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I hereby declare that this Doctor of Business Administration dissertation is my original work and it has been written by me in its entirety.

I have duly acknowledged all the sources of information which have been used in this thesis / dissertation.

This Doctor of Business Administration dissertation has also not been submitted for any degree in any university previously.

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Abstract: As an important personality trait, CEO curiosity is emphasized in practice but obtains little attention in theory. This dissertation aims to investigate the impact of CEO curiosity on firm innovation and the mediating role of external search. I argue that both diversive and specific curiosity of CEOs are positively correlated to firm innovation based on upper echelons theory (UET). Furthermore, search breadth mediates the positive connection between CEO diversive curiosity and firm innovation, while search depth mediates the positive connection between CEO specific curiosity and firm innovation. Besides, I explore the moderating effects of firm performance and market competition on the correlation between CEO curiosity and external search. Using survey data, I obtain strong empirical support for the theoretical model. This dissertation strives to investigate the connection between CEO curiosity and firm innovation, tackle the mechanism behind the relationship, and enrich the research of the upper echelons theory.

Keywords: CEO curiosity, firm innovation, external search

Content

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1. Introduction

Curiosity is an important personality trait of CEOs. As Adam Bryant, a columnist for The New York Times, argued "passionate curiosity" was one of the common themes among successful leaders he interviewed[1]. The importance of curiosity has been mentioned by various CEOs. For example, Indra Nooyi, one of the few female CEO of PepsiCo, who have promoted the revenue grew more than 80% during her tenure[2], proposed the "5C principle of leadership", namely, curiosity, creativity, citizenship, courage, and communication. She argued that a successful business leader must always keep curiosity, a strong thirst for knowledge, and the spirit of exploration. As the technologies develop quickly and the environment faced by firms becomes more and more turbulent, dealing with things unfamiliar becomes a new norm for CEOs, and curiosity plays a significant role in learning and exploring new ideas, which become more valuable under such a context. A large number of successful CEOs mentioned the importance of curiosity in their business and regard curiosity as a shared personality of successful CEOs[3]. For example, interviews with three successful start-ups also suggest that curiosity is helpful for entrepreneurs to start their companies and breed a culture of taking on challenges and being innovative, and thus contributes to the success of the

[1] Adam Bryant of The New York Times On What Makes Great Leaders Great https://www.forbes.com/sites/davidparnell/2014/07/01/adam-bryant-of-the-new-york-times-on-great-leaders/#e7d01b533de5

[2] Indra Nooyi Discusses Corporate Governance https://www.udel.edu/udaily/2019/april/corporate-governance-symposium-weinberg-center/

[3] Curiosity: the one shared trait of successful CEOs https://www.dukece.com/insights/curiosity-one-shared-trait-successful-ceos/

start-ups[4]. Although the importance of CEO curiosity attracted great attention in practice and emphasized by a lot of successful CEOs, it has not been explored enough in theory.

Extant research has explored the effect of curiosity in various fields, such as newcomer adaption (Harrison et al., 2011), well-being in adolescents (Jovanovic & Brdaric, 2012), educational attainment (Hassan et al., 2015), academic performance (Powell et al., 2017), individual creativity (Hagtvedt et al., 2019), job performance (Reio & Wiswell, 2000) and so on, but the influence of CEO curiosity lacks exploration relatively. According to the upper echelons theory (UET), curiosity remarked as one important CEO characteristics, may influence CEOs' strategic choices (Hambrick & Mason, 1984). Yet, the question of how CEO curiosity influences firm strategies remains to be explored. And thus, the goal of this dissertation is to demonstrate the correlation between CEO curiosity and firm innovation and further tackle the mechanism.

Innovation is a central element of firms' strategies to gain competitive advantages (Grimpe et al., 2019). And CEOs' psychological traits play important roles in the innovation process of firms based on the upper echelons theory (UET), especially curiosity. Curiosity enables CEOs to be more open towards new information and different opinions and becomes the symbol of

[4] Curiosity: One Secret to Success https://www.merckgroup.com/en/stories/curiosity-one-secret-to-success.html

leaders such as Amazon, Google and other innovators[5]. Curious CEOs show higher levels of creativity and exploration, and thus they will generate more innovative ideas (Hagtvedt et al., 2019; Harrison & Dossinger, 2017). Curiosity helps CEOs to view difficult situations firms faced more creatively and facilitate more innovation and positive changes in firms[6]. And thereby I believe that CEO curiosity contributes to promoting firm innovation. However, the curiosity on the executive level still lacks exploration, especially its effect on firm innovation.

CEO curiosity is an essential component in CEOs' knowledge searching and learning process (Harvey et al., 2007), which creates an open climate towards external knowledge and promotes the external search of firms. External search involves search breadth and search depth. A broader and deeper external search provides diverse and valuable knowledge for firms to innovate (Laursen & Salter, 2006). Therefore, I argue that CEO curiosity promotes firm innovation through influencing external search behaviors. Specifically, CEO curiosity is divided into specific curiosity and diversive curiosity (Berlyne, 1966; Harrison et al., 2011; Litman & Spielberger, 2003). CEOs with high diversive curiosity are willing to explore a range of diverse topics (Harrison & Dossinger, 2017) and may adopt a broader search strategy to seek information through plenty of sources (Cruz-González et al., 2015) and

[5] Curiosity Is a Key to Success for CEOs https://www.business2community.com/leadership/curiosity-key-success-ceos-01930831

[6] The Business Case for Curiosity https://hbr.org/2018/09/the-business-case-for-curiosity?ab=at_articlepage_recommendedarticles_bottom1x1

complement firms' internal knowledge (Tsinopoulos et al., 2019), thus promoting firm innovation. By contrast, CEOs motivated by specific curiosity tend to concentrate on a limited range of subjects and engage in a deeper search (Grossnickle, 2016). And the deep external search is beneficial for firms to obtain the required technical or market knowledge (Flor et al., 2018), thus facilitating firm innovation. Therefore, I believe that search breadth mediates the correlation between CEO diversive curiosity and firm innovation, while search depth mediates the connection between CEO specific curiosity and firm innovation.

The effect of CEO curiosity on strategic choice may be contingent on situations. For example, CEO curiosity may be critical for firms in the creative industry, but less significant for firms in industries that do not emphasize creativity and exploration. Excessive curiosity may motivate CEOs to choose unusual and risky solutions rather than simple and effective ones[7], and even be harmful to firms. In this dissertation, I discussed the moderating effects of contingent factors on the connection between CEO curiosity and external search, namely, firm performance and market pressure. Good firm performance provides more slack resources for CEOs to make and implement strategies while external pressure from various aspects may limit their strategic choices. From the aspect of internal resource support, well-

[7] What Happens When Leaders Lack Curiosity? https://www.forbes.com/sites/tomaspremuzic/2017/03/06/what-happens-when-leaders-lack-curiosity/?sh=275a54616b74

performing firms provide curious CEOs with more slack resources to search externally, and thus enhance the connection between CEO curiosity and external search. From the aspect of external pressure, fierce market competition makes CEOs feel stronger competitive threats and a higher level of tension when making decisions (Kilduff et al., 2016; Xu et al., 2019). Facing intense competition, curious CEOs face a high level of cognitive load and have less energy to search. And thus the positive influence of CEO curiosity on external search may be weakened in such a context.

Using survey data of 166 CEOs from China, I found strong support for my theoretical framework. This research strives to contribute to the extant research in aspects as follows. First, this paper extends the studies of curiosity by exploring its effect on firm innovation from the executive level, which enriches the research of the upper echelons theory (UET). Although curiosity in the workplace has attracted much attention in theory and practice (Celik et al., 2016; Harrison et al., 2011), effects of curiosity at the executive level on firm-level outcomes still lacks exploration. Therefore, this study investigates the connection between CEO curiosity and firm innovation and offers empirical evidence to give a deeper insight into the influence of curiosity at the executive level. Second, this dissertation explores the different effects of two types of curiosity on firm innovation and their mechanism, namely, diversive curiosity and specific curiosity (Berlyne, 1966; Hagtvedt et al., 2019; Litman & Spielberger, 2003). I propose that CEOs' diversive curiosity

promotes firm innovation by increasing external search breadth, while their specific curiosity facilitates firm innovation by improving external search depth. This dissertation extends the interpretation of the correlation between CEO curiosity and enterprise innovation by not only exploring the different impacts of diversive curiosity and specific curiosity but also examining the mediating effect of the search strategy. Third, this study provides new perspectives on external search behaviors. Prior research lacks exploration about the antecedents of external search depth and breadth (Dong & Netten, 2017). This study explores the antecedents of external search from the aspect of CEO curiosity to deepen the understanding of firms' external search strategies, which enriches the study of external search behaviors. Fourth, the dissertation demonstrates the moderating effect of firm performance and market competition on the correlation between CEO curiosity and external search behaviors, which enriches the applied contexts of our results.

2. Literature Review

2.1. CEO characteristics and firm innovation

Based on the upper echelons theory, CEOs take actions according to their personal interpretations of the contexts, and their interpretations are influenced by their experiences, personalities, and values (Hambrick, 2007; Hambrick & Mason, 1984). And thereby, CEOs' characteristics are important predictors of firms' strategies options (Hambrick, 2007). Firm innovation is an important strategic choice, and extant research has discussed the connection between various CEOs' characteristics and firm strategic choice.

Kitchell (1997) divided CEO characteristics into two categories: demographics like age, work experience, educational background, and tenure; and psychological attributes like personalities. Scholars have discussed a lot about the impacts of CEO characteristics on outcomes at the firm level, such as corporate social responsibility (Tang et al., 2015; Tang et al., 2018), firm performance (Chen & Nadkarni, 2016; Ou et al., 2018), innovation performance (Cummings & Knott, 2018; Sunder et al., 2017).

As a significant outcome, firm innovation is strongly affected by CEOs' characteristics (Tang et al., 2015). From the aspect of demographic characteristics, scholars believed that the demographics determine CEOs' individualized interpretations of the circumstances and options (Hambrick & Mason, 1984), and thus influence their strategic choices of innovation. Extant research has explored the effect of demographic characteristics like CEO age,

education, work experience (Barker & Mueller, 2002), pay (Balkin et al., 2000), tenure (Wu et al., 2005). But the effects of some demographics have not reached a consensus in prior studies. For instance, Barker and Mueller (2002) argued that there exists a positive connection between CEO tenure and firm innovation, while the results of Wu et al. (2005) suggested that short-tenured CEOs promote firm invention activities more effectively, while long-tenured CEOs spur invention in stable technology contexts more effectively. While the research of Li & Yang (2019) suggested that the correlation between CEO tenure and exploitative innovation of the firm is positive. In addition, scholars evaluated the impacts of different types of CEOs on firm innovation as well. For example, Cho and Kim (2017) posited CEOs who have shorter career horizons are likely to create fewer breakthrough innovations. Cummings and Knott (2018) suggested that compared with inside CEOs, the R&D productivity of the firm will go down during an outside CEO's tenure. Lee et al. (2020) argued that compared with professional CEOs, founder CEOs will develop more explorative innovations. I summarized several representative studies about the connection between CEOs' demographic characteristics and firm innovation in Table 1.

Table 1 Connection between CEO's demographic characteristics and firm innovation

Reference	Demographics	Findings
Barker and Mueller (2002)	Age Educational Work experience	Younger CEOs with advanced science-related degrees or work experience in engineering/ marketing/ R&D will

	Tenure	increase R&D investments; the impacts of the CEO on relative R&D spending are strengthened as CEO tenure increases.
Wu et al. (2005)	Tenure	There exists an inverted U-shape connection between CEO tenure and firm innovation.
Balkin et al. (2000)	Pay	CEOs' short-term compensation is related to innovation, while it does not apply to high-technology firms.
Lin et al. (2011)	Education level Professional background Political connection	The professional background, education level, and political connection of CEOs have positive effects on the firm's efforts to innovate
Loukil et al. (2020)	Education background	Compared with business and management educated CEOs, those with an engineering or a science degree tend to increase R&D investments.
Saggese et al. (2020)	Gender	Female CEOs positively moderates the positive relationships between women directors and innovation input.
Han (2019)	Political preference	Republican CEOs can negatively affect firm innovation.

In terms of CEO's psychological characteristics, prior research has evaluated the impacts of various CEO traits on firms' R&D investments and innovation outcomes, in particular their personalities. Recent researches have concentrated on the personalities that are generally considered to be harmful for firms and explored their potential benefits for firm innovation, such as overconfidence (Galasso & Simcoe, 2011) hubris (Arena et al., 2018; Tang et al., 2015), and narcissism (Kashmiri et al., 2017; Zhang et al., 2017). The summary of some representative papers about the correlation between the CEOs' psychological traits and firm innovation is displayed in Table 2.

Table 2 Connection between CEO's psychological characteristics and firm innovation

Reference	Psychologies	Findings
Ahn et al. (2017)	Positive attitude Entrepreneurial orientation Patience	The positive attitude, patience and entrepreneurial orientation of CEOs play critical roles in promoting open innovation in SMEs.
Kraiczy et al. (2015)	Risk-taking propensity	CEO risk-taking propensity facilitate new product innovation of firms
Zheng et al. (2020)	Self-regarding values	CEOs who have high self-regarding values tend to decrease their efforts on firm innovation
Jin et al. (2019)	Core Self-evaluation	CEOs who have high core self-evaluation promote firm innovation
Prasad & Junni (2017)	Risk propensity Organizational identification	Both CEO risk propensity and organizational identification facilitate firm innovation
Gal (2019)	Conscientiousness	The correlation between conscientiousness in the CEO and firm innovation is negative.
Galasso and Simcoe (2011); Hirshleifer et al. (2012)	Overconfidence	Overconfident CEOs tend to increase investment in the innovation activities, gain a larger number of patents and patent citations, and finally obtain more excellent innovative success
Kashmiri et al. (2017)	Narcissism	CEOs' narcissism may both positively and negatively influences firms' innovation-related behavior
Tang et al. (2015)	Hubris	CEO hubris can facilitate firm innovation, and the positive relationship may become weaker as the environment becomes more complex
You et al. (2020)	Sensation thinking	Sensation seeking of CEOs is positively related to firm innovation
Zhang et al. (2017)	Humility Narcissism	CEOs who are both narcissistic and humble tend to have socialized charm, develop an innovative culture, and improve innovative performance.

2.2. Curiosity

2.2.1. Concept of curiosity

Scholars generally define curiosity as an aspiration for new knowledge and novel sensory experience which can stimulate individuals' exploratory behavior (Berlyne, 1954; Litman & Spielberger, 2003; Loewenstein, 1994).

Curiosity, conceptualized by early theorists as a basic and homeostatic drive like hunger or thirst (Jones et al., 1961; Loewenstein, 1994), is regarded as an intrinsically evoked appetite for information, and the acquisition of knowledge can be intrinsically rewarding. However, in terms of the internal mechanism through which acquiring knowledge brought pleasure, scholars hold two distinctive opinions. Some thought it's rewarding just because it eliminates undesirable ignorance or uncertainty (Litman & Jimerson, 2004; Loewenstein, 1994). The others believed that when curiosity has been aroused, the attainment of knowledge is highly pleasurable because it stimulates one's interest (Kashdan et al., 2004). These two claims led to two main theories that attempt to excavate the origins of curiosity and exploratory behaviors: curiosity-driven theory and optimal arousal theory.

Personality taxonomies are critical for predicting an individual's curiosity, especially big five personality factors (Jani, 2014). For instance, Kashdan et al. (2011) found that curiosity has a moderate positive connection with extraversion and openness to experience, and is negatively correlated with neuroticism. Hunter et al. (2016) found that HEXACO personality account for 22.5% of the variance in the different measures of curiosity on average. Openness to experience, conscientiousness, and extraversion positively

influence curiosity, and openness is the strongest predictor for an individuals' curiosity among the personalities. Kashdan et al. (2020) argued that curiosity is positively connected with open mindedness and extraversion.

Curiosity is always considered as a construct with multiple dimensions. To clarify the concept of curiosity, scholars have developed different dimensions.

(1) Perceptual Curiosity & Epistemic Curiosity

Berlyne (1954) classified curiosity into two types, namely epistemic and perceptual curiosity. Perceptual curiosity (PC) indicates the curiosity leading to the growing perception of stimuli, and it could be evoked in both animals and human beings by novel stimuli such as visual, auditory and tactile stimulation and alleviated by exposing to these stimuli continuously. Epistemic curiosity (EC) is defined as the appetite or drive for knowledge that encourages the attempts to obtain novel ideas, narrow information gaps, and settle intellectual challenges (Berlyne, 1954; Loewenstein, 1994) which is purely human behaviors. Besides the intention to attain information-bearing stimulation for the elimination of uncertainties of the moment, epistemic curiosity also aims to gain knowledge, referring to information stored in the form of ideational structures that can act as guidance for future behaviors (Berlyne, 1966). It explains individuals' behaviors concerning approaching situations characterized by novelty, uncertainty, complexity, ambiguity, etc. (Berlyne, 1978). The study by Litman & Spielberger (2003) demonstrated that

EC and PC can be meaningfully distinguished from one another as two dimensions of a multifarious personality construct.

