Innovative CEO-Directors

Ning Gao Ian Garrett Yan Xu *†

December, 2017

Abstract

The leadership to cultivate and promote technological innovation is one of the most important aspects of a CEO's human capital. We investigate how this leadership affects a CEO's attractiveness on the outside directorship market. We find a robust positive relation between innovation performance of a CEO's own firm and the number of outside directorships held by this CEO, which is primarily determined by appointing firms that are also innovative. We also find that the presence of innovative CEO-directors on a firm's board significantly improves its innovation and operating performance in post-appointment years. Our results demonstrate that a CEO's leadership in cultivating and promoting innovation is highly valued in the market for outside directorship. These results also suggest that innovative CEO-directors constitute an important mechanism to propagate knowledge on innovation across firms.

JEL Classification: G30, E20, J40

Keywords: Innovation, CEO, outside directorships, leadership, knowledge transfer

*Accounting and Finance Group, Alliance Manchester Business School, The University of Manchester, Booth Street West, M15 6PB, United Kingdom.

†E-mail address: ning.gao@manchester.ac.uk (Ning Gao), ian.garrett@manchester.ac.uk (Ian Garrett), yan.xu@manchester.ac.uk (Yan Xu).

1 Introduction

The leadership to cultivate and promote technological innovation is one of the most important aspects of a Chief Executive Officer's (CEO) human capital. This type of leadership is scarce because it builds on a CEO's acumen in a firm's external environment (e.g., customer demands, industry dynamics and legal context) as well as her in-depth understanding of her own corporation (e.g., human and capital resources, corporate culture and corporate procedures). In today's fast moving economy, firms need innovations to thrive. Innovativeness, therefore, is more important for firms' success than ever before. Although the provision of innovation leadership is vested with the incumbent managers, the scarcity and complexity of innovation leadership and the limitation on incumbent managers' resources and expertise often require them to seek external advice. By appointing the CEO of an innovative firm onto its board, a firm can benefit from this CEO's expertise and experience. Recent studies underscore the value of a CEO's human capital on a firm's innovation activities and show that the CEO's observable human capital (such as their personal networks and general managerial skills gained over their education and work experience) and unobservable ability (measured by manager fixed effects) impact the variation in a firm's innovation performance (Chemmanur et al. 2014, Cho et al. 2016, Custódio et al. 2017, Faleye et al. 2014). In this paper, we ask whether a CEO's proven ability to cultivate and promote innovation in her own firm is recognized by the labour market for outside directors and how the appointing firms benefit from the appointment of an innovative CEO-director. Where needed, we also call a CEO's own firm the "sender" firm to distinguish it from the other company that appoint this CEO as an outside director.

CEOs from other firms are the most desired candidates for a company's outside directors.[1] With their power of dispensing resources as well as knowledge and experience of making decisions in complex organizations, CEO-directors are able to counsel incumbent managers in a way that other outside directors are not able to (Fahlenbrach

[1]See Young (1990) and more recent survey in Spencer Stuart Board Index (2003)

et al. 2010). Fama and Jensen (1983) suggests that the external labour market recognizes CEOs' human capital primarily by their performance as decision managers in their own firms. Related research also provides empirical evidence to support this view. These studies mainly focus on the past operating performance of a CEO's own company. Ferris et al. (2003) show that past firm performance has a positive effect on the number of directorships held by a CEO. Fich (2005) finds that CEOs of firms with better operating performance are more likely to be appointed as outside directors. Brickley et al. (1999) observe that the number of directorships held by retired CEOs is positively related to the firm performance prior to their retirement. Similarly, if the market for outside directors is efficient, a CEO's success in cultivating innovation in her own firm should have similar certification effect, which in turn results in more outside directorships held by this CEO. By appointing innovative CEO-directors, a firm can benefit from enhancing the effectiveness of board monitoring and advising. Meanwhile, since the number of innovative CEOs is limited, if a firm can successfully appoint an innovative CEO-director, it will reveal a strong signal of the firm's quality to the market. We expect these effects to be especially strong for innovative appointing firms because these firms' demand for innovation leadership is better met by the supply of CEOs from innovative firms.

