THE ROLE OF CEO'S PRIOR EXPERIENCE ON INNOVATION

- A CONTINGENCY PERSPECTIVE

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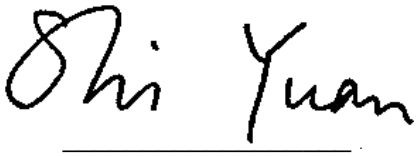
DECLARATION

I hereby declare that this thesis 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 the thesis.

This thesis has also not been submitted for any degree in any university previously.



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SUMMARY

Building on research on upper echelons, entrepreneurship and learning, this paper examines the contingent value of chief executive's experience on firm innovation. Using a sample of chief executives in US public firms in the biotechnology industry and accounting for endogeneity with several approaches, I find that it is not the single type of experience, but the bundles of multiple types of experience that affect innovative performance in a complex way. Specifically, I discover that CEO's experience falls into distinctive bundles that have significant effects on firm innovation. Empirical results suggest that broad experience in those areas relevant to innovation is beneficial, but limited relevant experience may be worse to innovation than no experience. Moreover, extensive experience in other areas and non-profit organizations appears to be a liability to corporate innovation. The alternative strategy of empowering R&D executives with attention and resource is at best in a weak positive relationship with innovation. The findings indicate the importance of the contingency role of CEO's experience-based capability on the macro-level innovation outcome. Additionally, consistent with the findings of prior research, I replicate the inverse U-shaped relationship between CEO tenure and firm innovation.

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CHAPTER 1 INTRODUCTION

This paper studies the contingent effects of CEO's prior experience on the innovative performance of high-tech firms. Instead of the common approach of testing the effects of isolated types of experience on performance, this study views the prior experience of chief executives as multiple bundles that have differentiating effects on innovation and investigates how the portfolios of single types of field and organization experience affect innovation. Specifically, I examine when the scope of CEO's prior field experience contributes or inhibits firm innovation, how CEO's experience in non-profit organizations affects firm innovation, and when CEO's experience matters more to innovation.

This issue of study is important for at least three reasons. First, although the literature in entrepreneurship and upper echelons have been informative on how managers affect firm performance, they each provide incomplete theoretical explanations of the manager's experience. Austrian economists (Hayek, 1945; Shane, 2000) view the essence of individual's prior experience as the difference in entrepreneurs' information about opportunities for the discovery of innovations. Hence, individuals are capable of recognizing and exploiting certain innovation opportunities from the environment via the knowledge corridor formed by such idiosyncratic prior knowledge (Shane & Venkataraman, 2000; Venkataraman, 1997). Despite Shane and Venkataraman's (2000) sound and broad definition of entrepreneurship, such view is seldom introduced to study the nexus of executives and firm dynamics after their IPOs. However, as opportunity is equally important throughout the organization life, an entrepreneurial view extended to the executives in established firms in the dynamic industries is critical. Moreover, most entrepreneurship research does not address when prior experience may inhibit opportunity identification.

Unlike the proactive view of managers' capability of opportunity recognition in new ventures, upper echelon scholars emphasize that the prior experience may restrict and bias executives' cognition base and strategic choice, which results in the research focus on relevant issues like controls and incentives (Hambrick & Mason, 1984). Following this view, abundant evidences are found for the mechanisms that prior experience plays a dynamic role in the allocation of attention to different issues (Cho & Hambrick, 2006). Studies on agency theories also point out how to manage incentives and arrange corporate governance to incentivize and control executives to

enhance R&D performance. Psychological factors like overconfidence or hubris of the chief executive are found to be associated with higher innovation (Galasso & Simcoe, 2011; Tang, Li, & Yang, 2012). Despite the rich studies up to date, upper echelons research seldom acknowledges executive experience as a micro-foundation of organization capability. Kroll, Walters, and Wright (2008) provide one of the rare examples by highlighting the role of board experience in achieving successful monitoring outcomes, which extends the cognition-based framework of individual level studies. One interpretation from the study is that cognition and control studies may not provide a complete picture of the interplay between executive and firm performance if the link between executive experience and capability is missing.

Second, while studies drawing performance implications from single types of executive experience have not been very fruitful, very few studies further examine the bundles of multiple types of individual experience. Organization learning scholars indicate that it is generally difficult to make straight-forward inferences on organizational outcome from executive's experience (Argote & Miron-Spektor, 2011; March, 2010). Canella, Finkelstein and Hambrick (2008a) in a review on studies of executive experience and organization performance conclude that no executive profile that is universally advantageous has been found so far. The same can be said to the vast studies on one of the specific learning outcome, the innovativeness of the firm. As scholars have noted for some time (Argote & Miron-Spektor, 2011; Cannella, Park, & Lee, 2008b; Wu, Levitas, & Priem, 2005), fine-grained studies on the impact of executive experience on innovation are scant. Moreover, most of the experience studies focus on the investigation of single types of experience without further considering the joint effects of multiple types of experience. As suggested in previous studies (Barker & Mueller, 2002; Hambrick & Mason, 1984), it has been neither sufficient nor very fruitful to examine the static effects of experience in single areas. Therefore, a broader look at the how the experience spans across multiple areas and when experience matters more is needed (Argote & Miron-Spektor, 2011; Hambrick, 2007).

Third, although it is the practical belief that hiring of new executives would source their rich experience and expertise to the organization (Dokko, Wilk, & Rothbard, 2009; Singh & Agrawal, 2011), current research provides little knowledge about whether extensive experience actually boosts performance. In popular press, most appointment announcements highlight the *extensive* experience that the executive would bring to the firm, indicating the expectation of the firm and the shareholders that these newly appointment executives will leverage their experience to create value

for the firm. For executives, Raskas and Hambrick (1992) report that around 70% of the CEOs rated the extensive experience in multiple functional areas as an important attribute for their successors. For investors, experience signals the quality of the human capital and affects major investment decisions (Higgins & Gulati, 2006). An earlier survey on venture capitalists reveals that deficiencies in management accounts for one third of all the failures in capital raising (Bruno & Tyebjee, 1985).

In this study, I propose that broad experience is not universally beneficial to innovation performance and that we should view experience as multiple bundles of knowledge, thinking and value across multiple fields and organizations. Innovation is a systematic and enduring effort that requires the capability to coordinate between different divisions, high tolerance for failures, and a long-term orientation (Manso, 2011). Therefore it is not the expertise in a particular field but rather the bundle of experience in many fields relevant to the innovative process that matters to the overall innovativeness of the firm. Furthermore, experience is not only the base for cognition but also the micro-foundation for capability – the complex interplay behind experience limits executives' vision in some fields while enabling the discovery of opportunities elsewhere. Therefore, different bundles of experience may carry either premium or liability to innovation to the point that it is confounding to treat all experience as equal.

Using a sample of CEOs of public biotechnology firms in the US and controlling for firm-level, TMT-level and CEO-level factors and multiple sources of endogeneity, I find that CEO experience significantly and robustly predicts innovative performance. I first replicate the inversed U-shape relationship between the basic temporal facet of CEO experience, tenure, and innovation. From there, it is found that the role of CEO experience on innovation is contingent upon whether such experience is in those fields relevant to innovation or not. Specifically, experience in limited number of innovation-related fields may be more harmful to innovation than no relevant experience. Broad experience in many innovation-related fields enhances CEO's capability to advance the innovativeness of the firm. Moreover, experience in other fields and non-profit organizations can be a liability to firm innovation. Finally, the power of CEO captured by CEO duality and founder identity moderates the relationship between CEO's experience in relevant fields and innovation in such way that the hurdle for reaping the benefits of broad experience is lowered and that the positive effect of broad experience is strengthened. I also examine whether the presence of R&D manager in TMT, which may enhance the TMT's attention on innovation and the power of R&D division, has an impact on the innovative

performance of the firm. Results suggest that the positive linkage between the presence of R&D managers in TMT and innovation is at best a weak one.

The rest of the paper will be organized as follows: Chapter 2 will briefly review and summarize the relevant literature in experience and innovation. Hypotheses on TMT level and CEO level will be introduced and elaborated in Chapter 3. Empirical methods are detailed in Chapter 4, and results from main analyses and robustness tests are presented in Chapter 5. Chapter 6 discusses the contributions and limitations of the study and summarizes the findings and their implications.

CHAPTER 2 LITERATURE REVIEW

This chapter will provide a brief review and critique of the current literature on the relationship between experience and performance grounded in entrepreneurship, TMT, and organizational learning research with a focus on individual-level analysis and innovation-related outcomes. First, I will integrate relevant findings on manager's experience and organization innovation and address several limitations of the current literature. Then I will highlight the scope of experience and summarize the positive and negative mechanisms surrounding it. Afterwards, I will propose several unanswered but important questions following this line of thought.

2.1 Entrepreneurs, Executives, and Firm Innovation

In a dynamic environment, executives such as CEOs play a crucial role in shaping the organization's innovative capability. Although the strategic importance of innovation to organizations is without question, executives have to consistently face the tension between emergent innovation initiatives and needs of incumbent core business (Tushman, Smith, & Binns, 2011). Moreover, opportunities for innovation are often non-obvious and require a long-term commitment of resources and high tolerance for failures (Manso, 2011; Shane, 2000). In order to achieve superior innovative outcome, executives need to constantly acquire, configure and combine the dynamic capabilities available to the firm (Hambrick & Mason, 1984). Such orchestration is no easy task, and thus, comprehensive working experience is almost always needed to achieve effective leadership in innovation (Bruno & Tyebjee, 1985; Kor & Mesko, 2013).

How do managers matter to innovation? Scholars working in the fields of entrepreneurship, upper echelons and organizational learning have established rich traditions in this line of inquiry. Entrepreneurship scholars attribute the identification of non-obvious opportunities to the knowledge and capability associated with the prior experience of the entrepreneur (Gruber, MacMillan, & Thompson, 2008; Shane, 2000). On the micro-level of individual cognition, serial entrepreneurs are found to have prototypes with clearer definition, richer content and a more realistic focus (Baron & Ensley, 2006). In a sample of founding teams of technology start-ups,

Gruber and his colleagues (2008) discover that founding teams with prior experience in entrepreneurship identify more opportunities for the market entry of the technology, which in turn lead to successful performance of the new venture. Moreover, Toole and Czarnitziki (2009) report that biotechnology entrepreneurs who have experience in academia have superior R&D performance compared to the non-academic counterparts. Furthermore, as the quality of new ventures is often difficult to determine, prior knowledge also has signaling effects and influences the external assessment of the entrepreneur's ability to access and allocate resources (Shane & Khurana, 2003). In a sample of MIT patents, Shane and Khurana (2003) find that the prior status of the academic entrepreneurs positively impacts the founding behavior. Similarly, management experience and academic status are also positive predictors of the investment raised and survival of the high-technology ventures in Israel (Gimmon & Levie, 2010). Despite the progresses made on the entrepreneurial view of individual's prior experience, such view is seldom extended to the studies of the innovative performance of the established firms, nor does the research address when the experience may hurt the entrepreneurial performance.