(2) Diversive Curiosity & Specific Curiosity

Scholars have theorized curiosity into two types: specific curiosity and diversive curiosity (Berlyne, 1966; Hagtvedt et al., 2019; Litman & Spielberger, 2003). Diversive curiosity refers to the curiosity reflecting an interest to learn and investigate new and unfamiliar topics, which stimulates individuals to seek a broad range of new information; while specific curiosity describes the curiosity reflecting an aspiration to reduce uncertainty or solve a particular puzzle (Litman & Jimerson, 2004; Loewenstein, 1994). Litman & Spielberger (2003) built on measurement of specific and diverse epistemic curiosity and discovered the two dimensions are highly associated with each other.

(3) State Curiosity & Trait Curiosity

Other than the above two dimensions of curiosity, the most universally studied division of curiosity by scholars concerns state curiosity and trait curiosity. State curiosity, defined as the curiosity in a specific circumstance, is usually motivated by environmental triggers. Trait curiosity is viewed as a common capacity or propensity to give rise to the desire for information that motivates exploration (Litman, 2005; Loewenstein, 1994). In contrast to state curiosity, it's a personality trait that sustains in a wide range of circumstances. And studies have found that people who are highly curious tend to experience

curiosity more frequently and intensely, given the exposure to various situations or recurrent goal-directed involvement with similar contexts (Litman, 2005; Litman & Silvia, 2006).

(4) Curiosity as a Feeling of Interest & Deprivation

Generally, curiosity-related behaviors are related to positive affect. Nevertheless, Loewenstein (1994) and Litman & Jimerson (2004)suggested that those behaviors might also be related to hate of uncertainty and tension, such as being bothered not having access to new information. This aspect is labeled as a feeling of deprivation, which stimulates individuals' persistent explorative behaviors until the craved knowledge is acquired or challenges are overcome.

Thus, curiosity can be viewed as containing both pleasant interest and unhappy deprivation, the former is labeled as CFI, and the latter is labeled as CFD. Loewenstein (1994) posited that the motivation of seeking information is to hate not having information, rather than to expect happiness from obtaining information, that is to say, CFD indicates a more influential intention for exploring and learning compared with CFI

Table 3 summarizes an overview of the dimensions of curiosity that are commonly studied.

Table 3 the dimensions of curiosity

Dimensions		Difference
PC & EC	Perceptual Curiosity	Motivated by the novel stimuli (visual, auditory, or tactile stimulation, etc.)

	Epistemic Curiosity	Applying to both animals and human beings Motivated by the desire or drive for knowledge Purely human behaviors
DC & SC	Diversive Curiosity	Motivated by the sensation of boredom or a yearning for incentive variation Often related to broad and indirect forms of exploratory behaviors
	Specific Curiosity	Motivated by the desire for deep knowledge about a specific topic Often related to narrow and direct forms of exploratory behaviors
SC & TC	State Curiosity	Usually motivated by the environment triggers Curiosity in a particular situation
	Trait Curiosity	Motivated by the desire for information that motivates exploration General capacity or propensity to experience curiosity, enduring across many situations
CFI & CFD	Curiosity as a Feeling of Interest	Aroused by pleasant feelings of interest
	Curiosity as a Feeling of Deprivation	Aroused by hate of uncertainty and tension

2.2.2. Related research on curiosity

The existing studies have explored the effect of curiosity in various fields and suggested that curiosity plays a distinct role in human behavior and development. For example, van Dijk & Zeelenberg (2007) suggested that curiosity can overcome peoples' regret aversion and promote them to make decisions with higher uncertainty. Jovanovic & Brdaric (2012) demonstrated that adolescents with high curiosity will actively engage in the exploration of new things and feel a higher level of positive well-being. Hassan et al. (2015) argued that epistemic curiosity drives people to seek new information, learn new things and keep thinking, it positively mediates the correlation between

personality characteristics and the efficiency of learning and training. Powell et al. (2017) found that the curiosity of advanced tertiary students is helpful to predict their academic performance. Syed et al. (2020) found that curious people tend to engage in activities with high risks and challenges, and thus the positive connection between entrepreneurial passion and innovativeness will be amplified by the curiosity of individuals.

Recently, scholars have started to discuss the effect of curiosity in the workplace. For instance, Reio & Wiswell (2000) argued that the curiosity of employees is closely connected with workplace learning and positively affects their job performance. Mussel (2013) found that curiosity becomes a good predictive indicator of job performance, employees with a high level of curiosity usually have better performance. Celik et al. (2016) explored the connection between the work-related curiosity of employees and their innovation performance and argued that work-related curiosity will promote employees' exploratory behaviors and enhance their work innovation, and thus it can be used as a predictor of employees' innovation performance in enterprise recruitment. Chang & Shih (2019) argued that employees' curiosity may facilitate creative performance through creative process engagement, such as identifying critical problems, acquiring new information, generating innovative ideas, and appropriate evaluation and implementation of these ideas.

A few studies paid attention to the influence of curiosity at the top

management level and started to investigate the influence of managerial curiosity on firms' strategy. For instance, Garrison et al. (2008) demonstrated that the curiosity of top management teams is positively correlated to firms' identification and early adoption of disruptive information technologies. Jeraj & Antoncic (2013) proposed the concept of entrepreneurial curiosity and develop its measure. Jeraj et al. (2015) found that the curiosity of entrepreneurs is helpful to facilitate a firm's growth. Arikan et al. (2020) argued the curiosity inspires entrepreneurs to create more opportunities. However, there still lacks exploration about the impact of curiosity at the executive level on firm strategy.

2.3. External search behavior

In the era of open innovation, it is hard for enterprises to survive and develop if they only depend on internal information and knowledge (Chesbrough, 2003), and enterprises have increasingly searched for knowledge beyond their boundaries (Badir et al., 2020; Cheng et al., 2020; Dahlander et al., 2021). This trend of inward knowledge transfer, known as "inbound open innovation" (Bianchi et al., 2016; Lyu et al., 2019), is increasingly emphasized in innovation theory and practice (West et al., 2014). The search for external knowledge provides firms good access to complement their internal knowledge stock with a great many benefits (Kotlar et al., 2013), such as a shortened innovation process, distributed costs and risks among partners, shared resources, and high returns (Du et al., 2014; Granstrand et al., 1992;

Segelod & Jordan, 2004). It enables firms to skip the development phases, access technology within mature phases (Steensma, 1996), and track the latest trends in advanced technologies (Hung & Tang, 2008).

The external search, referring to a series of activities to acquire new ideas and knowledge from external channels (Nelson & Winter, 1982), exerts a substantial impact on a firm's open innovation performance. Firms can obtain external technologies and knowledge through a lot of sources, such as their competitors, suppliers, customers, and so on (Cruz-González et al., 2015). Katila and Ahuja (2002) have classified external search behaviors into search depth and search scope. By introducing the concepts of search depth and search breadth, Laursen and Salter (2006) further proposed this division of external search activities: search breadth is regarded as a series of external channels or sources that firms use to obtain innovation opportunities, whereas search depth is commonly regarded as the degree to which companies depend on these external sources to improve performance. Both external search depth and breadth characterize firms' openness towards external information and knowledge (Laursen & Salter, 2006).

There has been a great proliferation of studies exploring the factors that affect firms' search strategies. The study of Veugelers and Cassiman (1999) demonstrated that an effective mechanism of technology protection causes the firms to decrease the likelihood of an exclusive external knowledge searching strategy. Cohen & Levinthal (1990) suggested that complex and sophisticated

technological knowledge accessed from outside requires a strong absorptive capacity to assimilate and integrate them successfully into the firm's activities Klevorick et al. (1995) pointed out that firms in industries with more technology opportunities will tend to increase the external search for knowledge, while those in industries with few technical opportunities are more likely to rely on internal resources. Jones et al. (2001) found the possibility of firms that are equipped with greater internal resources to search externally is relatively smaller. Ritter and Gemünden (2003) suggested that firms with a higher degree of openness of corporate culture are inclined to accessing external knowledge resources via developing inter-organizational relationships. Almeida et al. (2003) found that a growing size of startups might increase their opportunities to obtain and use external knowledge. Rosenkopf & Almeida (2003) indicated that the mobility of inventors and alliances helps firms to overcome the limited local search and increase firms' search breadth. Dong and Netten (2017) argued that information technology presents an inverted U-shaped correlation with search depth and breadth.

External search can also become a double-edged sword for innovation. From the aspect of search breadth, broad search from various sources brings more diversity to firms' knowledge base and can improve the heterogeneity of knowledge resources, which increases the possibility of acquiring precious knowledge for innovation (Leiponen & Helfat, 2010) and allows firms to create new combinations from diverse knowledge. A broad search helps firms

to notice new market and technology developments (Katila & Ahuja, 2002), enhancing their flexibility to adjust to unpredictable changes. But excessive broad search necessitates high costs as a result of the growing complexity to manage various relationships required to keep access to external resources (Leiponen & Helfat, 2010; Zhou & Wu, 2010). Engaging in search activities from too wide sources of knowledge may cause difficulty in allocating the limited managerial attention, and some valuable knowledge and information which are beneficial for firm innovation may be ignored (Laursen & Salter, 2006). From the aspect of search depth, a deep external search enables firms to sustain close cooperation with external participants (Laursen & Salter, 2006), identify the unique value of the knowledge elements that are not apparent (Katila & Ahuja, 2002; Leiponen & Helfat, 2010) and obtain the required technical or market knowledge (Flor et al., 2018). But the returns on the basis of the same knowledge may decrease, which makes a deeper search in the same knowledge components more expensive and the solutions excessively complicated (Dosi, 1988; Katila & Ahuja, 2002).

Therefore, although there have been various studies examining the connection between external search and firm innovation, the roles of external search have not achieved a consistent conclusion. Some studies argued that external search exerts no impact on firm innovation. For instance, the empirical results of Ferreras-Méndez et al. (2015) showed that the coefficients of search depth as well as search breadth are not significant, suggesting that

search depth and breadth seem cannot enhance firm innovation. Some scholars believe that there exists a curvilinear connection between external search and firm innovation. For example, with a sample of UK manufacturing firms, Laursen and Salter (2006) argued that companies with higher search depth and breadth are likely to be more innovative within a certain range, but after a point, an additional search of firms turns unproductive. Some studies found the linear influence of external search on innovation performance of firms. For example, Chiang and Hung (2010) proposed that external search breadth is beneficial to firms' radical innovation, but search depth can contribute to incremental innovation performance. Table 4 presents the main research about the influence of external search on firm innovation.

Table 4 Connection between external search and firm innovation

Relationship	Findings	Reference
Uncorrelated	Search depth and breadth cannot enhance firm innovation	Ferreras-Méndez et al. (2015)
Curvilinear relationship	The correlation between external search breadth and firm innovation as well as the correlation between external search depth and firm innovation is inverted U-shaped.	Laursen and Salter (2006)
	There exists an inverted U-shaped correlation between search breadth and firm innovation.	Wu (2013)
	The external search depth is inverted U connected with innovation performance	Katila and Ahuja (2002)
	External search breadth can exert an inverted U-shape effect on product innovation	Ardito & Messeni Petruzzelli (2017)
	There exists an inverted U shape in the correlation of external search breadth and tendency to engage in eco-innovations.	González-Moreno et al. (2019)

	Both search breadth and search depth are inverted U-shaped correlated to green innovations	Wang et al. (2020)
Linear relationship	External search breadth exerts a positive connection with firm innovation.	Katila and Ahuja (2002)
	External search breadth is positively connected with the firm's radical innovation performance, and search depth is positively connected with the incremental innovation performance.	Chiang and Hung (2010)
	Both external search breadth and depth exert positive impacts on firms' radical innovation	Flor et al. (2018)
	External search breadth exerts a negative impact on process innovation whereas the search depth exerts a positive influence on process innovation outcomes.	Terjesen & Patel, (2017)

From an analysis of prior work, it can be found that the antecedents of external search depth and breadth have not attracted sufficient attention in theory (Dong & Netten, 2017), especially the "human side" factors. Based on the upper echelons theory, CEO characteristics will affect firms' external search strategy, however, the correlation between CEO characteristics and external search behaviors lacks exploration in extant research. And the correlation between search behaviors and firm innovation has not achieved a consistent conclusion yet, which may be an important gap in the literature.

2.4. Summary

Since the upper echelons theory was proposed (Hambrick & Mason, 1984), a large number of studies investigated the influence of CEO characteristics on firms' strategies and firm-level outcomes. Innovation is a key strategy for firms, and extant research has explored various demographic or psychological attributes on firm innovation (Barker & Mueller, 2002; Cho

& Kim, 2017; Cummings & Knott, 2018; Sunder et al., 2017). Recent studies pay more attention to the impact of CEO personality on firm innovation, such as risk propensity (Kraiczy et al., 2015), overconfidence (Hirshleifer et al., 2012), and narcissism (Kashmiri et al., 2017).

Surprisingly, as an important trait mentioned many times by various CEOs in practice, the effect of CEO curiosity lacks exploration in theory. Prior research focused on the influence of curiosity on their individual behaviors. Recently, scholars have started to discuss the effect of curiosity in the workplace (Celik et al., 2016; Chang & Shih, 2019; Mussel, 2013; Reio & Wiswell, 2000). Only a few studies paid attention to the influence of managerial curiosity on firms' strategy (Arikan et al., 2020; Garrison et al., 2008). However, there still lacks exploration about the impact of curiosity at the executive level on firm strategy, especially on firm innovation.

Diversive curiosity and specific curiosity display great differences in the effects on individual behaviors (Berlyne, 1960; Hardy et al., 2017; Harrison et al., 2011). Therefore, the mechanism behind the relationship between different types of CEO curiosity and firm innovation is different. According to the concepts of the two types of curiosity, diversive curiosity reflects an interest to learn and explore unfamiliar and new topics, while specific curiosity indicates a desire to reduce uncertainty or solve a particular puzzle (Litman & Jimerson, 2004). Search breadth and search depth may be alternative mechanisms behind the relationship between different types of CEO curiosity and firm innovation.

The mechanism remains a “black box”, which needs to be further investigated.

3. Theoretical Framework

3.1. Diversive curiosity and specific curiosity

In this study, the dimensions of diversive curiosity and specific curiosity are adopted to assess the impact of CEO curiosity on firm innovation. As mentioned above, diversive curiosity reflects an interest to learn and explore unfamiliar and new topics, while specific curiosity indicates a desire to reduce uncertainty or solve a particular puzzle (Litman & Jimerson, 2004). The diversive curiosity drives individuals to search for novelty which offers feelings of excitement and interest for them (Litman, 2005) and motivates playful behaviors that promote them to understand the world from new perspectives (Harrison et al., 2011). Specific curiosity triggers exploration about unsolved puzzles out of the need to gain a sense of control and reduce uncertainty (Litman & Jimerson, 2004; Litman, 2008).

Individuals may develop different types of curiosity. Kerr & Beer (1992) found that junior high school students with a higher depression score owing to divorced and non-divorced parents may present stronger specific curiosity. Beck & Crie (2018) argued that online Virtual Fitting Rooms can increase consumers' specific curiosity about the product.

Scholars have developed valid and reliable measurement scales for the two types of curiosity. Silverstein et al. (1981) suggested that Howard's Maze Test can be used to measure diversive curiosity and specific curiosity. Litman & Spielberger (2003) developed and validated the scale to measure epistemic

curiosity with subscales of diversive curiosity and specific curiosity. Park et al. (2014) developed a scale to measure sports fans' specific curiosity including three dimensions: general information, specific information, and sports facility information. Collins et al. (2004) developed a measurement for perceptual curiosity, which contains subscales for diversive curiosity and specific curiosity.

Scholars explored the effect of both diversive curiosity and specific curiosity in many fields. Harrison et al. (2011) assessed the influence of curiosity on newcomers in an organization and discovered that the specific curiosity of newcomers can be positively connected with information seeking, and the diversive curiosity of newcomers can be positively connected with positive framing. Nishikawa & Amemiya (2017) found that two types of curiosity are correlated to individual differences in people's emotions: when people are given unintelligible pictures, people with strong diversive curiosity tend to feel more interest, while people with strong specific curiosity tend to feel confused. Harrison & Dossinger (2017) indicated that diversive curiosity can catalyze the process of feedback-seeking and help workers become more responsive to pliable guidance in the feedback they receive in creative works. Hardy et al. (2017) suggested that diversive curiosity facilitates creativity by stimulating individuals' information-seeking behaviors. Fang et al. (2018) demonstrated that specific curiosity initiates specific exploration and drives people to search for details, while people with strong diversive curiosity tend

to engage in diversive exploration. Hagtvedt et al. (2019) argued that specific curiosity can make individuals more creative, and idea linking exerts a mediating role on the positive correlation between specific curiosity and creativity.

Diversive and specific curiosity may result in different behaviors of individuals. Specifically, from the executive level, CEOs with different types of curiosity may make different strategic choices, but this issue has not been explored enough. The goal of this dissertation is to discuss the different effects of diversive curiosity and specific curiosity on firm innovation.

3.2. CEO curiosity and firm innovation

On the basis of the upper echelons theory (UET), CEO characteristics are important elements that can affect firms' strategic decisions and choices for innovation (Hambrick & Mason, 1984). Among different characteristics, CEO curiosity is a critical element in promoting innovation strategies of a firm but lacks enough attention in theory.