To test this hypothesis, we follow the recent literature on innovation (e.g., Aghion et al. (2013), Hall et al. (2005), Hirshleifer et al. (2013), Kogan et al. (2017)) to use patenting activities to measure firm innovativeness. To measure a CEO's popularity on the external director market, we use the actual number of a CEO's outside directorship as well as the number of outside directorships weighted by the appointing firm's innovativeness. Our empirical analysis relies on a dataset containing non-financial and non-utility firms in the S&P 1500 index spanning the period from 2000 to 2008. We find a strong positive relation between firm innovativeness and a CEO's attractiveness on the labour market for outside directors. The CEOs of firms with better innovation outcomes (measured by patent counts and citation counts) are more likely to serve as outside directors on other firms' board, and they also hold more outside directorships than CEOs of less innovative firms do. This finding is robust to using different measures of innovativeness. Firm random effect weakens but does not eliminate this positive effect, which suggests both firm and individual attributes contribute to an innovative CEO's attractiveness on the labour market for outside directors. Furthermore, consistent with the view that innovative CEO-directors are especially valuable for innovative firms, we find that the effect of firm innovativeness on the number of outside directorships is primarily driven by director appointment made by innovative firms.

Endogeneity occurs when there are omitted variables or unobservables that affect firm innovativeness as well as CEO outside directorships. To address this issue, we estimate two-stage least square (2SLS) regressions, in which we employ local gambling preference (a county's Catholics-to-Protestants ratio) and urban industrial diversity (one minus the Herfindahl index of local employment across two-digit industries in the county where the firm is headquartered) as instrumental variables. These two instruments are economically and empirically relevant to firm innovativeness and are less likely to have a direct effect on CEO outside directorships. Local gambling preference has been examined as an important aspect of corporate culture that can significantly influences a company's innovation strategy. Chen et al. (2014) demonstrate that firms located in gambling-prone counties tend to undertake more radical innovation strategies and in turn experience greater innovation performance. The prior literature also argues that most innovations are invented and spread in cities, particularly ones with more diversified industrial base. The industrial diversification in urban areas facilitates knowledge transfer across industries by reducing the searching costs, providing cross-industry inspirations and expertise, as well as provisions of alternative components on their new products (see Glaeser et al. (1992) and Duranton and Puga (2001)). Our first stage regressions confirm that the instruments are significantly associated with firm innovativeness measures. More importantly, after controlling for potential endogeneity, the positive effect of firm innovativeness on CEO outside directorships persists. Our results are also robust to several other robustness checks, such as addressing reverse causality, removing self-citations, and further controlling for CEO overconfidence and ownership.

To establish the relevance of appointing an innovative CEO-director, we proceed to examine how such appointment impacts the appointing firms innovation and operating performance. Recent works on boards of directors have emphasized that outside directors' advisory role, which built on their expertise (for example, experience in related industries, political influence, and financial expertise), significantly impacts firm value and performance (Adams and Ferreira 2007, Dass et al. 2014, Güner et al. 2008, Masulis et al. 2012, Meyerinck et al. 2015, Wang et al. 2015). With the expertise and knowledge of leading a firm's innovation, innovative CEO-directors enhance the appointing firms innovation performance by counselling incumbent managers on their innovative strategy. Further, if innovation successfully translates into productivity, one should also observe improved operating performance. Furthermore, recent literature underscores that friendly and tolerant boards have an impact on motivating innovation (Manso 2011, Kang et al. 2014). Innovative CEO-directors can better understand the risk and difficulty of undertaking innovative projects and are more tolerant of failure of innovation activities. According to Adams and Ferreira (2007), such tolerance and understanding could lead to better information transfer between managers and directors and result in better monitoring and advising. To evaluate how appointing an innovative CEO-director impacts firm's innovation performance, we adopt a difference-in-difference approach to address potential concerns due to firms' endogenous choice of outside directors. Empirically, we require our sample firm to have at least one patent before appointing an innovative CEO. In this way, we exclude firms whose productive function doesn't use innovation as input. Within this sample, we define the treatment sample as those appointing a CEO from an innovative (i.e. with at least one patent outcome during sample period) firm and the control sample as those appointing a CEO from a non-innovative (i.e. with zero patent outcome during sample period) firm. Consistent with our expectation, we find that firms with innovative CEO-directors outperform control firms in terms of innovation output in the three post-appointment years, and this outperformance is more pronounced when the CEO-director's own firm is more innovative (i.e., with more patent outcome), the technological proximity between the appointing and the sender firm (Jaffe 1986) is higher, and the appointing firm invests more on R&D. In addition, we find that firms appointing innovative CEO-directors have better operating performance in the post-appointment years, suggesting enhanced innovation capacity translate into productivity.