Unlike the entrepreneurship school's proactive view of experience as a foundation of capability in the individual-opportunity nexus, upper echelons research tends to frame the prior experience of managers as constraints on their cognitive models and shaping power of their value preferences (Barker & Mueller, 2002; Cannella et al., 2008a; Hambrick & Mason, 1984). Prior experience limits managers' field of perception in firms' everyday R&D activities, biases the interpretation of the current internal and external situations of the technological change, and thus affects their choice of innovation strategy (Dearborn & Simon, 1958; Hambrick & Mason, 1984). Chaganti and Sambharya (1987) report that TMTs with more R&D background executives, fewer finance background executives and less tenure tend to follow production innovation strategies in the tobacco industry. In computer industry, Thomas, Litschert, and Ramaswamy (1991) find that younger CEOs with R&D or marketing experience are associated with higher likelihood of following market innovation strategies. More recent studies find that younger CEOs who have primary experience in marketing and R&D and a graduate degree in science tend to invest more in R&D (Barker & Mueller, 2002), and founding teams with more PhDs are more likely to adopt open science policies (Ding, 2011). McGee, Dowling, and Megginson (1995) demonstrate the importance of the alignment of corporate strategy and executive experience and find that R&D differentiation strategy is most beneficial to the new venture when the management team possess extensive R&D experience. Such finding is corroborated

by the observation that R&D-intensive firms are more likely to select CEOs with R&D experience and higher education (Datta & Guthrie, 1994).

Since executives are bounded rational individuals who are limited in the cognitive capacity, biased in decision-making, and subject to opportunism especially in face of the long-term investment and risk of developing innovation, organizations need to design certain structure to effectively motivate the executives to innovate. The turnover of CEOs may positively impact the quantity and quality of the firm innovation (Bereskin & Hsu, 2011). The presence of a complete functional structure at the inception of the firm may help the firm to go public faster (Beckman & Burton, 2008). The design of the executives' incentive scheme is also an effective way to stimulate innovation. When the technological intensity is high for the firm, firms may align total incentives for executives with industrial impact of patents and scientific publications (Makri, Lane, & Gomez-Mejia, 2006). Tolerance for early failure and reward for successes in the long run should be incorporated in the compensation plan to motivate innovation (Manso, 2011). As Lerner and Wulf (2007) suggest, long-term incentives for corporate R&D supervisors may be associated with the innovativeness of the firm. While the external incentive schemes and organization designs are important to R&D and innovation without question, the study on executive experience and innovation may complement this research stream by suggesting that certain intrapersonal experience may also incentivize executives to tolerate risks and failures and make long-term commitment to corporate innovation.

Some micro-oriented upper echelon studies directly examine the attention and traits of managers and organizational innovation. Executive attention, which may emerge from external industrial environments and intrapersonal experience, has been found to influence strategic and technological change of the organization (Cho & Hambrick, 2006; Eggers & Kaplan, 2009; Nadkarni & Barr, 2008). In a study on the technological shift in telecommunication industry, Kaplan (2008) even suggests that attention from the CEO can counteract the negative effect resulting from the lack of organization-level capability. Outside the high-technology contexts, Yadav, Prabhu, and Chandy (2007) discover that CEO attention is an important driver of innovation, which is measured as the adoption speed of Internet service in US retail banks. They further elaborate that the attention-innovation link still exists when the content of attention is not innovation, or the outcome of innovation is not ambiguous or uncertain. Furthermore, prior experience may shape manager's attitudes and personality, and the past successes may engender hubris (Chatterjee & Hambrick, 2011; Musteen, Barker, & Baeten, 2010). Overconfident CEOs who make riskier

moves are found to be more likely to pursue innovation for the firms in multiple contexts (Galasso & Simcoe, 2011; Tang et al., 2012). CEOs with liberal attitudes are more likely to emphasize on the exploration and innovation of the firm (Musteen et al., 2010). This stream of micro-oriented literature generally does not account for executive-level experience until a recent study by Kroll and colleagues (2008) on directors suggest that director vigilance may be ineffective in monitoring and advising unless it is backed up by directors' relevant experience and knowledge.

Despite the rich findings in the realm of entrepreneurship and upper echelons outlined above, scant empirical evidence linking the executive's experience and firm performance has been found up to date. Two CEO studies shed light on this topic. In a survey on machinery and metalworking firms in Canada, Kitchell (1997) reports that younger, flexible and perseverant chief executives with less tenure and higher education is positively associated with firm innovation. Based on another survey of more than 2,000 German firms, Rodenbach and Brettel (2012) propose that CEO's experience is a micro origin of the dynamic capability of the firm. However, their findings are more mixed. In regression analyses, they find the only significant predictor of the organization's R&D capability among CEO's functional experience variables is the administration experience. Several major limitations further halt the interpretation and generalization of the already mixed results. First, the survey data prelude the objective measures of the innovation performance and experience. Second, the issues on the non-random selection of CEOs, or endogeneity, are overlooked, resulting in the concerns about the causal inference. Third, only single types of experience are examined, preventing us from knowing how the bundle of experience would affect innovation. When we jointly consider the more informative findings on strategy and performance in prior experience research, a nuanced interpretation may be that: whether experience drives managers to choose innovation-oriented strategies, and whether they are able to effectively deliver the innovation outcome with their experience, are two different stories.

Overall, the current literature on manager's prior experience and organization innovation suffers from several drawbacks that call for further investigation. First, compared with the works on TMT, few studies focus on the experience on individual executive’s level, and even fewer individual-level studies incorporate a team-level perspective. As Carpenter, Geletkanycz, and Sanders (2004) in their review on upper echelon research conclude from previous findings, the effects of individual executives on firm outcome can be divergent from those of the team (Bertrand & Schoar, 2003; Carpenter et al., 2004; Jensen & Zajac, 2004). Jensen and Zajac (2004) in their study

on executive background and diversification argue that CEO study is necessary to complete the TMT study, as results demonstrate that CEO has the highest predictive significance in the disaggregated analyses. Second, the capability view of the individual experience is generally missing and the flourishing research on non-observable executive characteristics usually does not account for the observable characteristics. While certain types of prior experience are acknowledged for the superior innovative outcome, a comprehensive and contingency view of when the experience will matter more and whether other experience may hurt performance remains unexplored. Third, most of the individual-level prior experience studies view functional experience as isolated factors and do not consider the collective effects of experience in multiple areas, inviting puzzles of how the combinations of experience would affect performance.

2.2 Scope of Experience and Performance

Prior experience also provides a crucial base for learning (Levitt & March, 1988). Individuals and organizations often encounter the myopia of learning in the innovative process, overlook distant and unfamiliar fields and focus excessively on the exploitation of incumbent capabilities (Levinthal & March, 1993; March, 1991). To overcome such trap in learning, individuals and organizations may extend their experience base into various areas, and leverage the bundle of diverse experience as the innovative capability (Cannella et al., 2008b; Kor, 2003; Nerkar & Roberts, 2004). In terms of innovation, specific technological expertise alone is not sufficient for success and should be combined with organization skills (Kakati, 2003). Studies on spin-outs have also shown that inheriting the non-technical know-how is at least as important as the transfer of technical know-how (Agarwal, Echambadi, Franco, & Sarkar, 2004; Chatterji, 2009).

Research on organizational learning and management teams has offered several key insights on how managers' broad experience in many areas would positively impact innovation. First, broad experience would expand the cognitive framework of the individual and allow him or her to identify more meaningful cognitive patterns from the complex arrays of external events (Baron & Ensley, 2006). These patterns "connecting the dots" would be a repertoire for potentially creative ideas (Schilling & Green, 2011). Such cognitive strength would also enable executives "to learn, and to sense, filter, shape, and calibrate" technological opportunities, which lays the micro

foundation for the dynamic capability (Cohen & Levinthal, 1990; Shipilov, 2009; Teece, 2007: 1326). Second, broader experience offers more diverse access to information and different sources of perspectives and opinions, and significantly enhances the knowledge base of the individual (Beckman, Burton, & O'Reilly, 2007; Harris & Helfat, 1997; Huber, 1991). Third, individuals with broad experience are more likely to have extensive social networks that entail many weak ties crossing functional faultlines (Cannella et al., 2008b; Hansen, 1999). They are also more likely to attract members with similarly diverse background into their organization (Beckman et al., 2007). Finally, the rich experience across many fields also signals the legitimacy to both internal and external members (Higgins & Gulati, 2006).

Empirical works have documented positive impact of broad prior experience. On the organization level, the scopes of experience in the product and market space (Nerkar & Roberts, 2004; Shipilov, 2009) and the search of technological knowledge (Katila & Ahuja, 2002; Kotha, Zheng, & George, 2011) are found to be associated with positive performance. On the project level, Macher and Boerner (2006) find that particular area experience improves R&D performance when it is combined with knowledge from other areas. On the team level, the diversity of TMT members' experience, often referred as TMT heterogeneity, has also received much attention. In new ventures, founding teams with broad experience in functional areas and organizations are found to get favorable investment decisions (Beckman & Burton, 2008; Beckman et al., 2007). In the airline industry, Hambrick and Chen (1996) find that diversity in TMT's functional experience is associated with the propensity, speed and magnitude of the strategic response, and they also find the overall positive effect of the diverse TMT on market performance. According to another study on global firms in the manufacture sector, TMT diversity may impact the innovativeness of the organization via the strategic choice on innovative field (Talke, Salomo, & Rost, 2010). Dokko et al. (2009) present one of the very few studies on the individual level, which proposes that the relevant knowledge and skills obtained from the prior related experience has a positive impact on the job performance of the employee. Moreover, Cannella and colleagues (2008b) provide another rare example by decomposing the TMT functional diversity into the individual level and find the positive impact of intrapersonal functional diversity on financial performance.