As noted, curiosity is a desire for information and knowledge, and a passion for learning and exploring (Berlyne, 1966). Curiosity is an essential component in the knowledge search process (Harvey et al., 2007). Curious CEOs tend to actively seek new information to fill their knowledge gaps between their existing knowledge and what they wish to acquire (Loewenstein, 1994). CEOs with high diversive curiosity have a broad interest in exploring and learning, their diverse knowledge reserve makes their understanding of the

world reorganized (Harrison et al., 2011) and provides new perspectives and inspirations for firm innovation. And CEOs with high specific curiosity show a desire to solve a particular puzzle and seek the related knowledge actively (Litman & Spielberger, 2003), their specific and specialized knowledge may provide strong support when firms encountering difficulties in the innovation process. It has been proved that both diversive and specific curiosity is closely related to creativity (Hagtvedt et al., 2019; Harrison & Dossinger, 2017) and creativity plays an important role in firm innovation (Revilla & Rodríguez-Prado, 2018). CEO curiosity may spark creative ideas (Garrison et al., 2008) that are beneficial for the process to develop new products and thus facilitating firm innovation performance. Furthermore, curious CEOs are likely more open to new ideas within and outside the organizations (Celik et al., 2016) and are more willing to adopt new technologies and knowledge (Garrison et al., 2008).

Therefore, this study believes that both diversive curiosity and specific curiosity may promote firm innovation, which suggests the hypothesis as follows:

Hypothesis 1a: *CEOs' diversive curiosity is positively connected with firm innovation.*

Hypothesis 1b: *CEOs' specific curiosity is positively connected with firm innovation.*

3.3. Mediating effect of external search

The mechanism of CEO diversive curiosity and specific curiosity on firm

innovation may be different.

From the aspect of diversive curiosity, CEOs with high diversive curiosity are more willing to explore a range of diverse topics (Harrison & Dossinger, 2017), learn something new (Hardy et al., 2017), and engage in a broader form of information seeking from a variety of sources (Langevin, 1971). Diversive curiosity is a stable personality trait (Litman & Spielberger, 2003), which affects CEOs' exploring and learning behaviors, and thus influences their strategic choice. It generates a feeling of excitement and an anticipated joy for discovering something new and motivates CEOs to frame and reframe knowledge in new ways (Harrison et al., 2011; Litman, 2005). Motivated by diversive curiosity, CEOs are more open to a broad range of new knowledge both within and outside the firm and creates an atmosphere to encourage employees to source knowledge from a series of sources. As a result, a firm run by a CEO with a higher level of diversive curiosity may seek information through a broad range of channels, like customers, suppliers, competitors, governments, and so on, namely, the external search breadth of the firm may be broader (Cruz-González et al., 2015).

A broader external search improves the number and variety of cooperators in the open innovation process, and thereby brings variety to a firm's knowledge base (Kobarg et al., 2019), complements firms' internal knowledge, and provides more opportunities to learn (Tsinopoulos et al., 2019). External search breadth promotes firms' ability to understand new

information and forecast technological changes (Flor et al., 2018), and thus improve their likelihood of gaining fruitful innovation (Leiponen & Helfat, 2010). It also offers more novel solutions to resolve various unexpected problems in the innovation process from a diverse knowledge base and thus facilitates firm innovation (Zang et al., 2014). Therefore, the assumption is as follows:

Hypothesis 2a: *External search breath mediates the positive relationship between CEOs' diversive curiosity and firm innovation.*

From the aspect of specific curiosity, CEOs motivated by specific curiosity tend to emphasize a limited number of topics and engage in a deeper search (Grossnickle, 2016). Specific curiosity is a more targeted form, which is goal-oriented, problem-focused, and committed to reducing perceived novelty in one's environment (Hardy et al., 2017). As a feeling of deprivation concerns, a trait-related specific curiosity in higher levels motivates CEOs to keep exploring new information deeply to reduce the original complexity of the situation and overcome uncertainty until the answer to the particular puzzle is found, which finally contributes to their improvement of competence (Mussel, 2013). CEOs with high specific curiosity may focus on particular problems faced by the firm and pay attention to details and concrete cues. They are more likely to seek deeply in their knowledge and experience and search for information that can go beyond what is needed to solve the particular conundrum (Loewenstein, 1994). When external sources of

knowledge provide potential solutions to their firms' challenges, they are likely to go deep into this source to fill in knowledge gaps (Harvey et al., 2007). Since the deep search in external sources needs lots of resources and is less likely to occur under strict budget constraints (Garriga et al., 2013), the support of CEOs with high specific curiosity is critical in increasing the external search depth.

The deep external search enables firms to establish and sustain good cooperation with external participants (Laursen & Salter, 2006). The transfer of tacit and complicated knowledge is facilitated by close collaboration with external partners (Kobarg et al., 2019), and close collaboration is also good for firms to obtain the required technical or market knowledge (Flor et al., 2018), which is critical for firm innovation. Therefore, I propose the following hypothesis:

Hypothesis 2b: *External search depth mediates the positive relationship between CEOs' specific curiosity and firm innovation.*

3.4. Moderating roles of firm performance and market pressure

The support of internal resources is critical for CEOs to make and implement strategies while the external pressure may limit their strategic choices. And thus in this part, I discussed the moderating roles of internal resources and external pressures on the relationship between CEO curiosity and external search strategies of firms, namely, firm performance and market competition.

(1) Moderating effect of firm performance

Improving firm performance is a key issue for CEOs (Crossland & Chen, 2013; Jenter & Kanaan, 2015). To guarantee the long-term success and viability of firms, CEOs need to monitor firm performance compared with competitors and take measures to avoid bad performance (Short & Palmer, 2003). Good performance of firm provide more support for CEOs to implement strategies, while bad performance increases pressures faced by CEOs.

Well-performing firms provide more resources to engage in exploratory and distant search activities (Cyert & March, 1963) and support CEOs to make and implement strategies (Lin, 2014). A high level of firm performance indicates high profit and a certain level of slack resources (George, 2005) and release firms from the pressure of performance in the short run (Martin et al., 2016; Wu & Tu, 2007). Slack resources refers to "the difference between total resources and total necessary payments" (Cyert & March, 1963), which is like a resource cushion for firms to respond to threats and seize opportunities (Bourgeois, 1981). Slack resources can be redeployed for better firm performance (Vanacke et al., 2017) and offer flexibility for CEOs to allocate resources in different activities (Martin et al., 2016), enabling CEOs to exert power and make strategic moves that require a large number of resources (Dutta et al., 2016). External search activities need a lot of resources, and thus slack resources are critical for firms to engage in external search activities.

Curious CEOs need enough resources to support them to make and implement external search strategies. Therefore, the positive effect of CEOs' diversive curiosity on search breadth as well as the positive influence of CEOs' specific curiosity on search depth will be amplified when firm performance is high.

In contrast, bad performance compared with competitors in the industry increases the performance pressure faced by CEOs. The probability of firms to dismiss CEOs is closely associated with poor firm performance (Fiordelisi & Ricci, 2014; Jenter & Kanaan, 2015). CEOs are likely to be fired after bad industry, because boards may mistakenly blame CEOs for bad firm performance in declining industries beyond their control (Jenter & Kanaan, 2015). And boards may use severe pay cuts to inspire CEOs who do poorly to improve corporate performance compared with their competitors in the industry (Gao et al., 2012). The threats of CEO change and pay cuts push CEOs to work hard to improve firm performance. Behavior theory points out that firms may search for solutions around the problems they are faced with, resulting in myopia and neglect of distant search (Cyert & March, 1963). When firm performance is bad, CEOs with high curiosity feels huge performance pressure, and have to focus on the problem of poor firm performance. They may be afraid of the failure of external search (Jianfeng Wu & Tu, 2007) and decrease distant and external search to improve firm performance as soon as possible. In addition, curious CEOs do not have enough resources to invest in external search behaviors when firm

performance is low (Lin, 2014), and they and thereby they may less likely to make and implement strategies to search broadly and deeply. Therefore, in firms with poor performance, the positive connection between CEOs' diversive curiosity and search breadth and that between CEOs' specific curiosity will be weakened.

Therefore, the assumption is proposed as follows.

Hypothesis 3a: *Firm performance positively moderates the correlation between CEOs' diversive curiosity and external search breadth. At higher levels of firm performance, the connection between diversive curiosity and external search breadth will be stronger, and vice versa.*

Hypothesis 3b: *Firm performance positively moderates the correlation between CEOs' specific curiosity and external search depth. At higher levels of firm performance, the connection between specific curiosity and external search breadth will be stronger, and vice versa.*

(2) Moderating effect of market competition

From the aspect of external pressure, fierce market competition makes CEOs feel stronger competitive threats and a higher level of tension when making decisions (Kilduff et al., 2016; Xu et al., 2019) and bear the huge pressure to outperform their competitors (Sheikh, 2018b). Intense market competition increases the possibility of CEOs' turnover (Sheikh, 2019), forcing them into a passive position (Kim et al., 2017). CEOs are more worried about the risk of failure and dismissal (Sheikh, 2018a) and they have

to make fast and frequent decision-making when market competition is high (Christie et al., 2003). Under pressure, individuals present a high level of anxiety and perform badly (Mesagno & Mullane-Grant, 2010). The pressure will increase the cognitive load of curious CEOs and deplete their attention, and thus influencing their behaviors and decisions about external search (Byrne et al., 2015). Under pressure from market competition, curious CEOs have less energy to explore and search. Furthermore, since external partners display higher levels of opportunistic behaviors and distrust in highly competitive markets, the possibility of failure from external search increases (Wu, 2012). Worried about the risk of failure, curious CEOs may narrow their external search strategies. Therefore, the connection between CEO curiosity and firms' external search will be weakened in firms facing fierce market competition.

By contrast, CEOs have more leeway in making mistakes in less competitive markets (Sheikh, 2018a). And thus curious CEOs feel less pressure from the external environment and have more freedom to explore and search when market competition is low. And thereby the positive impact of CEO curiosity on external search will be enhanced in markets with a low level of competition. Therefore, I proposed the following assumption:

Hypothesis 4a: *Market competition negatively moderates the correlation between CEOs' diversive curiosity and external search breadth. At higher levels of market competition, the connection between diversive curiosity and*

external search breadth will be weaker, and vice versa.

Hypothesis 4b: *Market competition negatively moderates the correlation between CEOs' specific curiosity and external search depth. At higher levels of market competition, the connection between specific curiosity and external search breadth will be weaker, and vice versa.*

Figure 1 displays the theoretical model according to the hypotheses mentioned above.

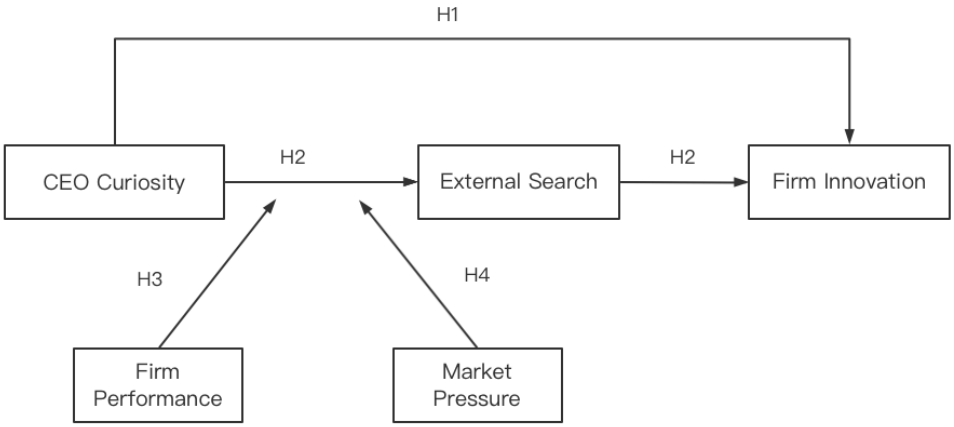

Figure 1 Theoretical model of CEO curiosity and firm innovation

4. Research Design and Methodology

4.1. Sample and data collection

I tested my theoretical model by collecting data from a sample of firms in China. 500 firms that have obtained or will obtain round A financing were selected through the four investment firms and 230 CEOs of these firms were contacted and invited to involve in my survey. To improve the interests and commitment of participants to offer accurate information, I promise the confidentiality of the data and provide them with the conclusions of this study.

I developed this survey in some steps as follows. First of all, I designed the questionnaire in English based on mature scales developed by prior research. Then, back translation is conduct, which is helpful to reduce cultural prejudice and improve the validity (Boyd et al., 2013). I invited two raters who are fluent in both Chinese and English to translate the questionnaire from English into Chinese. And then, two other raters are invited to translate the Chinese version of the questionnaire into English. Next, I compared the difference in the translations and discussed with raters thoroughly to achieve a consensus on the final questionnaire. Last of all, to guarantee the validity of the scales of my questionnaire to avoid the bias of culture and language in translation and ensure translated items express the same meanings, I invited 5 CEOs to complete the questionnaire pilot test and offer some suggestions for minor changes in this survey, such as the modification of the wording in the questionnaire. In addition, their test results were not included in my main

sample.

The data collection stage is from February to April in 2021, which lasts for two months. I first sent messages or E-mails to obtain their agreement to participate in this study and complete the two-wave questionnaire. In particular, I collect data of independent and dependent variables at two different time points to mitigate the potential adverse effect of common method bias. In the first round, CEOs are invited to complete the questionnaire including independent variables and control variables. And one week later, they are invited to evaluate their firms' external search activities, innovation performance and business environments. Among the 230 companies, 204 CEOs of these firms completed two rounds of the survey, and thus the response rate is 88.7%.

Questionnaires in which key items are not answered or answers are contradictory are not included in the sample. After eliminating invalid samples, 166 observations are included in the final sample of this study.

Among 166 CEOs in the sample, 80 of them are female. And 90.36% of them have undergraduate degrees or above and 63.86% have been in the position of chief executive officer for more than 2 years. The demographic characteristics of CEOs are displayed in Table 5.

Table 5 Demographic characteristics of CEOs

Characteristics		Number	Percentage
Gender	Female	80	48.19%
	Male	86	51.81%
Age	30 and under	44	26.51%

	31-40	66	39.76%
	41-50	45	27.11%
	51-60	11	6.63%
	61 and above	0	0%
Education	Below undergraduate	16	9.64%
	Undergraduate	81	48.80%
	Master	59	35.54%
	Doctor	10	6.02%
Tenure	Less than 2 years	60	36.14%
	2-4 years	38	22.89%
	4-6 years	23	13.86%
	6-8 years	21	12.65%
	8-10 years	8	4.82%
	More than 10 years	16	9.64 %

4.2. Measures

To measure the main constructs, existing scales from the literature are adopted. Specifically, I employ a five-point Likert scale to measure the main constructs.

4.2.1. Dependent variable

Firm innovation. According to Mihalache et al. (2012), I adopt a four-item scale to measure firm innovation. The items of the measurement are displayed in Table 6. Cronbach's alpha for the four items of firm innovation is 0.907, indicating that the internal consistency of the measurement of firm innovation is high.

Table 6 Measure of firm innovation

Dimensions	Item
Firm innovation	Introduced in the market many products and services that are completely new to us
	Our firm has launched several new lines of products
	Our firm places emphasis on product and process innovation

	We often experiment in the market with new products and services

4.2.2. Independent variable

Diversive and specific curiosity. To measure the two types of curiosity, the scales built and validated by Litman and his colleagues are adopted in this study (Litman, 2008; Litman & Spielberger, 2003). CEOs in the sample were instructed to demonstrate how they feel in general. Five items measured diversive curiosity and five items measured specific curiosity. The two kinds of curiosity and specific curiosity is presented in Table 7. Cronbach's alpha coefficient for the five items of diversive curiosity is 0.908, and it is 0.867 for the five items of specific curiosity, which suggests that the internal consistency of the two types of curiosity is high in this dissertation.

Table 7 Measure of CEO curiosity

Dimensions	Item
Diversive curiosity	Enjoy exploring new ideas
	Enjoy learning about subjects that are unfamiliar to me
	Find it fascinating to learn new information
	Learn something new, like to find out more about it
	Enjoy discussing abstract concepts
Specific curiosity	Hours on a problem because I cannot rest without answers
	Conceptual problems keep me awake thinking about solutions
	Frustrated if I cannot figure out a problem, so I work even harder
	Work like a fiend at problems that I feel must be solved
	Brood for a long time to solve problems

4.2.3. Mediating variable

I adopt the measurement of search breadth and depth developed by

Laursen & Salter (2006). The search breadth is evaluated by the total number of external information channels and sources used by the company during the innovation process, and the search depth is calculated as the number of external information sources the company greatly depends on. I included 11 sources of external knowledge in the questionnaire: suppliers, consumers, competitors, distributors, venture capital investment corporations, universities or research institutes, other business links, consultants, technology intermediary organizations, government, and media. CEOs are required to give the scores of each source according to the use frequency of the firm, and a higher score suggests a greater dependence of the firm on this source. The frequent use of a certain external knowledge channel indicates the firm are open to the source (Chen et al., 2011). The Cronbach's alpha coefficient of the scores of 11 sources is 0.876, suggesting a high level of internal consistency. The mean value and variance of firms' use of different knowledge in the sample are displayed in Table 8.

