The International Monetary Fund (IMF) reported that the productivity of SOEs was 25% lower, on average, than that of non-SOEs in 2017. Agency issues, political burdens, and soft budget constraints are the leading factors that influence the development of SOEs [84]. Unlike the manager market, executives at SOEs might lack professional management skills, as they are mostly appointed by government or superior officials [85]. Thus, individual relationships, networks, and even qualifications outweigh personal ability and experience in the recruitment process. Executives at SOEs act as both managers and government officials and prioritize political accomplishments, reputation, and promotion, hence they are responsible for the security of state assets, maintenance of social stability, growth of employment, and completion of administrative tasks, including innovation, which is just an assessment index, not connected with financial performance [41,82]. Moreover, executives at SOEs pursue uneconomic R&D results to improve their chances of being promoted, wasting large amounts of innovation resources that are unavailable for private enterprises. Hence, the assessment and promotion mechanism of these executives warrants reform and the management system of innovation activities at SOEs warrants improvement.

The effectiveness of R&D resource utilization and innovation output is a critical factor in transforming from innovation to sustainable development. Technological innovation aims to attain competitive advantage, develop new products, augment firm performance, lower production costs, and reduce harmful byproducts [7]. Innovation is one of the processes that can help a company to integrate sustainability into core business processes. If the objective of R&D results deviates from the intended target or the innovation process creates additional wasted resources, it breaks the link between innovation and social welfare. Although sustainable development is a global policy issue and macro topic, it is rooted in the micro level. To completely promote the positive impact of innovation on the sustainable growth process, firm-level and managerial issues should be considered [10]. Executives' preference could be a contradiction when companies attempt to implement innovation and sustainability strategies simultaneously [9]. Furthermore, academic CEOs' waste of R&D investments and specious patents for individual promotions at SOEs adversely affect not only firm performance and socioeconomic benefits, but also sustainability development.

5.2. Limitations and Future

This study has several limitations, which may also be present in future research. First, our measurement of innovation output had issues. We used patent applications to describe firms' innovation outcomes; however, not all innovation accomplishments are patentable and not all patentable output can be patented by firms. Some companies choose to keep technological secrets and protect their innovation products by eschewing patents. In addition, while patents represent an essential and popular measurement of innovation output, not all patents correlate with economic benefits and not all R&D results can be commercialized. Thus, patent applications can only partially capture a firm's innovation performance, and future studies should consider more precise variables to analyze the impact of CEO characteristics on innovation output. For example, Knott introduced research quotient (RQ), a new method of innovation measurement to evaluate R&D productivity, which was conducive to the studies on the correlation between R&D spending and returns [86]. Second, we only focused on the effect of CEOs' particular background and academic work experience on innovation performance and firm performance. The reasons for and sources of executives' influence on firm strategy are multitudinous and deep-seated. Simple CEO background or experience is inadequate to elucidate executives' preferences and behaviors. Hence, future research should open the black box of

executives' demographic background through psychological measurement and analysis, which will augment research reliability, validity, and explanatory power.

6. Conclusions

This is one of the few studies to explore the interaction effect of CEOs' specific experience and R&D activities on firm performance. Our findings support that the CEOs' academic work experience does not independently affect firms' financial performance, but does so interactively with innovation input and output. Corroborating prior hypotheses and results, with a higher level of R&D intensity, academic CEOs decrease not only innovation performance but also financial performance. On the other hand, overinvestment in R&D projects affects the economic efficacy of enterprises, reestablishing that academic CEOs have a lower level of capital utilization. In addition, our findings suggest that innovation output plays a more significant and quite different role in the correlation between academic CEOs and firm performance. Such executives are better at turning technical advantages into corporate profits rather than R&D investment; they have a clear understanding of the marketing value of innovation products and can grasp the economic effects of technical results precisely. A group regression analysis revealed that this effect is significant at POEs, as CEOs of listed companies under state control do not regard innovation output as a driving force of firm performance, but as a condition for political promotion. Although academic CEOs create more innovation achievements at SOEs, some of these achievements lack practical and economic value, resulting in no development of financial performance.

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