Meanwhile, as executives have limited cognitive resources and most management know-how can be highly tacit, prior experience can be a liability to innovation. Successful experience in the past may lead to self-reinforcement of familiar heuristics and rigidify the biased mode of thinking in ambiguous situation (Argote & Miron-

Spektor, 2011; Audia & Goncalo, 2007; Cannella et al., 2008b). Moreover, the initial effort to broad the experience base can be costly, and spreading executives' attention to several concurrent projects of wide scope may hurt the performance (Eggers, 2012; Macher & Boerner, 2006). Hence, the increase in the scope of experience does not always pay premium in performance. Prior TMT studies offer very little insight into this matter. A relevant study on CEO tenure and innovation may be illustrative, in which Wu and colleagues (2005) discover that the relationship between CEO tenure, the simplest form of temporal experience, and firm's innovation depends on whether CEO tenure exceeds a threshold. Beyond that we know very little about when the scope or breadth of key individual executive's experience matters more to innovation and whether broad experience may halt innovation in certain experiences. Given the complicated process and potential traps, barriers, and value of experience-based learning and doing, these are intriguing questions for research on individual experience and innovation.

CHAPTER 3 HYPOTHESES DEVELOPMENT

This chapter develops the main hypotheses of the study design. I will start with the replication of the established inverse U-shape relationship between CEO tenure and innovation. Then I will introduce hypotheses on CEO's experience scope in different types of fields and organizations. Last, I propose power as a potential moderator on the effects of CEO experience.

3.1 CEO Tenure and Innovation

Prior research has established the inverse U-shaped relationship between CEO tenure and firm performance. Tenure is the basic temporal facet of the CEO's firm experience, and thus provides an ideal starting point for our further exploration of other dimensions of experience. Managers need time to gain legitimacy and develop effective paradigms for innovation, but in the meantime their thinking becomes rigidified and their knowledge becomes obsolete (Hambrick & Fukutomi, 1991). At the very beginning, newly appointed chief executives lack the position- and organization-specific experience to understand the problems and implement strategies. In order to overcome the liabilities of newness, they often need to be engaged in the learning process to obtain legitimacy and create repertoire for innovation-related managerial tasks (Cannella et al., 2008a; Hambrick & Fukutomi, 1991; Shane & Khurana, 2003). As the CEO's tenure increases, they develop more paradigms in stock for problem-solving and may initiate innovative efforts on a legitimate ground. However, CEOs with long tenure may develop a strong sense of dependence on their own repertoires and lose the ability to learn new ideas from the outside (Barker & Mueller, 2002; Miller, 1991). Moreover, those CEOs who are near the end of their tenure are more likely to divert their cognitive resource to make arrangement for their departure and avoid taking risk for innovation in the incumbent firm (Simsek, 2007).

The inverse U-shaped relationships between CEO tenure and organization have been found in both technological and non-technological contexts (Henderson, Miller, & Hambrick, 2006; Miller & Shamsie, 2001; Wu et al., 2005). In film industry and food industry, CEO tenure of intermediate length is found to be most beneficial to financial performance (Henderson et al., 2006; Miller & Shamsie, 2001). Similar

curvilinear relationship is unveiled for the technological performance of biopharmaceutical firms (Wu et al., 2005). Empirical evidences also indicate that the dynamism of the industry lower the value of the turning point in tenure length (Wu et al., 2005). Based on the findings of the prior studies, I hypothesize the inverse U-shaped relationship between CEO tenure and innovation as below:

Hypothesis 1: CEO tenure has an inverse U-shaped relationship with the innovative performance of the firm, so that CEO tenure facilitates innovation before reaching the threshold, and halts innovation afterwards.

3.2 CEO's Experience Scope in Relevant Fields and Innovation

Few executives start their career as generalists in management, and they usually develop expertise in specialized fields before being promoted to management positions (Datta & Guthrie, 1994; Gupta, 1984). On one hand, their technological and managerial know-how inherited from the past experience can be a bundled capability for innovation that is difficult for other to imitate (Cannella et al., 2008b; Mendonça, 2009; Teece & Pisano, 1994). On the other hand, in face of the high risk of failure and long-term investment before substantial return of R&D activities (Manso, 2011), incomplete or narrow experience may significantly dampen executive's assessment and implementation of potential technological opportunities. Since innovation is a systematic effort that requires the coordination between competing functional areas of the organization, the versatility of the prior experience should impact organization innovation in a nuanced way.

In order to successfully initiate and sustain innovation in the complex organization, exposures to fields relevant to the creation, integration and recognition of innovation are valuable. First, experience in innovation-creation fields such as corporate R&D, academic research and law is beneficial, because such experience provides detailed knowledge on the development process of innovation. Executives with research background may have reasonable expectations of the risk and time of R&D projects, and better evaluations of the value of these projects per se. Prior research demonstrates that executives with R&D background may allocate more resources to research, and new ventures founded by academic entrepreneurs enjoy superior performance in invention (Barker & Mueller, 2002; Toole & Czarnitzki, 2009). Expertise in law may encourage the firm to convert R&D progress into protectable

intellectual properties (Somaya, Williamson, & Zhang, 2007). Executives with expertise in law may also take a tougher attitude to protect the intellectual properties (Agarwal, Ganco, & Ziedonis, 2009). Second, background in innovation-integration fields like operations and business development may enable the executive to put the innovative strategy on the general picture of operations across specialist functions. Specifically, chief executives with operations background may have insight into the technical needs of the daily operation, and effectively lower the organization-wide disturbance caused by significant research discoveries (Dewar & Dutton, 1986). Meanwhile, business development background helps the CEO to envision well-rounded long-term growth opportunities by connecting the development in R&D with the status quo of other functional divisions (Sørensen, 2012). Last but not least, CEOs who used to be entrepreneurs or venture capitalists may better identify and evaluate opportunities for innovation. Entrepreneurship experience may lead to better sense of where to seek opportunities of value creation, and experience in venture capital provides skills in assessment of the commercial value of nascent innovations. CEOs with such experience are also likely to tolerate failures and provide constant feedback in the innovative process.

When the scope of experience in these relevant fields to enhance innovation is increased from none to high, the marginal cost and benefit of extended relevant experience may go through different dynamics. As mentioned, innovation is a systematic effort affecting the whole organization. The marginal cost stems from the risk that the misinterpretation of the situation and inadequate coordination of innovation-related activities caused by the limited experience (Levitt & March, 1988). Such marginal cost is greatest when the executive possess limited relevant experience in innovation. Comparing with executives with no innovation-related experience, they are often more recognized for their past success in innovation-related fields and thus are more likely to have excessive confidence in the decision-making on innovation matters (Audia & Goncalo, 2007; March & Shapira, 1987). However, the limited cognition base may lead to oversimplification of the actual situation and ignorance of the wider impact of R&D projects to the organization (Levinthal & March, 1993). As the scope of experience increases from low to high, the marginal cost should see a decline as the executive will have a more comprehensive assessment of the situation and can better coordinate the whole organization. To sum, when relevant experience increase from zero to low, the marginal cost associated with learning myopia and

hubris bump from zero to high; when the relevant experience is raised from low to high, such marginal cost declines accordingly.[1]

Meanwhile, the marginal benefit of broader experience may increase substantially when CEOs have broad experience spanning many relevant fields. Such benefit should be less than the marginal cost when relevant experience is narrow. Nonetheless, versatile CEOs are less prejudicial and have considerable social capital from diverse sources (Cannella et al., 2008b; Raskas & Hambrick, 1992), indicating that the marginal benefit surpasses cost when experience is broad enough. As a result, they are also more likely to overcome the myopia in the search for innovation and secure convergent support from various parties on the value chain of innovation (Cannella et al., 2008b). Taken together, the total marginal effect may see an initial decline, and rise above zero afterwards. And thus we have the following hypothesis:

Hypothesis 2: CEO's experience scope in those fields relevant to innovation has a curvilinear relationship with the innovative performance of the firm, so that narrow experience scope below a certain point halts innovation but broad experience scope exceeding a certain point facilitates innovation.

3.3 CEO's Experience Scope in Other Aspects and Innovation

While some executives possess the knowledge, skills and value to promote R&D, others may view in-house R&D quite differently. Executive's the prior experience not directly related to the innovation and R&D process may be a liability to innovation for three reasons. First, executives with innovation-unrelated experience are more inclined to devote more of their cognitive resources to non-innovation aspects of the firm. Second, executives with innovation-unrelated experience are more likely to take a conservative attitude towards innovation and value in-house R&D less. Third, in face of the common failures in innovation, they are more likely to have less tolerance and feel more compelled to divert the resources elsewhere.

For illustration, CEOs with corporate finance background are more likely to view the firm as a portfolio of financial assets and seek quick growth through transactions in the financial market (Barker & Mueller, 2002; Jensen & Zajac, 2004). Similarly, marketing-oriented CEOs may also tend to be more favorable towards using marketing strategies to grow sales in the product market. Chief executives who used

[1] I thank an anonymous examiner for suggesting the argument.

to be consultants are likely apply the revenue and cost framework to address temporary problems (Ramanan, 2012), rather than make long-term commitment to the opportunities in innovation. Taken together, CEOs with these backgrounds may see R&D "as more of a discretionary expense subject to efficiency concerns" (Barker & Mueller, 2002: 786), and allocate more attention to the analyzing and forecasting the financial health and market position of the firm (Bamber, Jiang, & Wang, 2010). This is somehow consistent with the finding that firms with poor financial performance are more likely to select CEOs with expertise in finance (Guthrie & Datta, 1997). In the end, decisions on in-house R&D are often left to the discretion of the division and innovation often loses in the competition for resources (Tushman et al., 2011). Previous research show that finance CEOs are more likely to leverage financial controls by implementing acquisitions and unrelated diversifications, which is often at the cost of the long-term benefits of the in-house R&D (Herrmann & Datta, 2006; Hitt, Hoskisson, Johnson, & Moesel, 1996; Jensen & Zajac, 2004). Overall, the more experience the CEO accumulates in these fields, the more value they will emphasize on the market transactions and cost efficiency, and the less likely they will overcome the temporal myopia and endure the long-term commitment and high risk of innovation (Cannella et al., 2008a; Levinthal & March, 1993; Manso, 2011).