Table 8 The use of different external knowledge sources.

Sources	Mean	Standard deviation
Clients	4.713	1.415
Suppliers	4.305	1.476
Distributors	3.754	1.630
Competitors	4.335	1.334
Other business links	4.198	1.376
Venture capital investment corporations	3.994	1.433
Universities or research institutes	3.820	1.573
Consultants	3.575	1.538
Government	3.641	1.494

Media	4.090	1.366
Technology intermediary organizations	3.575	1.470

Search breadth and search depth. I construct search breadth as a sum of 11 external knowledge sources. Each source is a dummy variable: if the firm j uses source i for innovation, then source i in firm j is coded as 0; while when the firm does not adopt this source, the source is coded as 0. In practice, I give the variable of source i in firm j a value of 1 if CEOs of firm j choose a score of 0 in the scale for the source; while I will give it a value of 1 if they choose a score of 1-5 (Cruz-González et al., 2015). Then a new variable, namely, external search breadth, is calculated as the combination of the 11 dummy variables, ranging from 0 to 11. The value of search breadth of firms that do not use any external knowledge source but only use internal knowledge is 0, while the search breadth of those using all the external knowledge sources is 11.

Search depth is also constructed based on these 11 external knowledge sources. Following search breadth, I code each external knowledge source as a dummy variable independently with a value of 1 if the firm highly relies on the source, and 0 otherwise. In practice, I give the variable of source i in firm j a value of 1 if CEOs of firm j choose a score of 0-2 in the scale for the source; while I will give it a value of 1 if they choose a score of 3-5 (Cruz-González et al., 2015). Then the search depth is calculated as the sum of these dummy variables, ranging from 0 to 11. The value of search depth is 0 if the firm does

not highly rely on any external knowledge sources during their innovation procedure, while the search depth is 11 if the firm highly relies on all external knowledge sources.

4.2.4. Moderating variable

Firm performance. Return on asset (ROA) is employed to indicate firm performance. A high return on assets indicates a certain level of slack resources in the firm (George, 2005).

Market competition. I adopted the six-item scale proposed and developed by Desarbo et al. (2005). The detailed items of market competition are displayed in Table 9. The higher scores suggest that market competition is fierce and the external pressures for firms will be greater. The Cronbach's alpha coefficient for market competition is 0.853, suggesting a high level of internal consistency of the measurement.

Table 9 Measure of market competition

Dimensions	Item
Market competition	Competition is cutthroat
	Many "promotion wars" in industry
	Competitors can match offers readily
	Price competition in industry
	New competitive moves every day
	Competitors are relatively weak

4.2.5. Control variable

I included the effect of the firm, CEO, and industry in the regression to account for alternative explanations.

At the firm level, various variables are controlled in the model. Given

that research and development (R&D) investment is usually regarded as a proxy of firms' absorptive capability (Cohen & Levinthal, 1990; Huang et al., 2015), and positively affects firm innovation (Shefer & Frenkel, 2005), I controlled *R&D investment* in the model, which was measured as the logarithm of the sum of R&D expenses. *Firm size* was controlled and measured by the logarithm of the total asset. Larger companies usually have more resources to involve in innovative activities (Triguero & Corcoles, 2013) promoting the possibility of the success in commercializing new products (Ettlie & Rubenstein, 1987). Since the complexity of the firm may increase with age (Hussinger & Wastyn, 2016), I controlled the effect of *Firm age,* which was calculated as the logarithm of the overall number of years since the firm's establishment. Given that well-performing firms have more resources for innovation activities and may present high innovation capabilities, *Firm performance* was included and measured the return on asset.

At the CEO level, the gender, age, educational level, tenure, and share of CEOs were taken into considerations. The difference in the monitoring effectiveness (Jie Chen et al., 2018), network ties (Marvel et al., 2015) risk preference (Mahto et al., 2018) between female and male CEOs may result in different innovation performances of firms. Therefore, *CEO gender* was controlled in the model as a dummy variable. *CEO age* was also taken into consideration as it is closely related to the risk-taking of CEOs when making strategies (Yeoh & Hooy, 2020), and thus influences firm innovation (Barker

& Mueller, 2002). It was given values according to different age groups of CEOs. Given that *CEO tenure* is related to their propensity to invest in R&D activities (Barker & Mueller, 2002; Li & Yang, 2019; S. Wu et al., 2005), and thereby I included it in the model. In addition, the educational level of CEOs also plays an important role in firms' innovation process (Lin et al., 2011), Highly-educated CEOs are more likely to introduce an innovation in firms (Olivari, 2016), and thus *CEO education* is controlled in this study. I give a value of 1, 2, 3, 4 to the variable of CEO education for CEOs without college degrees, with a bachelor's degree, with a master's degree, with a doctorate degree respectively. Given that CEO ownership is closely associated with their risk taking when making decisions (E. H. Kim & Lu, 2011), and CEOs holding high shares may be more motivated to increase R&D intensity and make efforts to improve firm innovation (Lin et al., 2011), I included *CEO share* in the model, measured by the share proportion of the CEO.

At the industry level, a dummy variable of the *industry* is included in the model to control the influence of industry. It is coded as 1 if the firm is from the manufacturing industry, and as 0 if it is from the service industry.

5. Results

5.1. Descriptive statistics and correlations

Table 10 gives the descriptive statistics of variables with their means, standard deviations, the minimum and maximum value. The average size of firms is 7.802 in the sample, and the mean value of their R&D investment is 4.238. The average ROA of these firms is 45.7% and the mean value of firm innovation is 3.742. The mean score of diversive curiosity of CEOs in these firms is 3.854 and the mean value of specific curiosity is 3.667.

Table 10 Descriptive statistics of main variables

Variables	Mean	SD	Min	Max
(1) Firm innovation	3.742	0.917	1	5
(2) Diversive curiosity	3.854	1.018	1	5
(3) Specific curiosity	3.667	1.028	1	5
(4) Search breadth	10.066	1.933	0	11
(5) Search depth	7.530	3.162	0	11
(6) Firm size	7.802	2.829	3.091	24.545
(7) Firm performance	0.457	1.082	-0.222	10
(8) R&D investment	4.238	3.348	0	13.049
(9) Firm age	2.304	0.677	1.099	4.812
(10) CEO gender	0.518	0.501	0	1
(11) CEO age	2.139	0.887	1	4
(12) CEO education	2.380	0.743	1	4
(13) CEO share	36.692	31.848	0	100
(14) CEO tenure	2.560	1.638	1	6
(15) Industry	0.175	0.381	0	1
(16) Market competition	3.494	0.718	1.333	5

Note: N=166.

Table 11 gives the correlations between main variables.

Table 11 Correlations between main variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Firm innovation	1.000						
(2) Diversive curiosity	0.551	1.000					
(3) Specific curiosity	0.587	0.827	1.000				

(4) Search breadth	0.277	0.234	0.219	1.000			
(5) Search depth	0.382	0.420	0.389	0.565	1.000		
(6) Firm size	0.118	0.105	0.155	0.078	0.005	1.000	
(7) Firm performance	0.033	-0.005	-0.002	-0.019	-0.059	-0.194	1.000
(8) R&D investment	0.158	0.027	0.083	0.208	-0.020	0.570	-0.015
(9) Firm age	-0.106	-0.170	-0.116	-0.026	-0.142	0.347	0.046
(10) CEO gender	0.032	0.063	0.122	-0.054	-0.014	0.183	-0.033
(11) CEO age	0.135	0.235	0.268	0.051	0.114	0.107	-0.224
(12) CEO education	0.104	0.199	0.235	0.164	0.154	0.171	-0.027
(13) CEO share	0.231	0.193	0.163	-0.069	0.124	-0.126	-0.028
(14) CEO tenure	0.183	0.179	0.179	0.065	0.022	0.147	-0.033
(15) Industry	0.021	-0.028	0.022	0.034	0.038	0.108	0.142
(16) Market competition	0.442	0.307	0.386	0.318	0.332	-0.050	0.002

Variables	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(8) R&D investment	1.000								
(9) Firm age	0.199	1.000							
(10) CEO gender	0.165	0.194	1.000						
(11) CEO age	-0.033	0.127	0.383	1.000					
(12) CEO education	0.063	-0.059	0.022	0.104	1.000				
(13) CEO share	-0.161	-0.269	0.174	0.166	0.043	1.000			
(14) CEO tenure	0.078	0.268	0.279	0.526	0.008	0.315	1.000		
(15) Industry	0.159	0.262	0.126	0.161	0.064	-0.111	-0.002	1.000	
(16) Market competition	0.058	-0.093	0.051	-0.043	0.057	0.189	0.115	-0.011	1.000

Note: N=166, the absolute correlation larger than 0.12 is significant at 0.05 level.

As predicted, both diversive and specific curiosity are positively related to firm innovation significantly. Besides, diversive curiosity is positively connected with search breadth and specific curiosity is positively connected with search depth. Search breadth and depth are also positively connected with firm innovation. The correlation coefficients between variables are small relatively, which demonstrates that multicollinearity is not a significant problem in this dissertation. In addition, I also conduct the variance inflation factor (VIF) test (Wooldridge, 2010). The maximum of VIF is 3.87 and the mean VIF is 1.83, which are below the acceptable level of 5, suggesting low

multi-collinearity risks in our results (Chatterjee & Hadi, 1977). Together, these finds reveal that multicollinearity is not a big concern for my results.

5.2. Hypothesis test

(1) Main effect of CEO curiosity and mediating effect of external search

I used OLS regression analysis to validate my hypotheses. Table 12 demonstrates the regression results of the connection between CEOs' diversive curiosity and firm innovation as well as the mediating effect of external search breadth.

Table 12 The main effect of diversive curiosity and mediating role of search breadth

	Model 1 Firm innovation	Model 2 Search breadth	Model 3 Firm innovation
Firm size	0.002	-0.083	0.007
	(0.067)	(-1.054)	(0.297)
Firm performance	0.033	-0.064	0.037
	(0.761)	(-0.730)	(0.942)
R&D investment	0.048**	0.149**	0.038*
	(2.057)	(2.189)	(1.748)
Firm age	-0.039	-0.076	-0.034
	(-0.315)	(-0.162)	(-0.307)
CEO gender	-0.130	-0.381	-0.104
	(-0.999)	(-1.111)	(-0.806)
CEO age	0.000	0.029	-0.002
	(0.002)	(0.138)	(-0.023)
CEO education	-0.022	0.328*	-0.044
	(-0.249)	(1.740)	(-0.496)
CEO share	0.004**	-0.007	0.005**
	(2.117)	(-1.001)	(2.383)
CEO tenure	0.033	0.098	0.026
	(0.670)	(0.818)	(0.545)
Industry	0.087	0.073	0.082
	(0.563)	(0.166)	(0.551)
Diversive curiosity	**0.460*****	**0.417***	**0.431*****
	(6.269)	(1.841)	(5.971)
Search breadth			**0.069****
			(2.114)

Constant	1.686***	8.014***	1.136**
	(3.610)	(6.105)	(2.258)
N	166	166	166
R^2	0.357	0.137	0.375

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Hypothesis 1a forecasts a positive correlation between diversive curiosity of CEOs and firm innovation. Model 1 contains diversive curiosity and control variables. The coefficient of diversive curiosity is 0.460 at the significant level of 1%, which indicates that CEOs' diversive curiosity is significantly and positively associated with firm innovation (b=0.460, p<0.01), thereby supporting Hypothesis 1a.

Hypothesis 2a suggests that search breadth mediates the positive correlation between CEOs' diversive curiosity and firm innovation. Model 2 presents the regression results of the connection between diversive curiosity and search breadth. The results indicate that diversive curiosity is positively connected with search breadth at a significance level of 10% (b=0.417, p<0.10), offering evidence for part of Hypothesis 2a. Model 3 in Table 12 included search breadth and diversive curiosity. Search breadth is positively connected with firm innovation (b=0.069, p<0.05), which provides evidence for part of Hypothesis 2a. Also, Model 3 shows that the effect parameter of diversive curiosity diminishes, though still significant (b=0.431, p<0.01). Together, the positive connection between diversive curiosity of CEOs and firm innovation is mediated by search breadth. Furthermore, the Sobel test for the mediating effect of search breadth on the connection between diversive

curiosity and firm innovation suggests that the p-value is 0.098, which is significant at 10% level, and thus providing support for the mediating role of search breadth.

Similarly, Table 13 demonstrates the regression results on the connection between specific curiosity and firm innovation as well as the mediating role of search depth.

Table 13 The main effect of specific curiosity and mediating role of search depth

	Model 4 Firm innovation	Model 5 Search depth	Model 6 Firm innovation
Firm size	-0.002	-0.037	0.000
	(-0.073)	(-0.399)	(0.012)
Firm performance	0.025	-0.189	0.035
	(0.573)	(-0.662)	(1.035)
R&D investment	0.042**	-0.010	0.043**
	(2.058)	(-0.108)	(2.188)
Firm age	-0.049	-0.275	-0.034
	(-0.404)	(-0.592)	(-0.282)
CEO gender	-0.172	-0.394	-0.151
	(-1.327)	(-0.711)	(-1.212)
CEO age	-0.027	0.111	-0.033
	(-0.328)	(0.323)	(-0.400)
CEO education	-0.051	0.254	-0.065
	(-0.636)	(0.826)	(-0.790)
CEO share	0.005**	0.006	0.004**
	(2.146)	(0.739)	(2.034)
CEO tenure	0.041	-0.086	0.046
	(0.947)	(-0.468)	(1.012)
Industry	0.063	0.549	0.034
	(0.459)	(0.909)	(0.244)
Specific curiosity	**0.499*****	**1.136*****	**0.439*****
	(6.574)	(4.300)	(5.848)
Search depth			**0.053*****
			(2.756)
Constant	1.832***	3.660**	1.638***
	(4.306)	(2.439)	(3.936)
N	166	166	166

R2	0.397	0.179	0.424

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Hypothesis 1b states that the specific curiosity of CEOs positively influences firm innovation. Model 4 contains only control variables and CEOs' specific curiosity. The results show that the coefficient of specific curiosity is 0.499 at a significance level of 1%, suggesting a positive correlation between specific curiosity and firm innovation (b=0.499, p<0.01), thereby offering support for Hypothesis 1b. CEOs' specific curiosity contributes to promoting innovation performance of firms.

Hypothesis 2b indicates that the connection between CEOs' specific curiosity and firm innovation is mediated by search depth. Model 5 presents the regression results between CEOs' specific curiosity and external search depth. The results indicate that specific curiosity is significantly and positively correlated to search breadth (b=1.136, p<0.01). Model 6 included search depth and CEOs' specific curiosity. The results reveal that search depth is positively connected with firm innovation (b=0.053, p<0.01), lending support to Hypothesis 2b partly. And the effect parameter of specific curiosity diminishes but still significant (b=0.439, p<0.01). Therefore, the specific curiosity of CEOs facilitates firm innovation through enhancing external search depth, and Hypothesis 2b is supported. Furthermore, the Sobel test for the mediating effect of search depth on the connection between specific curiosity and firm

innovation suggests that the p-value is smaller than 0.001, and thus providing support for the mediating role of search depth.

(2) Moderating effect of firm performance and market competition

Table 14 demonstrates the regression results of the moderating effect of firm performance and market competition on the correlation between diversive curiosity and search breadth.

Table 14 The moderating effects on the relationship between diversive curiosity and search breadth

	Model 7 Search breadth	Model 8 Search breadth
Firm size	-0.091	-0.102
	(-1.127)	(-1.445)
R&D investment	0.150**	0.158***
	(2.194)	(2.627)
Firm age	-0.133	0.281
	(-0.282)	(1.010)
Firm performance	-0.165	-0.032
	(-1.493)	(-0.447)
CEO gender	-0.360	-0.491
	(-1.040)	(-1.478)
CEO age	-0.026	0.063
	(-0.120)	(0.301)
CEO education	0.328*	0.246
	(1.735)	(1.416)
CEO share	-0.007	-0.008
	(-1.125)	(-1.493)
CEO tenure	0.147	0.016
	(1.236)	(0.171)
Industry	0.136	-0.153
	(0.313)	(-0.450)
Diversive curiosity	**0.401***	**0.181**
	(1.790)	(1.009)
Diversive curiosity*Firm performance	**0.199***	
	(1.829)	
Market competition		0.829***
		(3.212)

Diversive curiosity*Market competition		**-0.951*****
		(-3.322)
Constant	9.780***	9.594***
	(8.963)	(10.143)
N	166	166
R^2	0.148	0.333

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Hypothesis 3a posits the positive moderating effect of firm performance on the relationship between CEOs' diversive curiosity and search breadth. In model 7, the interaction term between diversive curiosity and firm performance is positive for search breadth at a significance level of 10% (b=0.199, p<0.10), thereby offering support for Hypothesis 3a. And thus the positive effect of diversive curiosity on search breadth will be enhanced when firm performance is high.