Our paper contributes to the literature in three ways. First, we add to the literature on CEO-directors (e.g., Beavers and Mobbs (2015), Fahlenbrach et al. (2010), Fich (2005), Perry and Peyer (2005)). The prior literature demonstrates that a CEO's likelihood of taking outside directorship is affected by both the demand side factors (e.g., complexity of the appointing firm (Booth and Deli 1996), certification of firm quality (Fama and Jensen 1983) and the number of local firms (Knyazeva et al. 2013)) and the supply side factors (e.g., career concern (Aghion et al. 2013, Holmström 1999), building bonding relationship with other firms (Booth and Deli 1996) and information transfer across firms (Dass et al. 2014)). To the best of our knowledge, our paper is the first to analyze how a CEO's leadership of promoting innovation affects his availability and popularity on the market for outside directors.

Second, our paper suggests that appointing CEO-directors is a possible channel of knowledge transfer across firms. In particular, through appointing CEOs of innovative firms onto the board, a firm can fill the knowledge gap between different technology fields and identify new industry and technology trends, which in turn improves the firm's innovation output. Moreover, our findings further confirm the important role of managerial quality in promoting technological innovation (Chemmanur et al. 2014, Cho et al. 2016, Custódio et al. 2017).

Third, we contribute to the growing literature on the advisory role of corporate board (Adams et al. 2010). Recent studies postulate that directors with particular expertise, such as experience in related industries and financial expertise, are especially valuable for the firm (Dass et al. 2014, Güner et al. 2008, Masulis et al. 2012, Meyerinck et al. 2015). We extend this literature by showing that the leadership of cultivating and promoting technological innovation is a valuable trait sought after in the market for outside directors. Related, our finding provides practical guidance for firms who seek advice from outside directors. This enhances the practicability of our finding.

The rest of the paper continues as follows. Section 2 reviews the related literature and develops our main hypotheses. Section 3 describes the data and variable construction. Section 4 examines the relation between firm innovativeness and the number of outside directorships held by CEOs. Section 5 investigates the impact of innovative CEO-Directors on the appointing firms. Section 6 concludes.

2 Literature Review and Development of Hypotheses

2.1 Demand for innovative CEO-directors

Innovation is a driving factor in today's fast moving economy, but identifying future technology and industry trends is challenging and risky, it requires managers to deeply understand the firm's internal operation and also external environment the firm faces. However, managers' knowledge and experience are limited, a rational CEO with the objective to maximize shareholder value should seek external advice from perceived experts to make more effective strategic decisions. With the expertise of its members, a corporate board can counsel incumbent managers and contribute their opinions to making valuable corporate strategy and operating policy.

Growing research attention is being devoted to the advisory role of corporate boards and the importance of director expertise. Coles et al. (2008) examine the impact of board structure on firm value and highlight the advisory role of the board. They find that firms with greater advisory requirements have more outside directors on their boards, which is consistent with Dalton et al. (1999), Hermalin and Weisbach (1988) demonstrating that firms choose outside directors who can bring valuable experience and expertise to counsel the incumbent management team. Faleye et al. (2013) find that advisory directors hold more advanced education degrees, entrepreneurial background, CEO-level and board-level experience than other directors. Firms with advisory directors on the board are also associated with better strategic outcomes, such as higher acquisition returns, better-quality corporate innovation and higher firm value. Dass et al. (2014) investigate the impact of directors' industry experience on firm performance. They find that firms tend to appoint outside directors from related industries when they face larger information gap or have greater market power. Furthermore, they show that appointing outside directors from related industries significantly improves firm performance and helps the firm handle industry shocks better. Given these findings, we expect that CEOs of innovative firms are best suited to serve as outside directors in other firms to fulfil their advisory needs. Since their human capital is more specialized on innovation, we predict that innovative CEO-directors are more demanded by innovative firms.