Carpenter et al. (2004) in their review on upper echelons research suggests that the executives' past experience in non-profit organizations (NPOs) like governments and other organizations has generally been overlooked. As an extension to the experience in different functional fields, I will also examine the effects of NPO experience here. It is widely known that NPOs operate under logics and beliefs that are divergent from corporations. CEOs with NPO background often face more barriers in gaining legitimacy and overcome liability of newness in the firm than those dedicated their whole career in the corporate world. The disparate institutional norms imprinted from the past affiliations with NPOs may make their prior experience particularly difficult to interpret and learn from (Argote & Miron-Spektor, 2011; Hambrick & Mason, 1984). For example, the principles of search and exploitation of knowledge for non-profit use can be divergent or even contradictive to the norm in the industry (Bunderson, 2003; Huang & Murray, 2009). And in the case of the government, the focus is more on the monitoring and regulation of innovation rather than the creation of innovation. Moreover, executives with NPO background face more pressure to gain the legitimacy for their leadership in for-profit corporations, as they are subject to the more doubts about whether they can manage the firm *for profit*. As a consequence, these executives may be inclined to take more conservative attitude

towards risky R&D projects because of greater concern about the legitimacy for profit or the bureaucratic belief of "doing by the book". To sum up the arguments above, we have the following two hypotheses on the liability of experience in other fields and in non-profit organizations:

Hypothesis 3a: CEO's experience scope in other fields has a negative relationship with the innovative performance of the firm.

Hypothesis 3b: CEO's experience in other types of organizations has a negative relationship with the innovative performance of the firm.

3.4 The Moderating Effect of CEO Power

Several scholars have been aware of the gap between individual forces and outcomes on the higher level. For example, Argote and Miron-Spektor (2011) suggest that the experiential learning on the individual level have to be embedded in some supraindividual arrangement to enable the learning to occur on higher level. Similarly, Canella et al. (2008a) point out that the executive characteristics need to be converted into implemented strategic choices to achieve organizational outcome. To resolve the gap between executive and organization, Hambrick (2007) highlights the importance of exploring contingency factors that determine how much executives matter to the outcome. Similarly, Mackey (2006) concludes from previous literature that the environmental constraints limit the magnitude of the managerial influence on the organization. Nevertheless, CEOs with power from the founder identity and board control may be able to overcome such constraints and insert their positive impact into the organization routine. First, the power enhances the CEO's ability to mold the strategic choice at his or her will and thus strengthen his or her influence on the firm (Hambrick & Finkelstein, 1987). Second, the power facilitates deeper understanding of the firm-specific culture and politics and shields the implementation of innovation strategies from barriers originated from these factors (Groysberg, Lee, & Nanda, 2008; Huckman & Pisano, 2006). Third, the hazard of overconfidence and pitfall in learning can be alleviated for CEOs with more power in identity and control, because firm-specific knowledge from the very inception would compensate for their limited field experience, and the heightened responsibility for both the shareholders and employees resulted from duality would drive them to use extra caution when making decisions based on their individual experience (Donaldson & Davis, 1991).

Findings from relevant empirical works are largely consistent with the proposition that the power of the executives to make decisions shifts the impact on performance. Haleblian and Finkelstein (1993) propose that the TMT characteristics are significantly associated with performance only when executives have high managerial discretion. In their study on CEO turnover and innovation, Bereskin and Hsu (2011) report that internal CEOs who are supposed to have more power than outsiders may lead to inventions of higher quality and quantity. On the opposite end, the presence of predecessor executive, as a potential suppression force on the power of the incumbent CEO, is found to dampen the new CEO's chance to make significant gains in performance (Quigley & Hambrick, 2012). Based on the proposed mechanisms and prior findings, we have the final hypothesis on the moderating effects of power:

Hypothesis 4: CEO power has a moderating effect on the relationship between CEO's experience scope in relevant fields and the innovative performance of the firm in a way so that the negative relationship between scope and innovation below the threshold is attenuated and the positive relationship above the threshold is accentuated.

CHAPTER 4 METHODS

This chapter will cover the empirical strategies of the study in detail, including the description of the sample, procedures of data collection, calculation of measures and method of analysis. Generally, the sample is assembled from financial data, patent data and basic executive data on the firm level and the detailed biographic data on the CEO level from multiple credible sources. Accounts are given on the caculation and validation of the dependent variable, independent variables, controls and the correction for endogeneity bias. Fixed-effects count models will be used to generate reliable results from the sample.

4.1 Data and Sample

The sample of study is the public biotechnology firms founded in the US during 1995-2002. Biotechnology industry is a suitable setting for this study for several compelling reasons. First, as a representative industry of the high-tech sector, innovation is of high strategic importance that has to be constantly attended to by top executives, and a majority of the technological innovations are observed by patenting (Liu, Arthurs, Cullen, & Alexander, 2008). Second, in this dynamic industrial environment, the innovative performance is highly contingent upon the quality of the human capital (Tzabbar, 2009). Third, the industry as a whole has been accumulating experience since 1976, and a remarkable amount of heterogeneous experience should be accessible in the market in the study period.

I excluded private firms in the industry as reliable financial data are not readily available, yet controlling for financial aspect of the firm is necessary for the multilevel design of the study. I did not include biotechnology firms founded earlier because we need to collect and analyze detailed background data on CEOs affiliated to the sample firms from multiple electronic resources and the missing data tend to be more problematic for CEOs in earlier period.

The list of biotechnology firms which meet the criteria above was then obtained from the *BioScan Directory*, a credible data source of the biotechnology industry often used in studies of the industry. Based on the list of biotech firms, I assembled the financial data from *Compustat* and basic TMT data from *Capital IQ*, both databases

were accessed from *Wharton Research Data Services (WRDS)*. Patent data were obtained from the NBER Patent Project, which covers all US patents granted from 1976 to 2006 (Hall, Jaffe, & Trajtenberg, 2001). I first used dynamic match to obtain the patent records already matched to the sampled firms. Then I used the probabilistic matching algorithm (Blasnik, 2007) to match the standardized US patent assignee names and standardized *Compustat* names to further eliminate the error of missing matches.

Afterwards I proceeded to identify the CEOs from the basic executive data for the sample firms in the observation period and used the name and the affiliated firm of the CEO to collect his or her biography from the public information sources online. In order to minimize the measurement error caused by incomplete information in data, I made efforts to ensure the comprehensiveness of the biographic data by combining the biographic information of the same CEO from a variety of sources such as: the organization website, *LinkedIn* profile page, executive profile databases in *Businessweek*, *Forbes* and *Equilar Atlas*, CEO background introduction in *Wall Street Transcript* and announcements on management changes from *Factiva*. The final sample for analysis comprises 225 CEOs of diverse backgrounds and 101 dedicated biotechnology firms.

4.2 Variables and Measures

To measure innovative performance of the firm, our main dependent variable of interest is the patent count of the firm. Although patent-based innovation studies are subject to inevitable limitations, few other measures on innovation compare to patent in terms of scale and scope. *Patent* is calculated as the number of patents applied by the firm in one-year window. I also calculated the patent count in two-year window as an alternative specification in robust tests.

To test Hypothesis 1, CEO Tenure is measured by the variable *Tenure*, which is the number of years the CEO has been in office. The squared term of the variable *Tenure* is calculated as *Tenure Squared* to jointly test the inverse U-shaped relationship between CEO tenure and innovation.

To construct the measures for CEO's experience scope in different fields and organizations, a two-step procedure was implemented. First, based on CEO's biography, I created ten dummies for experiences in different fields and two dummies

for other types of organizations. Second, I aggregated dummies within different categories to create the experience scope measures for the regression analyses. To capture CEO's experience scope in relevant fields, I first categorized seven of the ten fields as fields relevant to innovation activities, which are: *Academic*, *Business Development*, *Law*, *R&D*, *Operations*, *Venture Capital* and *Entrepreneurship*. *Academic* was coded as 1 if the CEO has worked in an academia before taking charge of the firm, mostly as faculty member or researcher. *Business Development* was coded as 1 if the CEO has served positions related to business development and business planning such as Chief Business Officer. *Law* was coded as 1 if the CEO has expertise in law and intellectual property and served such positions as lawyer and general counsel. *R&D* was coded as 1 if a CEO has experiences working in the R&D division of corporations before and served such positions as Chief Science Officer and principal researcher. *Operations* was coded as 1 if a CEO has operation-related experiences and held positions like Chief Operations Officer. *Venture Capital* was coded as 1 if a CEO has worked in a VC firm before or has been endorsed for his expertise in venture capital. *Entrepreneurship* was coded as 1 if a CEO has experience in founding other start-ups or corporate ventures before. All dummies were coded as 0 otherwise. Then I calculated the experience scope in relevant fields as the sum of the seven field dummies for the CEO, *Relevant Fields*. To test the curvilinear relationship proposed in Hypothesis 2, I also calculated the squared term for the variable and labeled it as *Relevant Fields Squared*. As confirmation of the nonlinear relationships proposed in Hypothesis 1 and Hypothesis 2, I also tested both independent variables under the alternative linear assumptions.

Similarly, I summed the dummies for other fields (finance, marketing and consulting) not directly relevant to innovation activities and created the measure for CEO's experience scope in other fields. *Finance* was coded as 1 if a CEO has held positions related to finance and accounting before. *Marketing* was coded as 1 if a CEO has worked in the sales/marketing department before. *Consulting* was coded as 1 if a CEO once worked as a consultant. These dummies were given the value zero otherwise. The variable *Other Fields* is the sum of the three dummies above, and used as the independent variable for the test of Hypothesis 3a. To capture CEO's experience in other types of organization, I coded the two dummies, *Government* as the indicator of whether the CEO has working experience in government before, and *Other NPOs* as the indicator of CEO's experience in other non-profit organizations. The two dummies are summed as the variable *Other Organizations* to test Hypothesis 3b. To validate the categorization and the measure, I did three supplemental analyses

which will be detailed in the next chapter. First, I performed a placebo test by replacing the original experience scope variables with those calculated from two randomly assigned groups of the same structure. Second, I generated an experience scope variable for all field experiences as the substitute for the original scope variables and tested its effect. Third, I entered all the individual dummies to replace the scope measures and investigated if there is any consistent and significant effect by the individual experience dummies.

Hypothesis 4 proposes the moderating effect of CEO power on the relationship between relevant experience and innovation. The CEO power is measured by the variable *Power*, which was assigned the value 1 if a CEO is the chairman of board or the founder of the company, 2 if a CEO is a founder and a chairman, and 0 otherwise. I implemented control variables on the level of firm, TMT and CEO. Firm-level controls include variables capturing both financial and technological aspects. *R&D* controls for the research investment and orientation of the firm and was calculated as the ratio of R&D expense and sales. *Slack* controls for the slack resources available in the firm and was calculated as the current assets deducted by current liabilities, and then normalized by the total assets. *Sale* controls the firm size and is the total amount of annual sales in million dollars for a given year. *Age* controls for the organization age and is the number of years between the founding and observation time. *Technological (Tech.) Diversity* controls for the portfolio of the firm's patent stock and was calculated as one minus the sum of squared ratio of each 3-digit USPTO classes in the patent stock. I also included the dependent variable with 1-year lag, *Past Performance*, in the full model to check the effect of unobserved and variant factors.