Figure 2 displays the interactions between firm performance and diversive curiosity on search breadth. For instance, for firms that have a high level of ROA, search breadth in firms operated by CEOs with low diversive curiosity (one std. deviation lower than the average) compared with firms operated by CEOs with high diversive curiosity (one std. deviation higher than the average) increases by 13.6%. In comparison, when firm performance is low, search breadth in firms operated by CEOs with low diversive curiosity (one std. deviation lower than the average) compared with firms operated by CEOs with high diversive curiosity (one std. deviation higher than the average) increases by 3.8%. Therefore, diversive curiosity strengthens the

search breadth of firms when firm performance is high, in line with Hypothesis 3a.

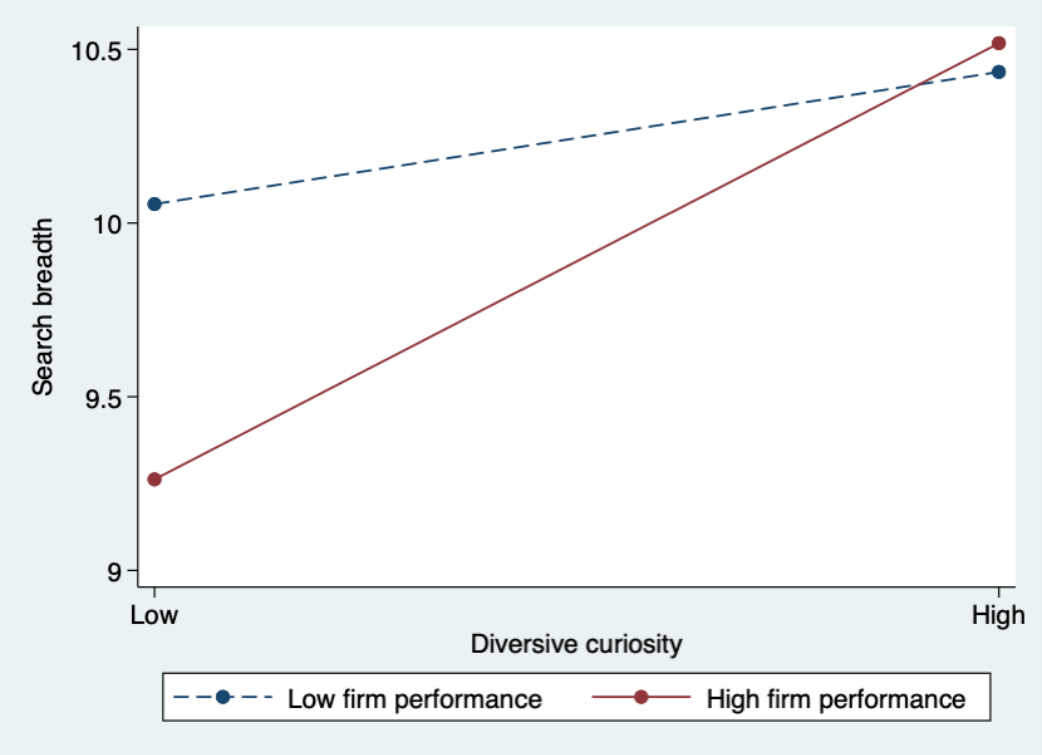

Figure 2 The moderating effect of firm performance on the relationship between diversive curiosity and search breadth

Hypothesis 4a suggests the negative moderating role of market competition on the positive connection between CEOs' diversive curiosity and search breadth. The result in Model 8 demonstrates a negative coefficient of the interaction term of CEOs'diversive curiosity and market competition (b=-0.951, $p<0.01$), offering powerful evidence for the negative moderating role of market competition, and thereby hypothesis 4a is strongly supported.

Figure 3 displays moderating role of market competition. I affirm that when market competition is fierce, search breadth in firms operated by CEOs with low diversive curiosity (one std. deviation lower than the average)

compared with firms operated by CEOs with high diversive curiosity (one std. deviation higher than the average) decreases by 9.0%. On the contrary, in less competitive markets, the search breadth in firms operated by CEOs with low diversive curiosity (one std. deviation lower than the average) compared with firms operated by CEOs with high diversive curiosity (one std. deviation higher than the average) increases by 20.0%. Therefore, the market competition weakens the positive influence of diversive curiosity of CEOs on search breadth, and the diversive curiosity may even diminish the search breadth when market competition is fierce, thereby supporting Hypothesis 4a.

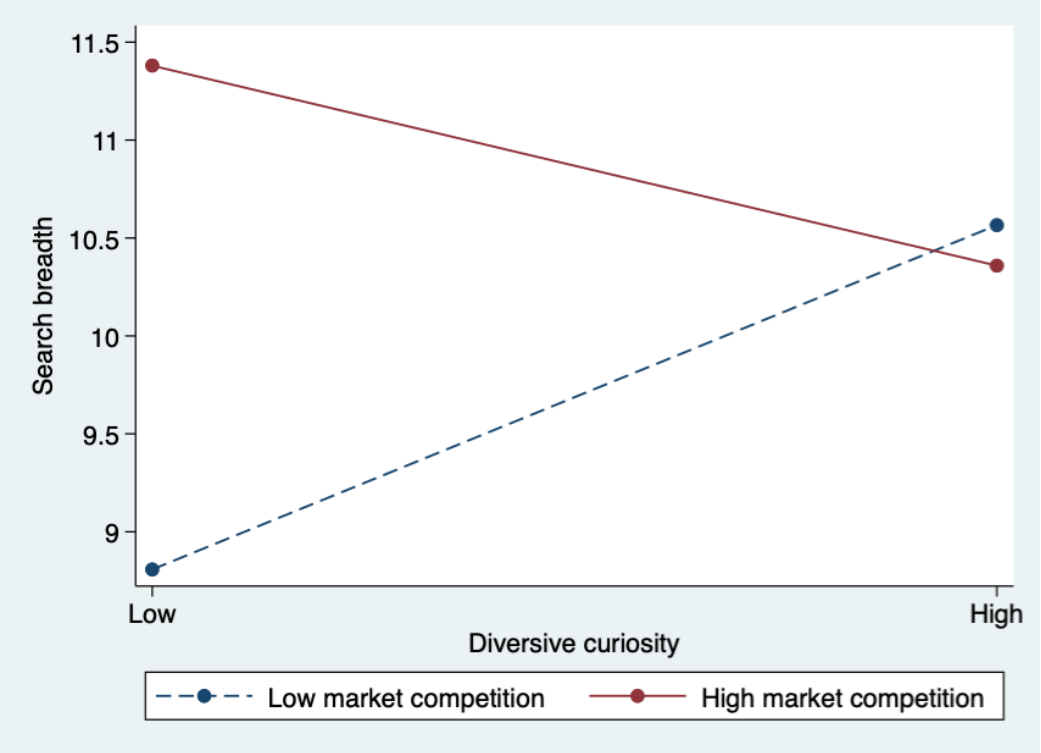

Figure 3 The moderating effect of market competition on the relationship between diversive curiosity and search breadth

Table 15 displays the regression results of the moderating effect of the firm performance as well as market competition on the correlation between specific curiosity of CEOs and search depth of firms.

Table 15 The moderating effects on the relationship between specific curiosity and search depth

	Model 9 Search depth	Model 10 Search depth
Firm size	-0.056	-0.039
	(-0.595)	(-0.393)
R&D investment	-0.006	-0.006
	(-0.061)	(-0.073)
Firm age	-0.384	-0.023
	(-0.803)	(-0.051)
Firm performance	-0.488**	-0.130
	(-2.114)	(-0.461)
CEO gender	-0.383	-0.531
	(-0.697)	(-0.993)
CEO age	-0.016	0.279
	(-0.046)	(0.850)
CEO education	0.258	0.250
	(0.843)	(0.839)
CEO share	0.005	0.004
	(0.612)	(0.536)
CEO tenure	0.025	-0.188
	(0.133)	(-1.079)
Industry	0.708	0.352
	(1.180)	(0.664)
Specific curiosity	**1.099*****	**0.816*****
	(4.193)	(3.009)
Specific curiosity*Firm performance	**0.464*****	
	(3.311)	
Market competition		0.971***
		(3.252)
Specific curiosity*Market competition		**-0.799*****
		(-3.498)
Constant	8.114***	7.543***
	(6.099)	(5.680)
N	166	166

R^2	0.203	0.259

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Hypothesis 3b predicts that the positive influence of CEOs' specific curiosity on search depth will be amplified in firms with high performance. In model 9, the coefficient of the interaction term between specific curiosity and firm performance is 0.464 at a significance level of 1% (b=0.464, p<0.01), indicating a positive moderating effect of firm performance for search depth. Therefore, Hypothesis 3b is validated.

Figure 4 displays the interactions between firm performance and CEOs' specific curiosity on search depth. I affirm that the search depth in firms operated by CEOs with low specific curiosity (one std. deviation lower than the average) compared with firms operated by CEOs with high specific curiosity (one std. deviation higher than the average) increases by 61.5% when firm performance is high, compared with the 16.5% increase when firm performance is low. Hence, the positive influence of specific curiosity on search depth is enhanced by firm performance, lending support for Hypothesis 3b.

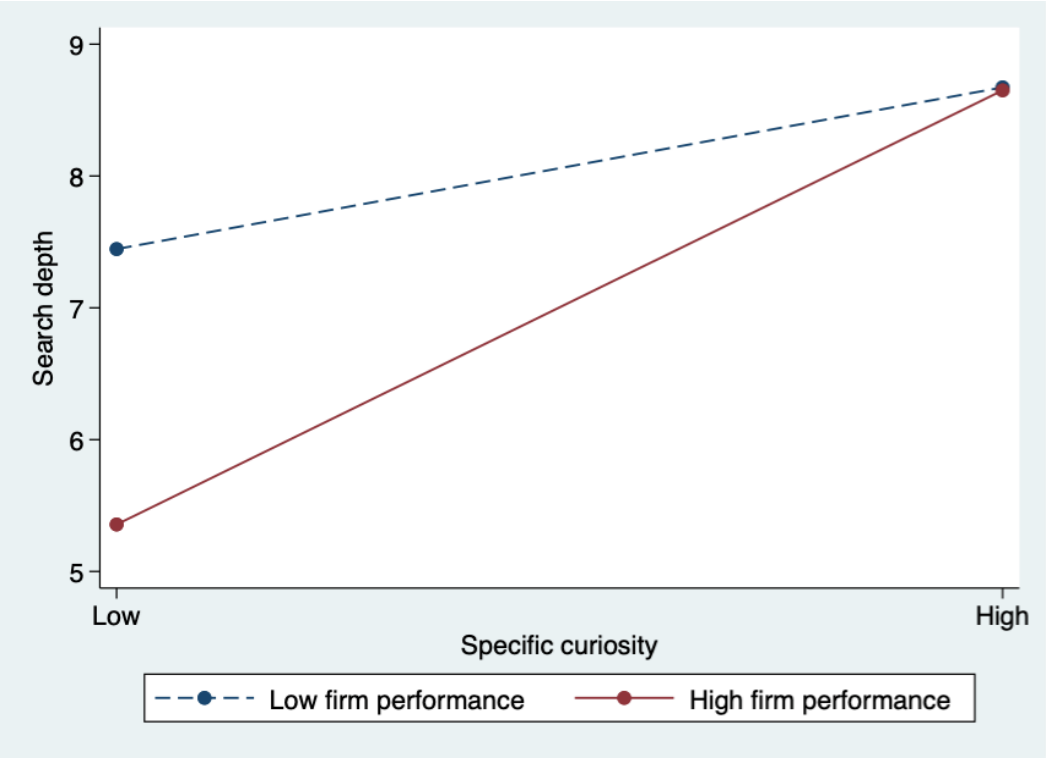

Figure 4 The moderating effect of firm performance on the relationship between specific curiosity and search depth

Hypothesis 4b suggests that the positive connection between specific curiosity and external search depth will be attenuated when firms are faced with intense market competition. The result in Model 10 demonstrates that the interaction term between market competition and specific curiosity of CEOs is negative at a significance level of 1% ($b=-0.799$, $p<0.01$), which indicates that market competition exerts a negative moderating effect on the correlation between specific curiosity and search depth, and thus providing strong evidence for hypothesis 4b.

Figure 5 indicates the interactions between specific curiosity of CEOs and market competition on search depth. For instance, when firms are faced with less intense market competition, search depth in firms operated by CEOs

with low specific curiosity (one std. deviation lower than the average) compared with firms operated by CEOs with high specific curiosity (one std. deviation higher than the average) increases by 50.7%, whereas the improvement is only 6.1% for firms in highly competitive markets. Therefore, at a high level of market competition, the correlation between specific curiosity and external search depth will be weaker, and vice versa.

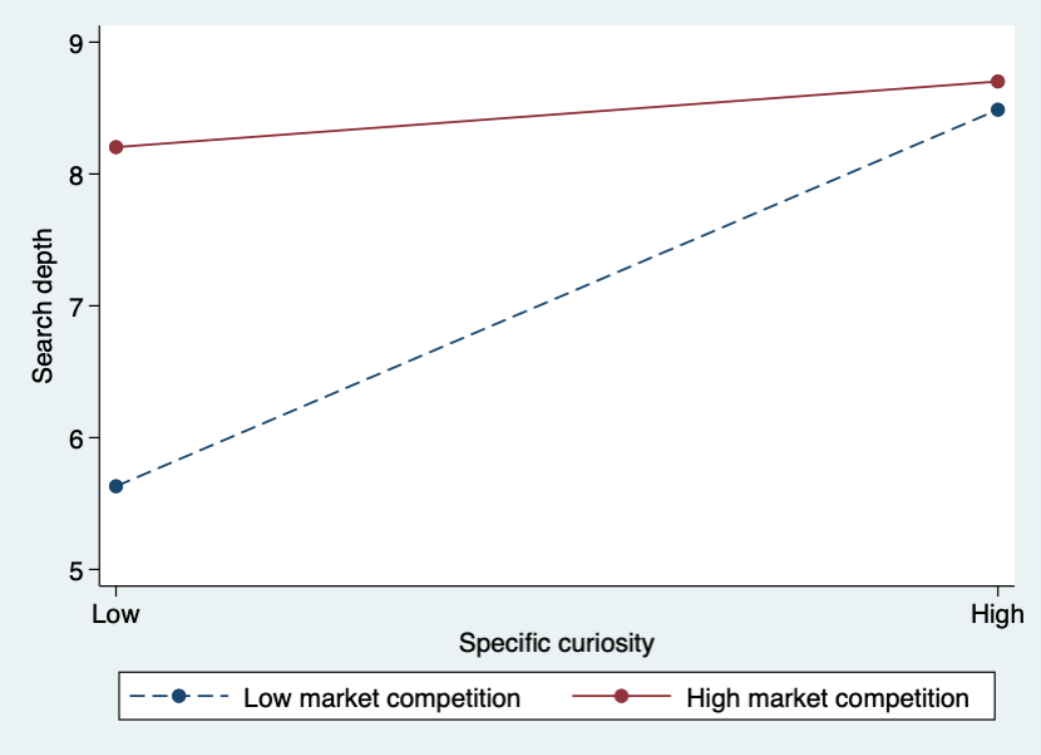

Figure 5 The moderating effect of market competition on the relationship between specific curiosity and search depth

In a word, all the eight hypotheses in the study are validated, and the theoretical framework is strongly supported. The results confirmed that both diversive curiosity and specific curiosity of CEOs are helpful to facilitate firm innovation. Search breadth positively mediates the positive connection between diversive curiosity and firm innovation, whereas search depth exerts a

positive mediating role on the positive connection between specific curiosity and firm innovation. Besides, the moderating effects of firm performance and market competition are also proved. Specifically, firm performance positively moderates the positive correlation between diversive curiosity and search breadth as well as the relationship between specific curiosity and search depth. Market competition exerts a negative moderating role on the positive correlation between diversive curiosity and search breadth, as well as that between specific curiosity and search depth.

5.3. Common method variance

Since the variables are answered by one participator, the common method variance may influence my results (Zhang et al., 2019). In order to attenuate the worry about common method variance, I employed Harman's One Factor Test in this dissertation. If the variance of the first factor in exploratory factor analysis of all variables is larger than 50% of the variance, then there exists a concern for common method variance (Fuller et al., 2016). The results of the test demonstrate that the variance is 36.62%, which is well below 50%. Therefore, common method variance is not a significant issue in this dissertation.

5.4. Robustness check

(1) Robustness check of the dependent variable

To check the robustness of the dependent variables, I adopt the scale developed by Jansen et al. (2009) as an alternative measurement of firm

innovation, which involves two dimensions of innovation, namely, exploration and exploitation. The items of firm innovation measurement are displayed in Table 16. The new measurement for firm innovation ranges from 1 to 5 with a mean value of 3.831. The Cronbach's alpha coefficient for firm innovation is 0.942, indicating a high level of internal consistency.

Table 16 Measure of firm innovation

Dimensions	Item
Exploration	Our organization accepts demands that go beyond existing products and services.
	We commercialize products and services that are completely new to our organization.
	We frequently utilize new opportunities in new markets
	Our organization regularly uses new distribution channels.
Exploitation	We frequently make small adjustments to our existing products and services.
	We improve our provision's efficiency of products and services.
	We increase economies of scales in existing markets.
	Our organization expands services for existing clients

Table 17 presents the regression results on diversive curiosity as the independent variable and the mediating role of search breadth, with the new measure of firm innovation.