Besides the advising benefit, appointing CEOs of innovative firms as outside directors onto the board may also increase the effectiveness of board monitoring, especially in innovative firms. Jensen (1993) points out that lack of expertise to fully understand related information is one of the major problems hindering directors to effectively monitor incumbent managers. Since the information gap between managers and board is likely to be greater in innovative firms, having innovative CEO-directors can help the board better understand innovation-related information, which in turn increases the effectiveness of board monitoring. Adams and Ferreira (2007) confirm this insight and further suggest that management-friendly boards perform better on monitoring and advising incumbent managers. In order to receive valuable advice from outside directors, a CEO has to provide relevant inside information to them. However, outside directors have low tolerance for manager's poor performance (Weisbach 1988), the more information a CEO reveals to outside directors, the greater the risk to this CEO that the board will monitor him more intensively. Consequently, a CEO is more likely to share information with the board when the board is friendly or the expertise of board members is particularly valuable. In addition, Manso (2011) emphasizes that substantial tolerance for failure of innovative activities is important when a firm desires the managerial incentive scheme to motivate innovation. He suggests that the appointment of outside directors who are friendly to manager could result in better innovation outcomes. Kang et al. (2014) provide empirical evidence to support this insight and show that firms with friendly boards produce more patents and citations. In short, we predict that, unlike typical outside directors, innovative CEO-directors are more likely to understand the risk and difficulty of undertaking innovative projects and therefore have more tolerance for failure of innovation activities. This tolerance can lead to better information transfer between managers and boards and in turn result in better monitoring and advising effect.

Another possible motivation of appointing CEOs of innovative firms as outside directors is the certification benefit. Because of the limited number of talented CEOs available on the labour market for outside directors, if a firm can succeed in appointing an outside CEO on its board, it will reveal a strong certification of the firm quality to the market. This certification effect could be especially valuable for innovative firms since they face much more risk to undertake innovation projects and their value largely depends on realizing valuable future growth opportunities. The prior empirical studies have highlighted this insight. Fich (2005) finds positive stock market reactions to CEO director appointments and that CEOs of well-performing firms are more popular on the directorship market. Ferris et al. (2003) also contend that directors who serve larger and better performing firms are more likely to attract directorships. More recently, Fahlenbrach et al. (2010) further investigate director appointments use a large sample over the period from 1989 to 2002 and also find higher stock market reactions to the CEO director appointments than the appointments of another type of outside directors, but only when it is the firm's first CEO director appointment.

2.2 Supply of innovative CEO-directors

As the firm leader, a CEO's time and effort are valuable and limited. Accepting outside directorships requires CEOs to put an extra amount of effort out of their own firms, and if CEOs accept outside directorships, in order to protect their reputation, they cannot considerably shirk their responsibility on the board. Consequently, holding too many outside directorships will reduce the time a CEO committed to her own firm, a rational CEO will accept outside directorships with his own firm's permission only when the total benefit from outside directorship jobs exceeds the opportunity cost of the time devoted to this job. Motivated by this insight, we predict that CEOs are more likely to serve on boards of firms with knowledge and information that are valuable to their main employing firms. For CEOs of innovative firms, outside directorship could be especially valuable, because it provides a possible channel to establish networks and keep a close eye on the external environment such as technology trends and industry dynamics (Faleye et al. 2014), which would eventually enhance a firm's ability to against industrial shocks and realize future growth opportunity.

Cultivating and promoting innovation is challenging and contains a lot of uncertainty, it may take many years to have a patent grant and even longer to translate innovation outcome into profits. As mentioned in Aghion et al. (2013) and Holmström (1999), concerns about the failure of innovation will reduce managers' motivation to promote innovation unless the external competition is very high. Meanwhile, Fama and Jensen (1983) demonstrate that outside directorships can be an independent certification and signal of the executive's managerial ability to internal and external markets. Masulis and Mobbs (2014) conclude that enhancing reputation is one of the most important incentives for accepting outside directorship jobs. Therefore, when intense product market competition forces CEOs to innovate, in order to secure their job position, rational CEOs should accept outside directorships to reveal a strong signal of their ability. Based on this career concern theory, we predict that CEOs of innovative firms are more likely to accept outside directorships in prestigious firms with good innovation outcome so that they can have more certification gains.

To sum up, based on our supply and demand analysis of the labour market for innovative CEO-directors, we predict that CEOs of innovative firms are more likely to hold outside directorships, and the number of outside directorships held by them is positively related to the level of firm innovativeness. We also expect this effect to be more pronounced when the appointing firms are also innovative. In addition, we expect that appointing CEOs of innovative firms onto its board has a positive impact on the firm's innovation performance in the post appointment years.