I further controlled several key TMT properties, including team size, average age and the presence of founders and R&D managers. *Size* is the number of executives in TMT, as a bigger team is more likely to include R&D officials. *Age* is the average age of executives in TMT. In a separate analysis I further divided TMT age into CEO age and the average age of other TMT members, and this finer-grained specification did not yield significantly different results. The presence of founders is controlled by the variable *Founders*, which was calculated as the number of founders in TMT. The presence of R&D personnel in TMT is calculated as the number of R&D officials among the TMT members in a specific firm and a given year, labeled as *R&D Personnel*. As the final stage of the control strategy, I controlled two CEO-level characteristics, gender and MBA education. *Gender* was coded as 1 if the CEO is

female, 2 if the CEO is transsexual[2], and 0 if a CEO is male. *MBA* was coded as 1 if a CEO holds a MBA degree and 0 if not[3].

4.3 Endogeneity Strategies

Endogeneity arises when the treatment of the sample is not randomly assigned in non-experiment settings, and accounting for endogeneity has been a widely accepted standard in management research in recent years (Hambrick, 2007; Hamilton & Nickerson, 2003; Reeb, Sakakibara, & Mahmood, 2012). Following previous research (Chatterjee & Hambrick, 2007; Gruber et al., 2008; Hamilton & Nickerson, 2003; Landis & Dunlap, 2000), I used two strategies to account for the potential bias caused by the endogeneity issues. First, I used inverse Mills ratio to correct for the potential selection bias from multiple sources in the sample. Second, I addressed reversed causality by switching the position of dependent variable, explanatory variables and the moderator in the next section.

Two primary sources of selection biases are directly linked to the research questions in this design, namely CEO's relevant field experience and CEO's experience in other types of organizations. In order to identify the effective selection models, I generated binary variables for whether CEO has innovation-related field experience and whether CEO has experiences in non-profit organizations as the dependent variables for the selection equations. Additionally I propose that the presence of R&D personnel in TMT may be endogenous and also correct for whether the TMT includes R&D executives.

To identify the selection functions, I entered all observable firm characteristics available and variables capturing firms' recent changes in finance and technology as the independent variables in the probit models with robust standard errors. The probit models are specified to predicting the binary outcomes generated earlier. Afterwards, I retained those variables that have stable and significant statistical power in predicting the outcome. Then I checked the correlations between the retained variables and the dependent variable of the main equation and further dropped those highly correlated variables. Finally, I checked whether any of the exogenous variables

[2] There is only one such case in the CEO sample.
[3] In unreported analyses, I also controlled for CEO's PhD education, however, I found the negative correlation between MBA education and PhD education is high in the sample (correlation = 0.44, $p < 0.001$) and thus decided to retain one variable on education. Nevertheless, including PhD education in the full model did not change the results significantly.

retained may significantly influence the outcome of the main equation and can be readily interpreted in the selection equation.

Three selection equations are thus identified. To predict whether the CEO has relevant field experience, firm age, firm size, financial performance and the location in the Greater Boston area are used in the probit model. It turns out that the firm is more likely to have a CEO with non-innovation background (i.e. background in finance and accounting, marketing and sales, or consulting) if the financial performance or the sales volume is poor. Moreover, younger firms and firms in the Greater Boston area, a renowned biotech cluster, are more likely to have a CEO with expertise in innovation. The last selection equation predicts whether the firm will have a CEO with experience in non-profit organizations. Probit model results show that older TMT, larger firm size and the location near Washington DC significantly increase the likelihood of having a CEO with non-profit organization background. Additionally, firm age, TMT size, CEO's PhD education and CEO's field experience are used to predict the presence of R&D personnel in TMT. It is found that older firms with larger TMT are more likely to have R&D officials in their team. CEO who lacks innovation-related experience and CEO with a PhD degree may also be more likely to invite R&D executives to their team. All the exogenous variables not included in the main equation have correlations of 0.05 or lower with the main dependent variable, and they do not have significant predicting power when entered in the main equation either collectively or separately. Based on the selection equations above, the inverse Mills ratios for the presence of R&D personnel, CEO's relevant field experience, and CEO's experience in other types of organizations were thus calculated, and labeled as *TMT R&D Personnel*, *CEO Field Experience*, and *CEO Org. Experience* respectively under the category of "Correction for Selection" in the analyses.

4.4 Method of Analysis

Our main dependent variable is the number of patents applied in the year of observation, so count models would be appropriate for further analysis. Moreover, fixed-effects models can account for the unobserved heterogeneity that is time-invariant or firm-invariant in our case. A further look at the descriptive statistics for the dependent variable demonstrates that negative binomial model is preferred over Poisson model for its capability to account for overdispersion of the data. Taken

together, I adopted the fixed-effects negative binomial regression models for the main analyses (Wooldridge, 2002). To ensure temporal precedence of the causal reference, 1-year lag is applied to independent variables and controls. Alternative specifications of the time lag will also be explored in robustness analyses.

Meanwhile, econometricians point out that negative binominal models may suffer from the incidental parameters problem (Allison & Waterman, 2002). Although using Poisson models to estimate overdispersed data would bias the standard errors of the coefficients downward, such estimations are consistent and unbiased (Wooldridge, 2002). As a robustness check, I used Huber/White/sandwich estimator to correct the biased standard errors and ran the full model with the fixed-effects Poisson model. Results from the Poisson model with robust standard errors are largely consistent with the main results, indicating that incidental parameters do not appear to bias the main results significantly.

In addition to utilizing inverse Mills ratio as is outlined in the last section, I also did two set of analyses to address the potential reverse causality in the results following Landis and Dunlap (2000). First, I switched the independent variables and the dependent variable and tested the alternative arguments based on reverse causality after making necessary changes to the model specification (e.g., dropping variables that are no longer meaningful, changing the model due to different nature of the variable). The results suggest that innovative performance does not reversely impact any of the independent variables in the sample. In all "switched" models, the only significant explanatory variable is the lagged term of the dependent variable. Second, I tested the moderating effect of CEO power on the reverse relationship between innovative performance and future CEO's field experience. The insignificant results again suggest that such reverse causality may not exist.

CHAPTER 5 RESULTS AND INTERPRETATIONS

In this chapter, I will start with an overview of the CEO-level data, and then go through the main analyses, interpret the major findings, and briefly report the additional results. From there I will also discuss several post hoc analyses performed in the study.

5.1 Basic Statistics on CEO Experience

Table 1 provides an overview of the CEOs' basic demographic characteristics and the distribution of their experience in different fields and organizations. The CEOs in the sample tends to be highly uniformed in terms of gender, with male CEO making up 96% of the sample. Little diversity may also be expected in race, where whites are in a similarly dominant position compared with non-whites in a subsample where racial information is available.[4] Meanwhile, around one third of CEOs have an MBA degree, and another one third with a PhD degree.

Insert Table 1 about here

In terms of the field experience relevant to innovation, nearly 40% of all the CEOs in sample have experiences in operations, which is also the highest proportion among all fields. This may indicate that experiences in operation functions is much valued in the general management role in this dynamic industry. Entrepreneurship, R&D and business development come next, each with 32-33% of the CEOs. The interpretation would be that experiences in the growing of the front-end business, back-end research, and the organization as a whole are all important assets for the executive. Next, CEOs with academic background constitute 23.56% of the sample, which is an observation consistent with prominence of academic entrepreneurs in this field (Ding, 2011). The

[4] I did not include the variable for race here because of missing data. Although I utilized CEOs' family names, undergraduate institutions, and most importantly, photos if available to identify the racial information, many cases still cannot be reliably identified. In a subsample where racial information is available, 90% of the CEOs are white, and all the none-white CEOs are male. Additionally, I tested the effect of CEO's race in the subsample and did not find significant results.

field experiences in law and venture capital are rare for CEOs in the sample, with less than 7% and 9% each. This is not surprising if we take into account the fact that these two fields are generally connected to many industries. Overall, more than 70% of the CEOs have experience in one or two fields. And as can be expected, fewer CEOs have broad field experience, with less than 22% of the CEOs' experience spanning across three relevant fields or more.

For CEO's experience in other fields and organizations, CEOs with financial or marketing background each constitute about 28% of the sample, demonstrating that expertise in financial and product market also have their own merits. Fewer CEOs have a background in consulting or NPOs (16%-19%). Very few CEOs (around 7%) have worked in the government before, possibly caused by the divergent gap in institutions and organizations.

To summarize, although CEOs in the sample may be homogeneous in terms of gender and race, their experience in education, different fields of the corporate functions and different types of organization is highly diverse. No single experience is shared by the majority of the CEOs, and fewer CEOs have broader experiences in many fields. These findings on the CEO-level data also warrant our further investigations into the impact of experience on innovation.

5.2 Main Findings on Executive Characteristics and Innovation

Table 2 provides the descriptive statistics and correlation matrix of the variables in the regression analyses. The descriptive statistics of the CEO-level variables in the firm-sample are consistent with the results represented in Table 1, suggesting that it is unlikely that CEOs with certain features are over-represented or under-represented in the analysis. Overall, the average of the CEO's experience scope in innovation-related fields is less than 2, which implies that most CEOs exploit their skills in one or two specific fields of expertise before taking over the general management role and that exploration to gain experience in many fields remains uncommon. Meanwhile, the average tenure in the sample appear to be long, suggesting that the labor market for the chief executive in this industry may be quite constrained in demand due to the moderate turnover rate. Moreover, CEOs are on average powerful in the sample, with one or two powerful CEOs in every three CEOs in the observation period. The correlation table did not yield any extremely high correlation between variables, and

the correlations between independent variables are below 0.15, suggesting good discriminant power. To confirm that multicollinearity does not distort the results severely, I further checked the variance inflation factor (VIF) of the main models in the post hoc analyses.