Table 17 Robustness regressions with an alternative measure of firm innovation (the main effect of diversive curiosity and mediating role of search breadth)

	Model 11 Firm innovation	Model 12 Search breadth	Model 13 Firm innovation
Firm size	0.025	-0.083	0.030
	(1.293)	(-1.054)	(1.512)
Firm performance	0.016	-0.064	0.020
	(0.371)	(-0.730)	(0.496)

R&D investment	0.018	0.149**	0.009
	(0.999)	(2.189)	(0.510)
Firm age	-0.042	-0.076	-0.038
	(-0.377)	(-0.162)	(-0.381)
CEO gender	-0.075	-0.381	-0.052
	(-0.698)	(-1.111)	(-0.496)
CEO age	-0.019	0.029	-0.020
	(-0.239)	(0.138)	(-0.262)
CEO education	0.083	0.328*	0.064
	(1.151)	(1.740)	(0.883)
CEO share	0.005***	-0.007	0.005***
	(2.683)	(-1.001)	(2.996)
CEO tenure	0.009	0.098	0.003
	(0.198)	(0.818)	(0.066)
Industry	0.166	0.073	0.162
	(1.188)	(0.166)	(1.201)
Diversive curiosity	**0.451****	**0.417***	**0.426****
	(6.915)	(1.841)	(6.677)
Search breadth			**0.059****
			(1.998)
Constant	1.569***	8.014***	1.098**
	(3.850)	(6.105)	(2.395)
N	166	166	166
R^2	0.430	0.137	0.446

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Hypothesis 1a indicates that CEOs' diversive curiosity helps to promote firm innovation. The results of Model 11 reveal that diversive curiosity of CEOs is positively connected with firm innovation at a significance level of 1% (b=0.451, p<0.01), and thereby offering additional support for Hypothesis 1a.

Hypothesis 2a states the positive mediating role of search breadth on the connection between the diversive curiosity of CEOs and search breadth. Model 12 indicates that diversive curiosity is positively connected with search breadth at a significance level of 10% (b=0.417, p<0.10), offering supports for

Hypothesis 2a partly. Model 13 suggests that search breadth is positively correlated to firm innovation at a significance level of 5% (b=0.059, p<0.05), again in line with Hypothesis 2a.

Similarly, Table 18 displays the regression results on specific curiosity as the independent variable and the mediating effect of search depth, with the new measure of firm innovation.

Table 18 Robustness regressions with an alternative measure of firm innovation (the main effect of specific curiosity and mediating role search depth)

	Model 14 Firm innovation	Model 15 Search depth	Model 16 Firm innovation
Firm size	0.025	-0.037	0.027
	(1.360)	(-0.399)	(1.397)
Firm performance	0.015	-0.189	0.023
	(0.302)	(-0.662)	(0.585)
R&D investment	0.013	-0.010	0.014
	(0.737)	(-0.108)	(0.766)
Firm age	-0.071	-0.275	-0.059
	(-0.629)	(-0.592)	(-0.524)
CEO gender	-0.115	-0.394	-0.098
	(-0.999)	(-0.711)	(-0.880)
CEO age	-0.029	0.111	-0.033
	(-0.363)	(0.323)	(-0.427)
CEO education	0.068	0.254	0.057
	(0.946)	(0.826)	(0.798)
CEO share	0.005***	0.006	0.005***
	(2.807)	(0.739)	(2.743)
CEO tenure	0.019	-0.086	0.023
	(0.469)	(-0.468)	(0.559)
Industry	0.142	0.549	0.118
	(0.982)	(0.909)	(0.838)
Specific curiosity	**0.429*****	**1.136*****	**0.381*****
	(6.128)	(4.300)	(5.419)
Search depth			**0.043****
			(2.382)
Constant	1.862***	3.660**	1.705***
	(5.004)	(2.439)	(4.696)
N	166	166	166

R^2	0.407	0.179	0.429

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Hypothesis 1b forecasts a positive connection between CEOs' specific curiosity and firm innovation. The coefficient of specific curiosity in Model 14 is 0.429, which is significant and positive, suggesting that specific curiosity is significantly and positively connected with firm innovation (b=0.429, p<0.01), thereby offering evidence for Hypothesis 1b.

Hypothesis 2b believes that the correlation between specific curiosity and firm innovation is mediated by search depth. Model 15 demonstrates that specific curiosity is positively and significantly correlated to search depth (b=1.136,p<0.01). Model 16 reveals that search depth is positively associated with firm innovation (b=0.043, p<0.05), which gives support for Hypothesis 2b partly. And the effect parameter of specific curiosity diminishes, though still significant (b=0.381, p<0.01), which is in line with Hypothesis 2b.

To sum up, the regression results using an alternative measurement of firm innovation are highly consistent with the results mentioned above, confirming the robustness of the main effect of CEO curiosity and mediating effect of external search and providing strong evidence for the theoretical framework in this dissertation.

(2) Robustness check of the mediating variable

To check the robustness of the mediating variable, I use another measurement of external search depth on the basis of the paper of Chen et al.

(2011). The mean value of the scores that CEOs give to the 11 external knowledge sources is used to measure search depth (Chen et al., 2011), which is more refined compared with the measurement proposed by Laursen & Salter (2006) to some extent. The alternative measurement of external search depth ranges from 0 to 5, with a mean value of 2.997 and a std. deviation of 0.982.

Table 19 presents the regression results on specific curiosity as the independent variable and the mediating role of search depth, with the new measure of search depth.

Table 19 Robustness regressions with an alternative measure of search depth (Main effect and mediating effect)

	Model 4 Firm innovation	Model 17 Search depth	Model 18 Firm innovation
Firm size	-0.002	-0.037	0.008
	(-0.073)	(-1.476)	(0.361)
Firm performance	0.025	-0.016	0.029
	(0.573)	(-0.156)	(1.098)
R&D investment	0.042**	0.035	0.034*
	(2.058)	(1.237)	(1.782)
Firm age	-0.049	-0.001	-0.049
	(-0.404)	(-0.008)	(-0.445)
CEOgender	-0.172	-0.101	-0.146
	(-1.327)	(-0.603)	(-1.182)
CEO age	-0.027	-0.005	-0.026
	(-0.328)	(-0.053)	(-0.325)
CEO education	-0.051	0.011	-0.054
	(-0.636)	(0.120)	(-0.653)
CEO share	0.005**	0.003	0.004*
	(2.146)	(1.162)	(1.847)
CEO tenure	0.041	-0.054	0.055
	(0.947)	(-0.947)	(1.318)
Industry	0.063	0.099	0.038
	(0.459)	(0.531)	(0.298)
Specific curiosity	**0.499*****	**0.444*****	**0.386*****
	(6.574)	(5.154)	(4.871)

Search depth			**0.254*****
			(4.502)
Constant	1.832***	1.556***	1.436***
	(4.306)	(3.441)	(3.491)
N	166	166	166
R^2	0.397	0.236	0.453

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Hypothesis 2b indicates that the positive impact of CEOs' specific curiosity on firm performance is mediated by search depth. Using an alternative measurement of search depth, I validate hypothesis 2b again. Model 17 reveals that specific curiosity is positively and significantly correlated to search depth (b=0.444, p<0.01), which gives evidence for Hypothesis 2b partly. Model 18 in Table 19 reveals that search depth is positively associated with firm innovation (b=0.254, p<0.01), and the effect parameter of specific curiosity diminishes, though still significant (b=0.386, p<0.01), again in line with Hypothesis 2b.

Table 20 displays the regression results of the moderating effect of firm performance as well as market competition on the correlation between specific curiosity of CEOs and search depth of firms, with the new measurement of search depth.

Table 20 Robustness regressions with an alternative measure of search depth (Moderating effect)

	Model 19 Search depth	Model 20 Search depth
Firm size	-0.044*	-0.036
	(-1.698)	(-1.428)

R&D investment	0.036	0.035
	(1.287)	(1.350)
Firm age	-0.039	0.078
	(-0.276)	(0.695)
CEO gender	-0.097	-0.148
	(-0.587)	(-0.915)
CEO age	-0.049	0.058
	(-0.507)	(0.617)
CEO education	0.012	0.010
	(0.137)	(0.112)
CEO share	0.003	0.003
	(1.015)	(0.953)
CEO tenure	-0.015	-0.089*
	(-0.263)	(-1.699)
Industry	0.155	0.033
	(0.845)	(0.207)
Firm performance	-0.119	0.006
	(-1.596)	(0.062)
Specific curiosity	**0.431*****	**0.329*****
	(5.107)	(4.123)
Specific curiosity*Firm performance	**0.161*****	
	(3.601)	
Market competition		0.353***
		(3.607)
Specific curiosity*Market competition		**-0.252*****
		(-3.010)
Firm performance		
Constant	3.307***	3.073***
	(7.829)	(7.554)
N	166	166
R^2	0.266	0.331

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Hypothesis 3b suggests that a positive moderating effect of firm performance and predicts that the positive influence of CEOs' specific curiosity on search depth will be enhanced when firm performance is high. In model 19, the coefficient of the interaction term of specific curiosity and firm

performance is positive for search depth at a significance level of 1% (b=0.161, p<0.01). Therefore, the firm performance positively moderates the correlation between specific curiosity of CEOs and search depth of firms, providing additional evidence for Hypothesis 3b.

As shown in figure 6, when firm performance is high, the search depth measured by the average scores of 11 external knowledge source in firms operated by CEOs with low specific curiosity (one std. deviation lower than the average) compared with firms operated by CEOs with high specific curiosity (one std. deviation higher than the average) increases by 38.36%. While if the firm performance is low, the increase for search depth is 13.67%. Therefore, the positive effect of CEOs' specific curiosity on search depth will be amplified in firms with high performance, and thus Hypothesis 3b is supported using new measurement.

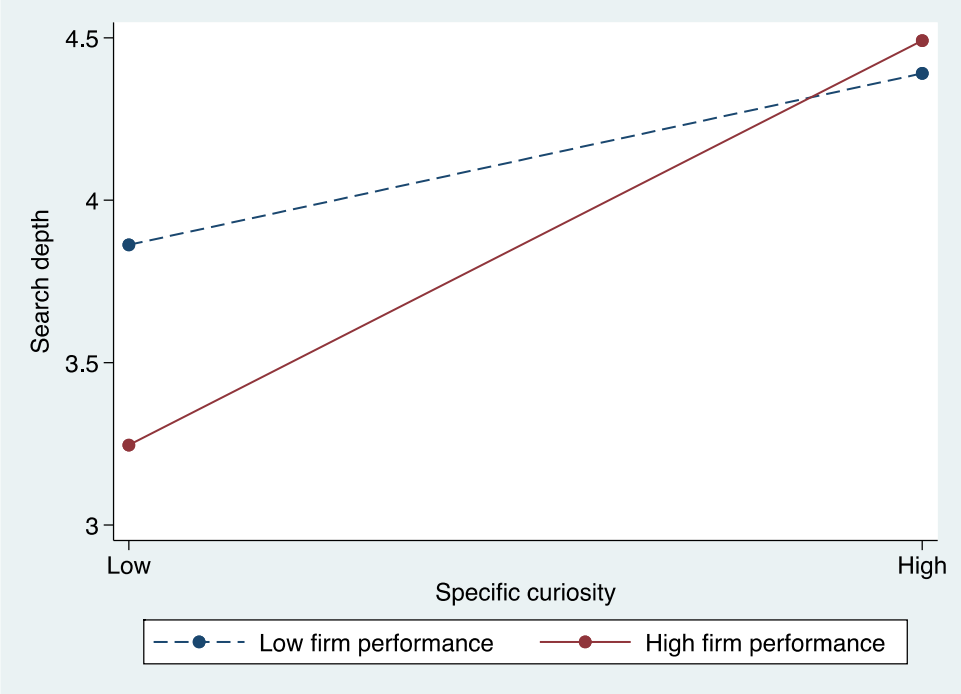

Figure 6 The moderating effect of firm performance on the relationship between

specific curiosity and search depth (with a new measure of search depth)

Hypothesis 4b indicates that market competition will weaken the positive correlation between CEOs' specific curiosity and search depth. The results in Model 20 shows a negative coefficient of the interaction term of market competition and specific curiosity at a significance level of 1% using an alternative measurement of search depth, which suggests that market competition has a negative moderating effect on the correlation between specific curiosity and search depth ($b=-0.252$, $p<0.01$). Therefore, the specific curiosity enhances the search depth for companies in less competitive markets, supporting Hypothesis 4b.

As shown in figure 7, the moderating effect of market competition is displayed. In markets with intense competition, the search depth in firms operated by CEOs with low specific curiosity (one std. deviation lower than the average) compared with firms operated by CEOs with high specific curiosity (one std. deviation higher than the average) increases by 7.29%. While the increase for search depth is 31.86% in markets with low competition intensity. Therefore, market competition exerts a negative moderating effect on the connection between specific curiosity of CEOs and search depth of firms, and thus hypothesis 4b is confirmed.

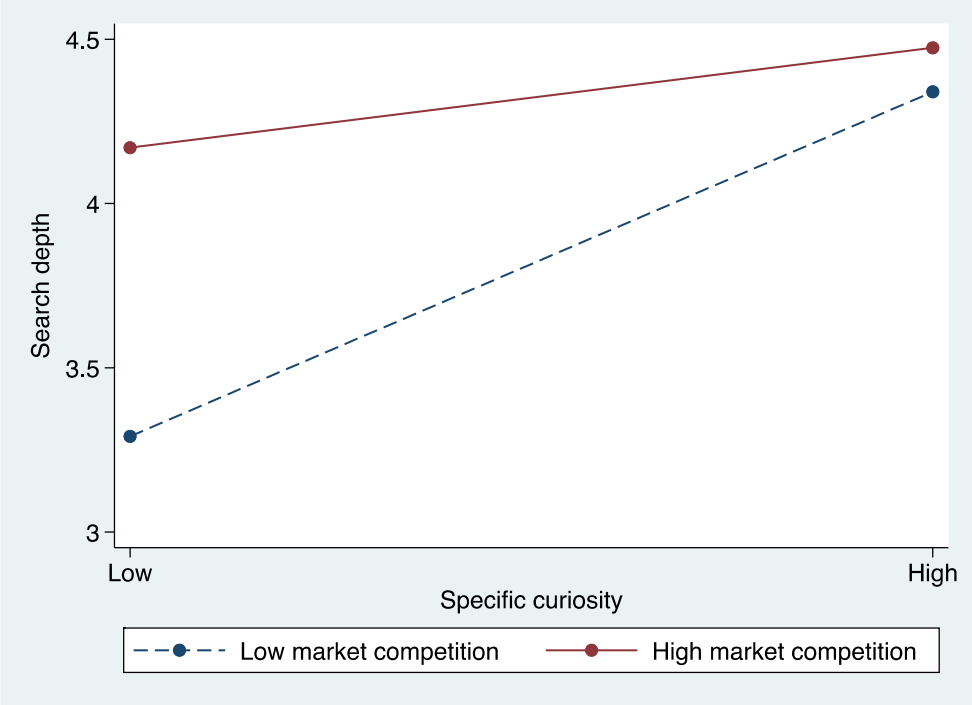

Figure 7 The moderating effect of market competition on the relationship between specific curiosity and search depth (with a new measure of search depth)

To sum up, the regression results with an alternative measure of search depth are highly consistent with the results mentioned above, confirming the robustness of the conclusions and providing strong support for my theoretical model. The main effect of CEO curiosity on firm innovation, the mediating effect of external search, as well as the moderating effects of firm performance and market competition are validated.

(3) **Robustness check of two types of curiosity**

Prior research also pointed out the relatively high correlation between diversive curiosity and specific curiosity. For example, the correlation coefficient between the two types of curiosity is 0.69 in the study of Harrison et al. (2011). In my sample, the correlation coefficient is also high, which is 0.827. I include two types of curiosity in the model simultaneously to test my main

effects and the mediating role of external search, which is presented in Table 21.