Insert Table 2 about here

Table 3 displays the main results from fixed-effects negative binomial regressions. First, I entered the basic firm-level controls in Model 1. Results are much as expected and similar to previous findings. More investment into R&D activities and more slack resources at disposal will increase innovative output. Obsolete firms are subject to higher chance of losing innovative capability. Maintaining a diverse technology portfolio that may offer more recombination opportunities can also enhance innovation. In Model 2, I added the TMT-level variables. As discussed earlier, the presence of R&D personnel in TMT may be endogenous, so I also included the inversed Mills ratio to correct the bias. In Model 3, I further added CEO-level variables into the model to test the differentiated experiential effects proposed in Hypothesis 1, Hypothesis 2, Hypothesis 3a and Hypothesis 3b. I added the corrections for the potential selection bias of CEO's field and organizational experience accordingly. Among the basic firm-level controls, sales, R&D intensity and firm age predict innovative performance. Among TMT-level variables, the coefficient of R&D Personnel becomes marginally significant ($p < 0.10$) in this more informative model specification. On the CEO-level, the results show that gender and MBA education of the CEO do not significantly impact innovation, while CEO's tenure and experience make a difference. Both the original term and squared term of CEO tenure are significant at highest level ($p < 0.001$), which is consistent with the inverse U-shaped relationship between CEO tenure and innovation proposed in Hypothesis 1.

As Hypothesis 2 would predict, I find the significant curvilinear relationship between experience scope in relevant fields and innovation. The interpretation is that broad experience in innovation-related fields enhances innovation and that narrow experience may be worse than no experience. Consistent with Hypothesis 3a, experience scope in irrelevant fields has a significant and negative relationship with innovation. Hypothesis 3b argues that experience in other types of organizations also

has a negative impact on innovation. The coefficient for experience in other types of organizations is negative and significant, offering empirical support for Hypothesis 3b. Furthermore, the correction terms for R&D personnel and CEO field experience are not significant, suggesting the selection bias may not be salient for both scenarios in the analyses. Nevertheless, the correction term for CEO's organizational experience is marginally significant, suggesting that there might be some selection effects for CEOs with NPO experiences ongoing.

In Model 4, I introduced the interaction term of CEO power and CEO experience scope in relevant fields to test the moderating effect of CEO power proposed in Hypothesis 4. All the previous findings are still valid in Model 4, and the newly-added interaction term is significant and positive, confirming the prediction of Hypothesis 4. From Model 4, we can also calculate the threshold for the curvilinear relationships proposed in Hypothesis 1 and Hypothesis 2. The calculation reveals that other conditions equal, the CEO enhances the innovative capability of the firm most in their third to fourth years of tenure. Moreover, CEOs' experience in fields relevant to innovation makes positive contributions to firm innovation when such experience falls into more than two relevant fields. Additionally, Wald test shows that the negative impacts from experience in irrelevant fields and organizations do not differ significantly in terms of magnitude.

To check whether unobserved but variant factors would significantly influence the estimation, I included the 1-year lagged term of the dependent variable (DV) as an additional control for past performance in Model 5 as suggested by previous research (Gruber et al., 2008; Hamilton & Nickerson, 2003). Results show that the estimation for all the other coefficients remains unaffected, and that the effect of the lagged dependent variable is highly insignificant. Therefore, the unobserved and variant factors not controlled by the fixed-effects model are unlikely to be a serious issue here. Finally, I tested the magnitude of multicollinearity in our models. The variance inflation factor (VIF) is 6.18 for Model 5 and 4.26 when the squared terms and the lagged DV are dropped. Neither of the values is close to 10, the rule of thumb for the detection of multicollinearity. Given the stable and significant estimations across different specifications, the multicollinearity does not seem to jeopardize our results here. In additional analyses unreported here, I tested the main effect of CEO power and its moderating effects on other experience variables, all of which are insignificant. It could be that CEOs not familiar with innovation devote their attention and leverage their power in other aspects of the corporation affairs.

Insert Table 3 about here

To conclude, Hypothesis 1 is empirically supported, as I find that CEO tenure is in an inverse U-shaped relationship with innovation, with the peak of the curve located somewhere between three years and four years. Empirical results are also consistent with Hypothesis 2, suggesting that CEO's experience scope in relevant fields only provides substantial benefits to innovation when the CEO has experience in more than two relevant fields. On the contrary, experiences in irrelevant fields and non-profit organizations have significant and negative impacts on innovation as predicted by Hypothesis 3a and Hypothesis 3b. Finally, I find empirical evidence that power significantly moderates the relationship between relevant experience and innovation, confirming Hypothesis 4.

5.3 Post-hoc Analyses

To further understand the moderating effect of CEO power and the dynamic impact of the CEO experience on innovation, I plot the marginal effect of CEO's experience scope in relevant fields in scenarios where CEO is neither a founder nor the chairman of board (power = 0, the least powerful), a founder or the chairman (power = 1, more powerful), or a founder and a chairman (power = 2, the most powerful). The moderating effect graph is presented as Figure 1.

Insert Figure 1 about here

In Figure 1, we can see that power moderates the relationship between CEO's experience scope in relevant fields and innovation differently depending on whether experience scope exceeds the threshold of two. When CEO's relevant experience covers no more than two fields, the slope between the marginal effect on patent output and experience is downward for all types of CEOs, but the steepest decline is observed for the least powerful CEOs and the trend is relatively flat for the most powerful CEOs. When CEO has relevant experience in more than two such fields, the

marginal effects become non-negative in the scenario of founder-chairman CEO first, and later when the CEO is least powerful. The widening gap between the marginal effects in different scenarios also suggests that the part of the upward slope is steepest for the most powerful CEOs and least steep for the least powerful CEOs. Comparing with the least powerful and most powerful counterparts, the marginal effect of relevant experience for the more powerful CEOs is always situated somewhere in-between, which is consistent with the prediction of the moderating effects. Additionally, statistics on the marginal effects show that contingent upon the power of CEO, the marginal effect of experience on patent count in three relevant fields ranges from -1.5 to 1.5. It is further estimated that CEO's extensive experience in more than three relevant fields would help the firm to yield additional 5 to 23 patents.

Table 4 presents four robustness tests on alternative specifications on the dependent variable, estimation model and relationships. First, I use the patent count in the next two years instead of one year as the alternative specification for the dependent variable in Model 1. Results suggest that CEO tenure and experience have a lasting effect on innovative performance, and all the main findings still hold in the longer window time. Second, to check the robustness of the results against different model specification, I run the regression with fixed-effects Poisson model and used robust standard errors to correct for the bias caused by the overdispersion of the variance. Fixed-effects Poisson model provides additional insight into the results because it can rule out the incidental parameters problem (Allison & Waterman, 2002). The results are consistent with the main analyses. Third, I test the alternative linear assumption on the relationship between CEO tenure and innovation in Model 3 by removing the squared term of CEO tenure. While all the other independent variables still remain consistent and significant, the original term for CEO tenure becomes highly insignificant, suggesting that such assumption does not work. Similarly, I also drop the squared term for relevant field experience in Model 4 to test the linear assumption on relevant field experience and innovation. The field experience variables, along with the moderator all drop to insignificance. Taken together, our results are robust to the longer time window and the alternative estimation model. The alternative linear assumptions on CEO tenure and relevant field experience do not receive empirical evidence.

Insert Table 4 about here

To further validate our experience measures, Table 5 provides the results of three supplemental analyses on the decomposed experience variables and two falsification tests. First, I replace the measure of relevant field experience by the seven dummies for the relevant fields in Model 1. It is found that the dummies for academic and entrepreneurship background are negative and significant. The variables for experience scope in other fields and organizations become insignificant. I then disaggregate the scope measures for other fields and organizations as the five corresponding field and organization dummies in Model 2. The relevant field experience scope variables are robust to the specification. Marginal statistical significance is detected for the finance dummy and the other NPO dummy, both of which demonstrate negative effects. Last, I decompose all the measures and entered all the dummies in Model 3 to fully examine the potential effects of individual dummies. All the dummies are insignificant, and several coefficients have reversed signs. I rule out the possibility of inflated standard errors caused by multicollinearity by calculating the VIF for the model and the dummies. The VIF for the dummies ranges from 1.16 to 4.34, and the mean of the VIF for all dummies is 2.05. The value of VIF for the full model is 5.11. None of these indicators show any sign of severe multicollinearity. Taken together, none of the individual dummies demonstrates stable and significant statistical effect on the dependent variable, it is the joint force of various field and organization experiences, rather than the experience in a specific field that matters to CEO's capability to lead the firm to innovate.

Insert Table 5 about here

The falsification analysis in Table 5 has two parts, a placebo test reported in Model 4 and a test of the alternative measure of experience scope based on all fields reported in Model 5. In order to justify that the dichotomy of relevant fields and other fields is not arbitrary and that the statistical results are not driven by methodological artificiality, I perform a placebo test in Model 4 by replacing the independent variables with two fictitious experience scope variables while keeping the rest of the model in the exact same form (Nanda & Sørensen, 2010). Instead of the meaningful categorization of the ten fields based on relevancy to innovation, I randomly assign the ten field dummies into two groups, with Group I standing for fictitious relevant

fields and Group II standing for fictitious other fields[5]. Group I includes venture capital, finance, business development, operations, law, R&D and consulting, and Group II includes entrepreneurship, academic and marketing. *Random Group I* is the sum of the dummies in Group I, and *Random Group II* aggregates the dummies in Group II. Additionally, *Random Group Experience* functions as the fictitious control for selection of whether CEO's field experience falls in certain random group. Results of Model 4 suggest that fictitious experience scope measures based on random assignment do not have sufficient statistical power in predicting performance like their actual counterpart.

Finally, I drop the categories and aggregated all field experience into a single experience scope variable, *All Fields*, to test whether all experiences matter to innovation in the same way. Model 5 in Table 5 reports the results of the test, indicating the non-significance of the aggregated measure. Additional test of the linear assumption on the aggregated experience scope also produces insignificant results. Therefore, I posit that experiences in different fields fall in different categories depending on its relevance to innovation, and it is confounding to examine all experiences without necessary differentiation. Furthermore, to rule out the possibility that the effect is driven by some specific combinations of experience instead of the general scope, I count the number of combinations of the relevant field experience for CEOs in the sample. It turns out that there are 12 actual combinations for 2 fields, 17 for 3 fields, and 9 for more than 3 fields. Hence, it is unlikely that the results are driven by certain particular experience patterns.

[5] The random assignment starts with sorting the dummies alphabetically. Then a random number between 0 and 1 is assigned to each of the dummies following the order. If the random number falls below 0.30, I assigned the dummy to Group II, otherwise the dummy goes to Group I. The assignment process terminates when the slots in one of the group are all filled. Group I has seven slots resembling relevant fields, and Group II has three.

CHAPTER 6 DISCUSSIONS

In this final chapter of the paper, I will discuss important implications from the findings, limitations and future directions of the study. Then I will summarize the key contributions of the study to research and practice. Finally, I will wrap up the paper with a brief conclusion of the study.

6.1 Implications from the Findings

Several implications can be drawn from the main findings. First, different types of experience may be interrelated and function in a collective way. As we find that it is the portfolios of experience, rather than single types of experience that matter to organizational outcome. Second, experience falls into distinct bundles that have differentiating effects on innovation. Some experience can be premiums, while other experiences are liabilities to firm innovation. Third, relevant experience is not always good, as limited relevant experience leads to misinterpretation with overconfidence and failure in coordination. Successful innovative efforts require the not only the creation, but also the assessment and integration of the R&D outcomes. Overall, CEO's individual experience only functions as the micro-foundation of firm's innovative capability when it is both relevant and broad.

Alternative explanations may suggest that R&D executives assume more direct responsibility for innovation than CEO and thus matter more to innovation. The inclusion of R&D executives in TMT brings attention (Cho & Hambrick, 2006; Tushman et al., 2011), knowledge (Hambrick & Cannella, 2004) and legitimacy (Higgins & Gulati, 2006) to R&D and innovation. Nevertheless, the weak empirical findings on the positive link between R&D personnel in TMT and innovative performance suggest that R&D heads may be more subject to the control of CEO in the organizational hierarchy and their role in innovation might not be as salient as expected.

Another implication from the findings stems from the endogeneity issues. Regression results demonstrate that the majority of hypothesized effects are significant even after endogeneity is accounted for. Moreover, the correction terms do not reach conventional significance level, indicating that the selection issue might not be too

severe. To understand why endogeneity does not overturn the key findings, I will review the two main alternative arguments grounded in endogeneity, which are 1) CEOs with certain prior experience are appointed by the firm to solve specific problems; and 2) CEOs with certain experience have superior capability to select firms with high potential for innovation. Reasonable as these arguments sound, they both bear very strong assumptions about the effective matching process of the human capital market for executives in this industry, namely 1) Firms that wish to hire CEOs with certain experience *can actually* get their ideal candidates; and 2) capable CEOs who successfully identify the high-potential firm *can* join the firm at their will. As the descriptive statistics have demonstrated earlier, the market for highly skilled executives in biotech industry is not a big one. Not many people are qualified and available to lead high-tech firms to succeed in this competitive industry. Even if we assume that the supply of executives for biotech firms is abundant, whether the demand side of the market is strong enough to allow CEO candidates to "select" which company to go is questionable. Therefore, empirically endogeneity might not be a severe issue in this case, and theoretically the imperfection of the matching mechanism of the market for executives may partially offset the bias caused by non-random selection.

6.2 Limitations and Future Directions

The study has several limitations that can be addressed by future studies on the similar track. First, this is a single-industry study that only examines a very specific form of innovation, the patented technological innovations. Although the paper makes an effort to offer a general view of executive experience in hope that it is applicable to other industries, it is also expected that different industrial contexts would produce very different profiles for the ideal executive. Future studies analyzing managers' experience in small firms, in non high-tech industry, and in emerging economies would be valuable. Moreover, innovation comes in a wide array of forms other than patents, although patenting as a form of technological innovation is a critical aspect of innovation performance in this context. Therefore, it is important to acknowledge that although some types of CEO experience appear to be a liability for technological innovation here, they may be valuable assets for innovations in other realms. Even in the realm of patenting analysis, I only measure the quantity but not the quality of the patents, which invites the question for future scholars to explore

whether CEOs will have influence on the quality of innovation. It also remains largely unknown how the same types of executive experience would matter to other dimensions of the firm performance, such as social responsibility performance. Future research addressing these puzzles can provide extra value to the literature as well.

Third, due to the constraint of data, I cannot provide a more detailed examination of the mechanisms of how executive experience drives innovation. But some empirical results may still point to the potential solutions to the black-box problem, which is a common criticism of TMT research (Hambrick, 2007). In Table 3, we can observe that the variable for financial slack becomes marginally significant after TMT-level variables are introduced (Model1 to Model 2), and variables for financial slack and technological diversity of the patent stock lose significance after CEO-level variables are entered. These changes suggest a possible mediating process that invites future research: the effect of technological and financial resources available to R&D might be mediated by the configuration of TMT and CEO, suggesting that it is how the TMT and CEO allocate the current financial slack and leverage the technology portfolio that makes a difference to future innovative outcome. Future work that can unveil the quality of the experience, the sequence of the experience and the interaction of the experience between different individuals will also significantly advance our understanding of the experience effects.

6.3 Contributions to Research and Practice

Notwithstanding, this study makes several key contributions to the experience study in TMT, entrepreneurship and organizational learning. First, this study contributes to the upper echelons research by showing that how the combination of diverse field experience of the chief executive may lay the micro-foundation of the innovative capability of the firm while acknowledging that certain other experience may also constrain executives' capability to innovate. Second, this study also extends the prior experience research in entrepreneurships by demonstrating that experience may not always pay in performance and that the possession of information elsewhere can lead to the overlook and suppression of opportunity discovery in the focal area. Third, this study also enrich the learning literature by proposing that myopia, superstitions and hubris in learning create significant initial hurdles for individual's experience spanning that might enhance outcome on the organization level. Fourth, by analyzing

ten fields and two organizational types on the CEO level, incorporating important TMT-level and firm-level attributes and accounting for multiple sources of endogeneity, I provide a most comprehensive empirical analysis on CEO functional experience and innovation.

With cautions on the limitation of the research, several practical implications can be drawn from the study. First, for firms in search of ideal executives, it appears that executive turnover at a certain pace is good and that generalists are preferred over specialists for the CEO position. Second, for firms which have versatile CEOs in office, it might be advisable that the CEO have more say and credit in making innovation strategies so as to leverage his or her rich experience. Third, for educators in the executive development programs, while this study reiterates the well-known importance of exposure to diverse functional areas, it also suggests that executives should be reminded the limitation of their own experience even when it is highly relevant. The message that needs to be conveyed is that what they know and what they see may not be the full picture even if they believe so.

6.4 Conclusion

Integrating perspectives and findings from research in upper echelons, entrepreneurship and organizational learning, I provide a comprehensive view of how chief executive's experience may affect the organization's innovative performance. The value of CEO experience for innovation is found to be contingent upon relevancy and power, and only the rich combination of relevant experience delivers the value. Moreover, results suggest that CEOs face initial hurdles when leveraging their relevant experience to achieve superior innovative outcomes for the firm.

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APPENDIX

Table 1. Distribution of CEO Experiences[1]

Variables	Observations	Proportion
Gender		
Male	216	96.00%
Female	8	3.56%
Education Experience		
MBA	77	34.22%
PhD	81	36.00%
Experience in Relevant Fields		
Academic	53	23.56%
Business Development	74	32.89%
Entrepreneurship	73	32.44%
Law	14	6.22%
Operations	86	38.22%
Research & Development	82	32.44%
Venture Capital	19	8.44%
Experiences in One Field	80	35.56%
Experiences in Two Fields	79	35.11%
Experiences in Three Fields	36	16.00%
Experiences in More than Three Fields	13	5.78%
Experience in Other Fields		
Finance	64	28.44%
Marketing	64	28.44%
Consulting	41	18.22%
Experience in Other Types of Organizations		
Government	16	7.11%
Other NPOs	37	16.44%

[1] n = 225

Table 2. Descriptive Statistics and Correlation Matrix[1] [2]

Variable	Mean	Std. Dev.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Firm-level:																		
1. Patent	0.84	3.42	1															
2. R&D	22.36	97.71	0.01	1														
3. Sale	63.09	197.34	0.13*	-0.07*	1													
4. Slack	-0.08	7.94	0.02	-0.54*	0.02	1												
5. Age	7.88	3.56	-0.28*	-0.03	0.05	-0.06*	1											
6. Technological Diversity	0.12	0.27	0.43*	-0.01	0.17*	0.03	-0.32*	1										
TMT-level:																		
7. Size	3.28	1.29	-0.11*	0.03	3E-3	-2E-3	0.21*	-0.14*	1									
8. Age	49.90	5.91	-0.11*	0.01	0.08*	-0.08*	0.45*	-0.20*	0.13*	1								
9. Founders	0.72	0.80	0.05	-0.01	-0.11*	-0.01	0.02	0.05	0.33*	0.01	1							
10. R&D Personnel	0.36	0.61	0.06*	0.03	-0.06*	-0.07*	-0.02	0.04	0.37*	-2E-3	0.37*	1						
CEO-level:																		
11. Gender	0.05	0.30	-0.02	0.12*	0.08*	-0.17*	-1E3	0.04	5E-3	-0.05	0.07*	-0.07*	1					
12. MBA	0.36	0.48	0.01	-0.07	-0.03	0.03	0.05	-0.02	0.11*	0.02	-0.02	0.03	0.10*	1				
13. Tenure	4.57	3.05	-0.17*	-0.08*	0.10*	0.04	0.53*	-0.15*	0.10*	0.33*	0.15*	-0.02	0.06*	-0.03	1			
14. Relevant Fields	1.76	0.99	0.06	0.10*	-0.02	-0.07*	-0.08*	0.05	0.10*	0.07*	0.04	0.06*	0.12*	-0.13*	0.07*	1		
15. Other Fields	0.69	0.73	-0.04	2E-3	-0.11*	-0.05	0.05	-0.04	0.01	-0.06*	-0.05	0.07*	-0.08*	0.26*	-0.11*	-0.14*	1	
16. Other Organizations	0.17	0.38	0.02	0.13*	0.16*	-0.10*	-0.03	0.01	0.03	0.08*	-0.08*	-0.09*	0.25*	-0.11*	-0.09*	0.14*	-0.13*	1
17. Power	0.67	0.71	0.01	0.04	-0.05	-0.01	-0.09*	0.10*	-0.16*	-0.11*	0.35*	0.02	0.11*	-0.16*	0.19*	-0.04	-0.14*	-0.06*

[1] n = 730
[2] * p<0.05

Table 3. Fixed-effects Negative Binomial Regressions on Patent Count[1 2]