Table 21 results of main effects and mediating effects including two types of curiosity

	Model 21 Firm innovation	Model 22 Search breadth	Model 23 Search depth	Model 24 Firm innovation
Firm size	-0.004	-0.085	-0.047	0.001
	(-0.153)	(-1.055)	(-0.496)	(0.047)
Firm performance	0.023	-0.066	-0.200	0.033
	(0.564)	(-0.758)	(-0.748)	(0.986)
R&D investment	0.044**	0.148**	-0.001	0.039*
	(2.090)	(2.201)	(-0.013)	(1.938)
Firm age	-0.030	-0.074	-0.172	-0.021
	(-0.246)	(-0.158)	(-0.375)	(-0.183)
CEO gender	-0.157	-0.387	-0.313	-0.132
	(-1.231)	(-1.112)	(-0.578)	(-1.071)
CEO age	-0.030	0.022	0.092	-0.035
	(-0.379)	(0.104)	(0.262)	(-0.430)
CEO education	-0.051	0.321*	0.252	-0.071
	(-0.632)	(1.681)	(0.836)	(-0.853)
CEO share	0.004**	-0.007	0.006	0.004**
	(2.099)	(-1.001)	(0.635)	(2.135)
CEO tenure	0.036	0.098	-0.113	0.037
	(0.810)	(0.820)	(-0.619)	(0.809)
Industry	0.072	0.069	0.600	0.048
	(0.519)	(0.157)	(0.976)	(0.347)
Diversive curiosity	**0.168**	**0.351**	**0.923****	**0.122**
	(1.337)	(1.273)	(2.249)	(0.989)
Specific curiosity	**0.365*****	**0.082**	**0.402**	**0.348*****
	(2.781)	(0.317)	(0.983)	(2.643)
Search breadth				**0.034**
				(0.853)
Search depth				**0.037**
				(1.619)
Constant	1.658***	8.008***	2.703*	1.289**
	(3.637)	(6.085)	(1.689)	(2.489)
N	166	166	166	166
R^2	0.407	0.138	0.206	0.432

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

As shown in Table 21, in model 21, the coefficient of diversive curiosity is positive but not significant (b=0.168, p>0.1), which can not offer support for hypothesis 1a. The coefficient of specific curiosity is positive and significant (b=0.365, p<0.01), suggesting a positive connection between specific curiosity of CEOs and firm innovation. And thus hypothesis 1b is supported. In model 22, the coefficients of diversive curiosity and specific curiosity for search breadth are positive but not significant. In model 23, the coefficient of specific curiosity for search depth is positive but not significant. However, in model 24, the coefficients of search breadth and search depth are not significant, and thus the mediating effects of search breadth and search depth are not confirmed. Thereby, hypothesis 2a and hypothesis 2b are not supported.

I also investigate the moderating effects of firm performance and market competition including two types of curiosity. The results are displayed in Table 22.

Table 22 results of moderating effects including two types of curiosity

	Model 25 Search breadth	Model 26 Search breadth	Model 27 Search depth	Model 28 Search depth
Firm size	-0.091	-0.111*	-0.063	-0.044
	(-1.110)	(-1.715)	(-0.654)	(-0.437)
R&D investment	0.148**	0.165***	-0.003	-0.001
	(2.196)	(2.905)	(-0.029)	(-0.013)
Firm age	-0.142	0.264	-0.343	0.043
	(-0.298)	(0.962)	(-0.725)	(0.095)
CEO gender	-0.336	-0.529	-0.188	-0.456
	(-0.938)	(-1.625)	(-0.339)	(-0.868)
CEO age	-0.029	0.116	-0.041	0.278

	(-0.133)	(0.555)	(-0.116)	(0.821)
CEO education	0.321*	0.305*	0.251	0.255
	(1.667)	(1.748)	(0.825)	(0.867)
CEO share	-0.008	-0.008	0.002	0.004
	(-1.163)	(-1.438)	(0.263)	(0.434)
CEO tenure	0.148	0.004	0.014	-0.212
	(1.230)	(0.037)	(0.075)	(-1.216)
Industry	0.127	-0.154	0.750	0.411
	(0.288)	(-0.493)	(1.239)	(0.760)
Firm performance	-0.121	-0.021	-0.354	-0.138
	(-1.020)	(-0.258)	(-1.584)	(-0.523)
Diversive curiosity	0.377	0.268	0.980**	0.866**
	(1.385)	(1.064)	(2.464)	(2.338)
Specific curiosity	0.042	-0.121	0.303	0.126
	(0.168)	(-0.459)	(0.777)	(0.333)
Diversive curiosity *Firm performance	**0.501**		**1.211***	
	(1.390)		(1.800)	
Specific curiosity* Firm performance	**-0.310**		**-0.714**	
	(-0.889)		(-1.102)	
Market competition		0.769***		0.985***
		(3.274)		(3.188)
Diversive curiosity *Market competition		**-0.185**		**0.110**
		(-0.438)		(0.232)
Specific curiosity* Market competition		**-0.872****		**-0.831***
		(-2.327)		(-1.771)
Constant	9.892***	9.539***	8.317***	7.425***
	(8.830)	(9.939)	(5.987)	(5.534)
N	166	166	166	166
R^2	0.151	0.374	0.238	0.282

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

As shown in Table 22, the interaction term between CEO diversive curiosity and firm performance for search breadth is not significant in model 25. And thus the moderating effect of firm performance on the relationship between CEO diversive curiosity on search breadth is not supported. That is to say,

hypothesis 3a is not supported. In model 26, the interaction term between diversive curiosity and market competition is negative but not significant. And thereby hypothesis 4a is not supported. In model 27, the interaction term between specific curiosity and firm performance is negative and not significant, and thus hypothesis 3b is not supported. Model 28 displays a negative and significant interaction term between specific curiosity and market competition ($b=-0.831$, $p<0.1$), offering additional support for hypothesis 4b.

In a word, due to the high correlation between diversive curiosity and specific curiosity, many hypotheses proposed in this dissertation can not be supported when including two types of CEO curiosity in our model. The reason for it may be the sample in my survey involves founder CEOs whose diversive curiosity and specific curiosity are high at the same time or the measurements for two types of curiosity are not able to distinguish them. Therefore, it is a better choice to run the regressions for diversive curiosity and specific curiosity separately. Future studies can further refine the measurement for the two types of curiosity, and use different samples to test the hypotheses.

5.5. Supplement analysis

A high correlation between specific curiosity and diversive curiosity of CEOs in our results makes the relationship between CEO curiosity and external search can be more complicated. I further investigate the correlation between two types of curiosity and two types of external search, and the results are

displayed in Table 23.

Table 23 regression results of CEO curiosity and external search

	Model 29 Search breadth	Model 30 Search breadth	Model 31 Search depth	Model 32 Search depth
Firm size	-0.083	-0.081	-0.041	-0.037
	(-1.054)	(-1.022)	(-0.422)	(-0.399)
Firm performance	-0.064	-0.062	-0.190	-0.189
	(-0.730)	(-0.674)	(-0.701)	(-0.662)
R&D investment	0.149**	0.145**	0.003	-0.010
	(2.189)	(2.171)	(0.033)	(-0.108)
Firm age	-0.076	-0.114	-0.181	-0.275
	(-0.162)	(-0.237)	(-0.393)	(-0.592)
CEO gender	-0.381	-0.418	-0.283	-0.394
	(-1.111)	(-1.226)	(-0.525)	(-0.711)
CEO age	0.029	0.029	0.126	0.111
	(0.138)	(0.139)	(0.352)	(0.323)
CEO education	0.328*	0.322*	0.285	0.254
	(1.740)	(1.672)	(0.966)	(0.826)
CEO share	-0.007	-0.006	0.006	0.006
	(-1.001)	(-0.972)	(0.639)	(0.739)
CEO tenure	0.098	0.109	-0.117	-0.086
	(0.818)	(0.874)	(-0.634)	(-0.468)
Industry	0.073	0.050	0.616	0.549
	(0.166)	(0.116)	(0.991)	(0.909)
Diversive curiosity	**0.417***		**1.243*****	
	(1.841)		(4.812)	
Specific curiosity		**0.362**		**1.136*****
		(1.638)		(4.300)
Constant	8.014***	8.373***	2.734*	3.660**
	(6.105)	(6.849)	(1.703)	(2.439)
N	166	166	166	166
R^2	0.137	0.127	0.201	0.179

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

As shown in Table 23, Model 29 indicates a positive relationship between CEO diversive curiosity and search breadth, but the coefficient of specific

curiosity in Model 30 is not significant, which cannot provide support for the correlation between specific curiosity and search breadth. Together, the results suggest that CEOs with a high level of diversive curiosity are more likely to engage in broad external search activities compared with those with a high level of specific curiosity, which is in line with my hypotheses. The positive and significant coefficients of diversive curiosity in Model 31 and specific curiosity in Model 32 for search depth suggest that both diversive curiosity and specific curiosity are positively associated with search depth. Diversive curiosity reflects an interest to learn and explore unfamiliar and new topics (Litman & Jimerson, 2004). Although CEOs with a high level of diversive curiosity may engage in both broad and deep external search activities, I argue that they will be more likely to increase search breadth according to the concept of diversive curiosity, but the complex relationship still needs further exploration.

6. Discussion

The empirical results provide strong support for my theoretical framework. All hypotheses in this study are validated using the survey data of 166 firms from China. The robustness check using alternative measurement of firm innovation and search depth, providing additional evidence for the theoretical model. In a word, the results confirmed that both diversive curiosity and specific curiosity of CEOs are positively associated with firm innovation. Search breadth positively mediates the positive connection between diversive curiosity and firm innovation, whereas search depth positively mediates the positive connection between specific curiosity and firm innovation. Firm performance positively moderates the positive correlation between diversive curiosity and search breadth as well as the relationship between specific curiosity and search depth. Market competition exerts a negative moderating effect on the positive correlation between diversive curiosity and search breadth, as well as that between specific curiosity and search depth.

The results of this dissertation emphasize the value of CEO curiosity in the innovation process of firms. Prior research has demonstrated the positive impact of curiosity on some positive outcomes that are positively related to innovation, such as individual creativity (Harrison & Dossinger, 2017; Schutte & Malouff, 2020), worker innovation (Celik et al., 2016), information seeking (Gottlieb et al., 2013; Hassan et al., 2015), learning and exploration

(Jovanovic & Brdaric, 2012; Kashdan et al., 2004), and risk taking (Syed et al., 2020; van Dijk & Zeelenberg, 2007), which provides the primary evidence for the further relationship between CEO curiosity and firm innovation. But there still lacks an exploration of the effect of curiosity at the executive level on the innovation outcomes at the firm level. The results of this dissertation offer a nuanced new insight of the connection between CEO curiosity and firm innovation and make contributions to enrich the studies of the upper echelons theory (UET).

Specifically, the results show the different mechanisms behind the connection between two types of CEO curiosity and firm innovation. Diversive curiosity inspires CEOs to explore a range of diverse topics (Harrison & Dossinger, 2017) and thus CEOs with high diversive curiosity may seek information through plenty of sources and make broader search strategies (Cruz-González et al., 2015), and thus promoting firm innovation. In contrast, specific curiosity encourages CEOs to focus on a limited range of subjects and engage in a deeper search (Grossnickle, 2016), and CEOs with high specific curiosity may increase the external search depth to facilitate firm innovation. The results display the difference in diversive curiosity and specific curiosity, and further distinguish the different mechanisms of two types of CEO curiosity on firm strategies.

The positive mediating effect of external search on the connection between CEO curiosity and firm innovation suggests a positive correlation

between external search and firm innovation, which is consistent with prior studies (Chiang & Hung, 2010; Terjesen & Patel, 2017). External search plays a key role in today's era of open innovation (Lopez-Vega et al., 2016; Mina et al., 2014). With the development of technology and intensification of competition, firms are not able to innovate and sustain competitive advantage through internal research and development only, and they have to expand their borders to acquire, assimilate and utilize external knowledge (Dong & Netten, 2017; West et al., 2014). External knowledge provides firms good access to complement their internal knowledge stock (Kotlar et al., 2013). The sourcing of external technologies and information could help firms compensate for the lacking of knowledge and capabilities and shorten product life cycles (Tsai et al., 2011). A broad and deep external technology sourcing enables firms to adapt to dynamic market demands (Laursen & Salter, 2006), thus promoting innovation performance (Li-Ying et al., 2014; Tsai et al., 2011).

The moderating effects confirmed in this study demonstrate the value of slack resources to support curious CEOs for innovation activities and the adverse impact of external pressure for the role of CEO curiosity. Behavior theory points out that firms may search for solutions around the problems they are faced with, resulting in myopia and neglect of distant search (Cyert & March, 1963). In firms faced with fierce market competition, CEOs have to deal with problems caused by intense market competition, and thus they may become myopic and search information in the vicinity of the problem, and

reduces external and distant search, and thus the positive impact of diversive curiosity and specific curiosity on external search breadth and depth will be weakened when market competition is intense. In contrast, when the firm performance is high, curious CEOs have enough slack resources to support them for distant search, and they may be less worried about the failure of external search owing to high performance at present. And thus the positive influence of CEO curiosity on external search may be enhanced in firms with high performance. The contingent factors validated in this study help us to further understand the role of CEO curiosity on firm strategies.

7. Conclusions and future research

7.1. Conclusions

The dissertation examines the connection between CEO curiosity and firm innovation, and the mechanism behind the relationship. Using survey data of CEOs from 166 firms, I find strong empirical support for my theoretical framework. There are some interesting findings in this study, which can be concluded as follows.

First, both diversive and specific curiosity of CEOs are positively associated with firm innovation. The firms operated by CEOs with high diversive curiosity or specific curiosity display higher levels of innovation capabilities.

Second, the mechanisms behind the relationship between two types of curiosity of CEOs and firm innovation are different. Specifically, CEOs' diversive curiosity helps to promote the external search breadth of firms, and thereby facilitate firm innovation. That is to say, search breadth positively mediates the correlation between CEO diversive curiosity and firm innovation. While the connection between CEO specific curiosity and firm innovation is mediated by search depth. The specific curiosity of CEOs is positively associated with firms' external search depth, and thus promotes firm innovation.

Third, internal resources and external pressures moderate the correlation between CEO curiosity and external search. Specifically, firm performance

plays a positive moderating role on the positive connection between CEO curiosity and external search, while market pressure negatively moderates the correlation. When firm performance is high, CEOs with high curiosity have more resources to search, and thus the positive impact of CEO's diversive curiosity on search breadth as well as the positive influence of CEO's specific curiosity on search depth will be strengthened in firms with high performance. When market competition is high, CEOs have to focus on the competitive problems they are facing and have little energy to search, therefore, the positive connection between CEO's diversive curiosity and search breadth as well as the relationship between specific curiosity and search depth will be attenuated when firms are facing with fierce market competition.

7.2. Theoretical contributions

This dissertation strives to contribute to prior research in the following aspects. First of all, this dissertation helps to enrich the research of the upper echelons theory (UET) by exploring the influence of CEO curiosity on firm innovation. On the basis of the upper echelons theory, CEO curiosity will influence firms' strategic decisions and choices for innovation (Hambrick & Mason, 1984) as an important personality trait (Litman & Spielberger, 2003) of CEOs. Extant research has further explored the influence of various CEO characteristics on enterprise innovation, such as CEO narcissism (Kashmiri et al., 2017), humility (Zhang et al., 2017), overconfidence (Galasso & Simcoe, 2011), hobbies (Sunder et al., 2017), tenure (Wu et al., 2005) and

compensation (Xue, 2007). At the same time, the influence of curiosity in the workplace has also been widely discussed, such as its positive effect on employees' creativity (Hagtvedt et al., 2019), newcomer adaption (Harrison et al., 2011), and worker innovative behaviors (Celik et al., 2016). However, there still lacks executive-level studies to further explore the correlation between curiosity and enterprise strategies. Therefore, I discuss the connection between CEO curiosity and firm innovation and give empirical evidence. By exploring the effect of CEO curiosity on search strategy and firm innovation, this dissertation contributes to the upper echelons theory.

Second, this dissertation explores the mechanism behind the relationship between two kinds of curiosity and firm innovation, namely, diversive curiosity and specific curiosity (Berlyne, 1966; Hagtvedt et al., 2019; Litman & Spielberger, 2003). Prior research on the connection between CEO characteristics and firm outcomes often regards the mechanism as a black box limited to data. Using survey data, this dissertation is able to investigate the mechanism behind the relationship and open the black box. Specifically, different forms of CEO curiosity may influence firm strategies through different mechanisms. The empirical results indicate that CEOs' diversive curiosity promotes firm innovation by increasing external search breadth, while their specific curiosity facilitates firm innovation by improving external search depth. The mediating roles of search breadth and search depth deepen the understanding of the mechanisms of CEO diversive curiosity and specific

curiosity on firm innovation, which contributes to opening the “black box” between CEO curiosity and firm innovation.

Third, this dissertation provides new perspectives on external search behaviors. The antecedents of external search depth and breadth do not obtain enough attention in prior research (Dong & Netten, 2017). This study explores the antecedents of external search from the aspect of CEO characteristics. I argue that CEOs with high diversive curiosity will more interested in exploring a wide range of topics and information (Harrison & Dossinger, 2017), and thus increasing the external search breadth of firms. By contrast, CEOs with high specific curiosity will engage in a deeper search of information (Grossnickle, 2016), and this positive effect of CEO specific curiosity on search depth will be positively moderated by internal and external pressure. Moreover, this study also demonstrates the mediating role of external search between CEO curiosity and firm innovation, which enriches the study of external search behaviors.

Fourth, this dissertation examines the moderating effect of both internal resource and external pressure on the correlation between CEO curiosity and external search strategies, which is helpful to extend the applied contexts of the results. The results of this dissertation demonstrate that the relationship between CEO curiosity and external search will be enhanced in firms with high performance, but be attenuated when firms in markets with intense competition. The positive moderating effect of firm performance indicates that

the importance of resource support for amplifying the role of CEO curiosity, and the negative moderating effects of market competition suggest that external pressures limit the positive influence of CEO curiosity. The analysis of contingent contexts contributes to deepening the understanding of the connection between CEO curiosity and external search and extending the applied contexts of the results in this study.