	Model 1 Firm-level		Model 2 TMT-level		Model 3 CEO-level		Model 4 Moderator		Model 5 Lagged DV	
Firm-level:										
R&D	2E-3*	(6E-4)	2E-3*	(8E-4)	2E-3*	(7E-4)	2E-3*	(7E-4)	2E-3*	(7E-4)
Sale	2E-3	(2E-3)	1E-3	(1E-3)	0.01†	(0.01)	0.01†	(0.01)	0.01†	(0.01)
Slack	0.72**	(0.28)	0.52†	(0.30)	0.18	(0.32)	0.19	(0.32)	0.20	(0.32)
Age	-0.43***	(0.04)	-0.56***	(0.07)	-0.87***	(0.26)	-0.62*	(0.28)	-0.63*	(0.28)
Tech. Diversity	1.58***	(0.26)	0.97**	(0.30)	0.10	(0.33)	0.07	(0.34)	0.07	(0.34)
TMT-level:										
Size			-0.29	(0.24)	-0.88	(0.75)	-0.44	(0.88)	-0.57	(1.00)
Age			-0.05*	(0.03)	0.19	(0.14)	0.21	(0.16)	0.20	(0.16)
Founders			-0.21	(0.28)	0.26	(0.45)	0.21	(0.46)	0.22	(0.46)
R&D Personnel			0.34	(0.22)	0.41†	(0.21)	0.37†	(0.21)	0.36†	(0.21)
CEO-level:										
Gender					3.72	(2.80)	3.96	(3.32)	3.87	(3.22)
MBA					-0.93	(1.10)	-1.84	(1.58)	-1.79	(1.51)
Tenure					1.60***	(0.27)	1.46***	(0.27)	1.42***	(0.31)
Tenure Squared					-0.20***	(0.03)	-0.20***	(0.03)	-0.20***	(0.04)
Relevant Fields					-6.55**	(2.09)	-9.45**	(3.09)	-9.32**	(3.04)
Relevant Fields Squared					1.68**	(0.56)	2.42**	(0.80)	2.40**	(0.78)
Other Fields					-3.03*	(1.34)	-3.59*	(1.52)	-3.65*	(1.53)
Other Organizations					-2.02*	(0.97)	-2.92**	(1.12)	-2.98**	(1.14)
Relevant Fields × Power							0.52*	(0.25)	0.51*	(0.25)
Correction for Selection:										
TMT R&D Personnel			1.51	(1.36)	4.29	(4.39)	1.86	(5.12)	2.55	(5.73)
CEO Field Experience					-6.70	(5.38)	-6.33	(5.90)	-6.31	(5.92)
CEO Org. Experience					-13.49†	(7.49)	-15.02†	(9.05)	-14.74†	(8.83)
Past Performance									3E-3	(0.01)
Constant	0.77*	(0.33)	7.31*	(2.94)	-16.74	(16.00)	-21.35	(19.75)	-19.55	(20.30)
Observations	484		422		388		388		388	
Log-likelihood	-323.71		-239.76		-191.34		-188.58		-188.55	
Chi-squared	252.83		231.05		170.26		178.80		179.77	
p-value	0.00		0.00		0.00		0.00		0.00	

[1] Standard errors in parentheses

[2] † p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Table 4. Robustness Tests on Alternative Specifications[1 2 3]

	Model 1 2-Year DV		Model 2 QML Poisson		Model 3 Tenure-Linear		Model 4 Fields-Linear	
Firm-level:								
R&D	2E-4	(5E-4)	2E-3***	(5E-5)	2E-3*	(9E-4)	2E-3*	(8E-4)
Sale	-4E-4	(9E-3)	-0.01	(0.02)	0.01†	(3E-3)	0.01*	(3E-3)
Slack	0.18	(0.22)	0.35	(0.24)	0.61†	(0.35)	0.43	(0.36)
Age	-0.84***	(0.25)	-5.30***	(0.51)	-0.75***	(0.23)	-0.84***	(0.24)
Tech. Diversity	0.18	(0.26)	0.15	(0.46)	0.86**	(0.33)	0.86**	(0.33)
TMT-level:								
Size	-0.36	(0.66)	-0.32	(1.42)	-1.40*	(0.68)	-1.60*	(0.73)
Age	-0.16	(0.21)	-0.26	(0.61)	0.08	(0.08)	0.08	(0.07)
Founders	0.39	(0.39)	-0.59	(0.54)	-0.49	(0.33)	-0.44	(0.32)
R&D Personnel	0.36*	(0.17)	0.17	(0.26)	0.25	(0.24)	0.15	(0.25)
CEO-level:								
Gender	#		74.87***	(17.85)	1.52	(1.61)	2.53†	(1.46)
MBA	-0.88	(1.23)	1.53	(14.40)	-0.74	(0.79)	-0.67	(0.77)
Tenure	1.18***	(0.24)	5.94***	(0.46)	-0.03	(0.14)	0.02	(0.14)
Tenure Squared	-0.17***	(0.03)	-0.19***	(0.04)				
Relevant Fields	-10.46***	(2.95)	-86.12***	(12.20)	-4.28*	(1.90)	-0.21	(0.35)
Relevant Fields Squared	2.64***	(0.78)	16.21***	(3.70)	1.18*	(0.52)		
Other Fields	-3.81**	(1.31)	-43.25***	(4.60)	-2.45*	(1.05)	-1.52	(0.95)
Other Organizations	-2.73**	(0.88)	-37.69***	(2.28)	-3.04**	(0.96)	-2.40**	(0.84)
Relevant Fields × Power	0.59**	(0.22)	5.76***	(0.63)	0.41*	(0.20)	0.16	(0.16)
Correction for Selection:								
TMT R&D Personnel	1.38	(3.77)	1.42	(7.90)	7.98*	(3.93)	9.37*	(4.23)
CEO Field Experience	1.14	(2.94)	-3.59	(3.51)	-2.54	(4.44)	-3.40	(4.53)
CEO Org. Experience	6.09	(12.98)	15.26	(36.41)	-6.04	(4.17)	-6.49†	(3.32)
Constant	36.23	(32.23)			7.59	(11.08)	5.36	(10.30)
Observations	330		388		388		388	
Log-likelihood	-203.13		-205.21		-212.64		-215.00	
Chi-squared	331.82		4933.07		229.90		212.76	
p-value	0.00		0.00		0.00		0.00	

[1] Standard errors in parentheses

[2] † p<0.10, * p<0.05, ** p<0.01, *** p<0.001

[3] # omitted for collinearity

Table 5. Supplemental Analyses on Decomposed CEO Experience Variables[1 2]

	Model 1 Relevant Fields		Model 2 Others		Model 3 All Experiences		Model 4 Placebo Test		Model 5 All Fields	
Firm-level:										
R&D	2E-3 *	(7E-4)	2E-3*	(7E-4)	2E-3 *	(7E-4)	2E-3*	(7E-4)	2E-3*	(7E-4)
Sale	0.02*	(0.01)	0.01†	(0.01)	0.02*	(0.01)	0.01***	(3E-3)	0.01*	(3E-3)
Slack	0.36	(0.31)	0.18	(0.32)	0.38	(0.32)	0.33	(0.28)	0.29	(0.31)
Age	-0.89*	(0.37)	-0.87**	(0.27)	-1.03†	(0.60)	-0.88***	(0.20)	-0.94***	(0.22)
Tech. Diversity	-0.04	(0.33)	0.09	(0.33)	-0.06	(0.35)	0.16	(0.33)	0.12	(0.33)
TMT-level:										
Size	0.46*	(0.23)	0.27	(0.19)	0.41†	(0.24)	0.49	(0.42)	0.12	(0.09)
Age	0.97	(1.09)	-0.75	(0.78)	0.79	(1.19)	0.13	(0.08)	-0.78*	(0.39)
Founders	0.04	(0.49)	0.18	(0.50)	0.06	(0.53)	-0.84	(0.72)	0.12	(0.47)
R&D Personnel	0.27	(0.22)	0.43†	(0.22)	0.29	(0.27)	0.34	(0.22)	0.40†	(0.22)
CEO-level:										
Gender	19.69**	(6.91)	5.34	(4.08)	14.13*	(6.96)	4.71	(2.01)	3.87†	(2.02)
MBA	-8.83**	(3.12)	-1.72	(1.89)	-6.09	(4.14)	-1.64	(1.05)	-2.00†	(1.14)
Tenure	2.01***	(0.36)	1.63***	(0.27)	2.12***	(0.61)	1.50***	(0.25)	1.50***	(0.27)
Tenure Squared	-0.20***	(0.03)	-0.20***	(0.03)	-0.20***	(0.03)	-0.20***	(0.03)	-0.19***	(0.03)
Relevant Fields			-7.33**	(2.52)						
Relevant Fields Squared			1.92**	(0.69)						
Venture Capital	-8.38	(461.29)			0.70	(2438.37)				
Business Development	-3.84	(3.29)			-4.53	(2.97)				
Academic	-0.63	(2.20)			-2.13	(5.84)				
R&D	-2.26*	(1.09)			-2.70	(1.88)				
Operations	-0.02	(3.02)			-0.23	(2.18)				
Law	-9.97	(7.59)			0.57	(7.71)				
Entrepreneurship	-7.09*	(2.89)			-9.71	(8.45)				
Other Fields	0.51	(2.94)								
Finance			-4.22†	(2.24)	5.47	(5.41)				
Marketing			-2.97	(2.08)	0.46	(3.91)				
Consulting			-2.23	(2.94)	-5.39	(5.49)				
Other Organizations	-4.06	(2.63)					-1.89†	(1.01)	-1.79*	(0.85)
Government			-2.03	(2.88)	-8.85	(5.85)				
Other NPOs			-1.87†	(1.03)	-3.86	(3.85)				
Random Group I							-3.90	(2.76)		
Random Group I Squared							0.83	(0.68)		
Random Group II							-1.01	(1.00)		
All Fields									-1.87	(1.55)
All Fields Squared									0.21	(0.26)
Correction for Selection:										
TMT R&D Personnel	-5.85	(6.19)	3.53	(4.55)	-4.84	(6.69)	2.39	(2.36)	3.72†	(2.26)
CEO Field Experience	-5.69	(5.86)	-6.21	(5.96)	-6.30	(7.16)				
CEO Org. Experience	-30.88*	(13.30)	-18.55	(11.53)	-27.54†	(14.10)	-8.39†	(4.51)	-8.84†	(4.76)
Random Group Experience							-18.96	(11.93)		
Constant	-71.55*	(27.81)	-27.89	(25.22)	-64.37*	(29.80)	-9.26	(10.35)	-5.27	(11.53)

Observations	388	388	388	388	388
Log-likelihood	-187.18	-191.02	-186.54	-194.49	-195.91
Chi-squared	189.97	173.23	186.25	174. 96	159.21
p-value	0.00	0.00	0.00	0.00	0.00

[1] Standard errors in parentheses
[2] † p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Figure 1 Moderating Effects of CEO Power on Relevant Field Experience