7.3. Managerial implications

This dissertation also offers rich implications for practice, which can be concluded as follows.

First of all, the positive influence of CEO curiosity on firm innovation proved in this study provides a reference for firms to select appropriate key decision-makers and for CEOs to develop and keep curiosity. As shown in this study, both diversive curiosity and specific curiosity are positively related to firm innovation. As a pivotal source of competitive advantage, innovation is critical for firms' development (Barney, 1991; Crescenzi & Gagliardi, 2018). And the curiosity of CEOs plays a pivotal role in the process of innovation. CEOs with high curiosity hold more open attitudes towards new information, and are more willing to engage in external search behaviors and develop a creative climate in firms to encourage employees to innovate. Curiosity becomes one shared personality of successful CEOs and more and more CEOs have realized the magnitude of curiosity[8]. For example, the CEO of Dell,

[8] Curiosity: the one shared trait of successful CEOs https://www.dukece.com/insights/curiosity-one-shared-trait-successful-ceos/

Michael Dell regarded curiosity as one attribute that CEOs need most for success in turbulent environments and argued that curiosity encourages CEOs to constantly look for new ideas and methods to keep up with changes and stay ahead of competitors[9].

In order to promote firm innovation, firms and CEOs should value curiosity. From the aspect of firms, the level of curiosity can be taken into consideration when firms need to promote or hire new CEOs. Furthermore, given the importance of firm innovation on a firm's market value, CEO curiosity may also be taken into considerations for investors to choose invested firms. From the aspect of CEOs, they need to be always curious about new things. Although many CEOs have realized the importance of curiosity, most of them still miss the point of becoming more curious. A survey of 402 CEOs indicates that 79% of them think that they require the capability to transform themselves and their firms[10]. They need to change their mindset and stimulate curiosity to expand their boundaries of knowledge. As an article in *Harvard Business Review* said, curiosity is like a muscle, and it can be weakened if not used enough. When curiosity fades, people fall into routine and complacency, which can lead to chaos in the firms[11]. Therefore, CEOs need to realize the importance of curiosity and take measures for cultivating

[9] Curiosity Is a Key to Success for CEOs https://www.business2community.com/leadership/curiosity-key-success-ceos-01930831

[10] The Call for Curiosity: Cultivating Inquisitive Leadership https://www.egonzehnder.com/ceo-insights/volume-6-call-for-curiosity-cultivating-inquisitive-leadership

[11] SurveyMonkey's CEO on Creating a Culture of Curiosity https://hbr.org/2019/01/surveymonkeys-ceo-on-creating-a-culture-of-curiosity

their curiosity.

Second, the results of the dissertation demonstrate the importance of the external search for firm innovation. In today's era of open innovation, firms need always be receptive to knowledge and information beyond their boundaries (Cappa et al., 2019; Pollok et al., 2019; Tsinopoulos et al., 2018). In order to complement internal knowledge and trace the latest technologies, firms need to search for information from various sources, such as suppliers, competitors, customers, distributors, the government, universities, consultants, and media. Prior research has confirmed the positive impact of customer engagement (Mahr et al., 2014; Ngo & O'Cass, 2013), supplier participation (Paulraj et al., 2008; Yan et al., 2018), strategic alliances (Gilsing et al., 2007; Hohberger et al., 2015) and R&D collaboration (Maietta, 2015; Schilling & Phelps, 2007; van Beers et al., 2008) on firm innovation. Firms can involve clients and suppliers in their process of designing and introducing new products and build partnerships with other organizations such as universities, consultants, and even competitors to gain valuable knowledge and facilitate firm innovation. The results in this study suggest that external search breadth as well as depth are helpful to promote firm innovation, when searching information outside the organization, firms need to pay attention to breadth as well as depth.

Third, the positive moderating roles of firm performance and the negative moderating effect of market competition indicates that resource support is

important for amplifying the positive influence of CEO curiosity on external search. Slack resources in firms with good performance support curious CEOs to make strategies to search externally, while the external pressures limit their search. Therefore, organizations need to encourage CEOs to be curious and provide them with enough support to make strategies of searching beyond their organizational borders and engage in innovation activities, especially when market competition is high.

7.4. Limitation and future research

There are also several limitations in my dissertation. First of all, this study demonstrated the positive effect of CEO curiosity on firm innovation. In order to promote innovation, CEOs need to keep open and creative (Revilla & Rodríguez-Prado, 2018), and these traits are closely related to curiosity (Hagtvedt et al., 2019; Harrison & Dossinger, 2017; Hunter et al., 2016; Kashdan et al., 2020). Therefore, I believe that CEO curiosity plays a positive role in firms' innovation process. But curiosity may not always be good. For example, CEOs with excessive curiosity may choose unusual and risky solutions rather than simple and effective ones, which may be a waste of resources[12]. The adverse effect of CEO curiosity on firm-level outcomes may be an interesting topic. Future studies can explore the potential bad influence of CEO curiosity on other firms' strategy choices.

[12] What Happens When Leaders Lack Curiosity? https://www.forbes.com/sites/tomaspremuzic/2017/03/06/what-happens-when-leaders-lack-curiosity/?sh=275a54616b74

Second, the effect of encouraging an innovative atmosphere may be an alternative mechanism for the positive relationship between CEO curiosity and firm innovation. CEO personality may influence the strategic performance by shaping the relationships with their employees and changing the organizational climate (Herrmann & Nadkarni, 2014). It is supposed that CEOs can inspire curiosity in their teams and firms by being inquisitive themselves[13]. Curious CEOs are open to new information and innovative ideas, and they will encourage others to take advantage of their own curiosity to pursue knowledge and exploration (Garrison et al., 2008). The interaction between curious CEOs and employees may be an interesting topic. Future research can investigate the potential mechanism and compare the effect of CEO curiosity in innovative teams with that in conservative teams.

Third, my results suggest the positive connection between CEO diversive curiosity and search breadth as well as a positive correlation between specific curiosity and search depth. However, there is a high correlation between specific curiosity and diversive curiosity. According to the concept of diversive curiosity and specific curiosity, I argued that CEOs with a high level of diversive curiosity will more likely to engage in broad search activities, while those with high specific curiosity tend to increase search depth. But does diversive curiosity also promote search depth or does specific curiosity facilitate search breadth? The complex relationship between two types of CEO

[13] The Business Case for Curiosity. https://hbr.org/2018/09/the-business-case-for-curiosity

curiosity and external search needs to be further investigated.

Last but not least, as the CEOs involved in this survey are all founders of these firms, and thus I am not able to observe the influence of the change in CEOs with different curiosity levels on firms' external search and innovation performance. Future studies can include different types of CEOs in the survey and investigate whether CEOs with different levels of curiosity in a firm make different strategies.

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Appendix

SURVEY TO CEO

The first round of questionnaire

BACKGROUND INFORMATION ABOUT YOURSELF

1. Your gender: □Male □Female
2. Your age：□30 or below □31-40 □41-50 □51-60 □ 61 or above
3. Your highest academic degree：□ Bachelor or below □ Bachelor □ Master □ PhD
4. The major of your highest degree：□ Natural Sciences □ Engineering □ Social Sciences □ Business □ Others（Please specify:_____）
5. Are you the founder of the company：□Yes □No
6. Your share proportion of the company_____%the share proportion of other members of your family:_____%.（If none, then 0）
7. Does your company have a board of directors? □Yes □No
8. Do you have a seat on the board of directors? □Yes □No
9. Are you the president of the board of directors? □Yes □No
10. Through which channel did you become CEO？□Internal promotion □External recruitment
11. How many years have you been CEO? □2 years below □2-4 □4-6 □6-8 □8-10 □10 years or above

BACKGROUND INFORMATION ABOUT YOUR COMPANY

1. The establishment year of your company: ____; registered address: _____(Province) _____(City)
2. The ownership of your company：□ State-owned/State Holding □ Collective/collective holding □ Private (not including foreign capital) □ Wholly Hong Kong, Macao and Taiwan-owned □ Wholly foreign-owned □ Joint venture □Others _____
3. The industry of your company：
   □ Mining □ Hotel and Restaurant □ Production and supply of electricity, heat, gas and water □ Education □Manufacturing □ Whole sales and retail trade □ Transportation, warehousing and postal services □ Farming, forestry, animal husbandry and fishery □Financial Services □Real estate □ Information transmission, software and IT services □ Residential services, repair and other services □ Construction □ Health and social work □ Leasing and business service □ Water conservancy, environment and public facilities management □ Scientific research and technical services □ Culture, sports and entertainment □Others__
4. Share proportion of the largest shareholder: ____ %; total share proportion of the Top 5 shareholders：_____ %。
5. The number of employees: ___; the number of full-time employees: ___; the number of part-time

staff: ___. On average, the number of new comers every year: ___; the number of leavers every year: ____。

6. **By the end of 2018,** the total assets of your company: _____(million yuan); the operating income:___(million yuan); the net income:_____(million yuan); the total liabilities: ____(million yuan); the R&D investment:____(million yuan).（If none, then 0）

7. **By the end of 2019,** the total assets of your company: _____(million yuan); the operating income:___(million yuan); the net income:_____(million yuan); the total liabilities: ____(million yuan); the R&D investment:____(million yuan).（If none, then 0）

8. **By the end of 2020,** the total assets of your company: _____(million yuan); the operating income:___(million yuan); the net income:_____(million yuan); the total liabilities: ____(million yuan); the R&D investment:____(million yuan).（If none, then 0）

9. The average profit margin of your industry for the recent 3 years:_____%。

10. What is the position of your company's average profit margin among the industry in recent 3 years?

□Top 20% □20%-40% □40%-60% □60%-80% □ 80%-100%

INDIVIDUAL TRAITS

1. To what extent are the following statements true about your personal characteristics in general? (1= Not at all true, 3 =Somewhat true, 5 = Very true).

	Not at all true				**Very true**
1) Hours on a problem because I can't rest without answer.	1	2	3	4	5
2) Brood for a long time to solve problem.	1	2	3	4	5
3) Conceptual problems keep me awake thinking.	1	2	3	4	5
4) Frustrated if I can't figure out problem, so I work harder.	1	2	3	4	5
5) Work like a fiend at problems that I feel must be solved.	1	2	3	4	5
6) Enjoy exploring new ideas.	1	2	3	4	5
7) Find it fascinating to learn new information.	1	2	3	4	5
8) Enjoy learning about subjects that are unfamiliar to me.	1	2	3	4	5
9) Enjoy discussing abstract concepts.	1	2	3	4	5
10) Learn something new, like to find out more about it.	1	2	3	4	5

The second round of questionnaire

FIRM INNOVATION

1. There are 13 sources listed in this section. Please evaluate the frequency of using innovative knowledge from different sources in your company. (0 = Never use, 1 = Seldom use, 5 = Always use).

	Never					**Always**
1) Clients or customers	0	1	2	3	4	5
2) Suppliers	0	1	2	3	4	5
3) Distributors	0	1	2	3	4	5
4) Competitors	0	1	2	3	4	5
5) Companies in other industries	0	1	2	3	4	5
6) Investors or venture capital investment corporations	0	1	2	3	4	5
7) Universities or research institutes	0	1	2	3	4	5
8) Consultants	0	1	2	3	4	5
9) Technology intermediary organizations	0	1	2	3	4	5
10) Intellectual property rights organizations	0	1	2	3	4	5
11) Government	0	1	2	3	4	5
12) The media	0	1	2	3	4	5
13) Professional conferences, meetings	0	1	2	3	4	5
14) Related standards and regulations	0	1	2	3	4	5

2. To what extent are the following statements true about the situation of your company? (1= Not at all true, 3 =Somewhat true, 5 = Very true).

		Not at all true				**Very true**
1)	we introduced in the market many products and services that are completely new to us	1	2	3	4	5
2)	our firm has launched several new lines of products	1	2	3	4	5
3)	our firm places emphasis on product and process innovation	1	2	3	4	5
4)	we often experiment in the market with new products and services	1	2	3	4	5

3. To what extent are the following statements true about the situation of your company? (1= Not at all true, 3 =Somewhat true, 5 = Very true).

		Not at all true				**Very true**
1)	Rules and procedures within our organization are regularly renewed.	1	2	3	4	5
2)	We regularly make changes to our employees' tasks and functions.	1	2	3	4	5
3)	Our organization regularly implements new management systems.	1	2	3	4	5

4) The policy with regard to compensation has been changed in the last three years.	1	2	3	4	5
5) The intra- and inter-departmental communication structure within our organization is regularly restructured.	1	2	3	4	5
6) We continuously alter certain elements of the organizational structure.	1	2	3	4	5

4. To what extent are the following statements true about the situation of your company? (1= Not at all true, 3 =Somewhat true, 5 = Very true).

	Not at all true				**Very true**
1) The business model offers new combinations of products, services, and information.	1	2	3	4	5
2) The business model brings together new participants;	1	2	3	4	5
3) Incentives offered to participants in transactions are novel;	1	2	3	4	5
4) The business model gives access to an unprecedented variety and number of participants and/or goods;	1	2	3	4	5
5) The business model links participants to transactions in novel ways;	1	2	3	4	5
6) The way to conduct transaction is novel;	1	2	3	4	5
7) The way to generate revenues is novel;	1	2	3	4	5
8) Created new sources of revenues;	1	2	3	4	5
9) The business model adopts new ideas and methods to conduct business;	1	2	3	4	5
10) The business model adopts new operational processes, routines, and norms to conduct business;	1	2	3	4	5
11) Overall, the company's business model is novel.	1	2	3	4	5

5. To what extent are the following statements true about the situation of your company? (1= Not at all true, 3 =Somewhat true, 5 = Very true).

	Not at all true				**Very true**
1) Our organization accepts demands that go beyond existing products and services.	1	2	3	4	5
2) We commercialize products and services that are completely new to our organization.	1	2	3	4	5
3) We frequently utilize new opportunities in new markets	1	2	3	4	5
4) Our organization regularly uses new distribution channels.	1	2	3	4	5
5) We frequently make small adjustments to our existing products and services.	1	2	3	4	5
6) We improve our provision's efficiency of products and services.	1	2	3	4	5
7) We increase economies of scales in existing markets.	1	2	3	4	5
8) Our organization expands services for existing clients	1	2	3	4	5

6. To what extent are the following statements true about the situation of your company? (1= Not at all true, 3 =Somewhat true, 5 = Very true).

	Not at all true				Very true
1) In your opinion, how disruptive were your SBU's new product introductions during the past 5 years?	1	2	3	4	5
2) This SBU rarely introduces products that are disruptive in nature.	1	2	3	4	5
3) This SBU lags behind in introducing disruptive product innovations.	1	2	3	4	5
4) During the past 5 years, the new products that were introduced by this SBU were very attractive to a different customer segment at the time of product introduction.	1	2	3	4	5
5) During the past 5 years, the new products that were introduced by this SBU were those where the mainstream customers found the innovations attractive over time as they were able to satisfy the requirements of the mainstream market.	1	2	3	4	5

BUSINESS ENVIRONMENT

1. To what extent are the following statements true about the business environment faced by your company? (1= Not at all true, 3 =Somewhat true, 5 = Very true).

	Not at all true				Very true
1) In our kind of business, customers' product preferences change quite a bit over time.	1	2	3	4	5
2) Our customers tend to look for new product all the time.	1	2	3	4	5
3) Sometimes our customers are very price-sensitive, but on other occasions, price is relatively unimportant.	1	2	3	4	5
4) We are witnessing demand for our products and services from customers who never bought them before.	1	2	3	4	5
5) New customers tend to have product-related needs that are different from those of our existing customers.	1	2	3	4	5
6) We cater to many of the same customers that we used to in the past.	1	2	3	4	5

2. To what extent are the following statements true about the business environment faced by your company? (1= Not at all true, 3 =Somewhat true, 5 = Very true).

	Not at all true				Very true
1) The technology in our industry is changing rapidly	1	2	3	4	5
2) Technological changes provide big opportunities in our industry	1	2	3	4	5
3) It is very difficult to forecast where the technology in our industry will be in the next 2–3 years	1	2	3	4	5
4) Technological developments in our industry are rather minor	1	2	3	4	5

3. To what extent are the following statements true about the business environment faced by your company? (1= Not at all true, 3 =Somewhat true, 5 = Very true).

		Not at all true				**Very true**
1)	Competition is cutthroat	1	2	3	4	5
2)	Many “promotion wars” in industry	1	2	3	4	5
3)	Competitors can match offers readily	1	2	3	4	5
4)	Price competition in industry	1	2	3	4	5
5)	New competitive moves every day	1	2	3	4	5
6)	Competitors are relatively weak	1	2	3	4	5

4. On each of the following dimensions, how predictable or unpredictable is the external environment faced by your company? (1 = Highly predictable, 3 =Neutral, 5 = Highly unpredictable)

		Highly predictable				**Highly unpredictable**
1)	Product and/or process technology	1	2	3	4	5
2)	Market demand	1	2	3	4	5
3)	Customer needs and buying behavior	1	2	3	4	5
4)	Competitors’ actions	1	2	3	4	5
5)	Availability of needed talent	1	2	3	4	5
6)	Relevant policies	1	2	3	4	5
7)	Goals and actions of alliance partners	1	2	3	4	5