3 Sample and Data

3.1 Sample construction

Our sample consists of firms in the S&P 1500 index, excluding financial firms, utilities and firms headquartered out of US.[2] We use several databases to construct our sample. The BoardEX database provides information on CEO and board characteristics. Standard and Poor's Execucomp provides CEO and board ownership data and CEO option compensation data used to construct CEO overconfidence measure. All accounting data are from Compustat, and stock return data are from CRSP. Patent data are from the dataset used in Kogan et al. (2017), which provides detailed information on more than 4 million patents grants from to 1926 to 2010. We observe that the number of patent applications that are eventually granted drops dramatically after 2008 because many patent applications filed during these years were still under review, therefore we end our sample at 2008. Our final sample includes all firms in the intersection of BoardEX, Compustat, CRSP and patent database. Firm-years with missing data on any of controls variables and dependent variables in the baseline regression are deleted. The final sample consists of 5,415 firm-year observations for 1,234 CEOs at 814 firms during the period from 2000 to 2008.

3.2 Measures of innovativeness

Following the innovation literature, we rely on patent data to measure firm innovativeness. We construct three variables to capture a firm's innovation activity.

[2]We remove firms headquartered outside of US because we control for local demand for outside directors in our analysis.

First, we use the number of patent applications (patent counts) that are eventually granted as the measure of a firm's innovation volume. However, patent counts are subject to a truncation bias. Patents are recorded in the database only if they are eventually granted. Since the average lag between patent application and patent grant is around 2 years, many patent applications filed in 2009 and 2010 could be still under review and may not appear in the database. We follow Hall et al. (2001) to exclude the last two years in the patent database to resolve this problem.

Second, to further measure the importance of a firm's innovation activity, citation-based measures are utilized. Patent citations also suffer a time truncation bias. Patents keep receiving citations for many years after they are granted, because of the finite length of the sample, patents granted in later years have less time to accumulate citations than patents granted in earlier years. We follow Hall et al. (2005) to adjust citations of each patent by multiplying the weighting index estimated by the empirical distribution of the total citations in the same technology class using untruncated data to deal with the time truncation bias. We use two citation-based measures in this paper. The first one is the citation counts, which is the total number of citations summed across all patent applications that are eventually granted during each firm-year. Because the expected citation contains information about both innovation volume and quality, we use it as a proxy of a firm's innovation power. The second measure is the number of citations per patent, which captures the average quality of patents.

Furthermore, we follow innovation literature to use the natural logarithm transform of innovativeness measures. To avoid losing firm-year observations with zero patents or zero citations, we use one plus the actual values when taking the natural logarithm.

3.3 Measure of technological proximity

Technological proximity measures the similarity of two firms' innovation activities in the technology space. Following the literature, we use the Jaffe measure (Jaffe 1986) to estimate the technological proximity between two firms. This measure characterizes a firm's innovation activities by the distribution of its patents in 426 technology classes classified by the USPTO. Then, the technological proximity between firm i and firm j is defined as the uncentered correlation between the two firms' technology activities:

$$\text{Technological Proximity}_{ij} = (T_i T_j' / (T_i T_i')^{1/2} (T_j T_j')^{1/2} \tag{1}$$

where T_i=(T_{i1}, T_{i2},..., T_{i426}) and $T_{i\tau}$ is the average share of patents of firm i in technology class τ over 30 years prior to the appointment.

3.4 Measures of outside directorships

Since the BoardEX keeps adding new firms in their database, the number of outside directorships recorded in the database may increase because more firms' board profiles have been covered in the database rather than the CEO actually accepts new directorships. To deal with this bias, we only count a CEO's outside directorships in S&P 1500 firms since the coverage of S&P 1500 firms in the BoardEX is relatively stable.

As mentioned earlier, innovative firms may have higher advisory needs for innovative CEO directors, meanwhile non-innovative firms may not have interest in innovative CEOs because their unique knowledge and experience related to innovation is less useful for these firms. To take into account the advisory needs of the appointing firm, we calculate the weighted number of outside directorships as follows:

$$\text{The weighted number of outside directorships}_t = \sum_{1}^{n} \frac{1_{it}}{\text{Ranking}_i} \tag{2}$$

where 1_{it} refers to one directorship a CEO holds in firm i at time t, Ranking_i is the decile ranking of the appointing firm's citation counts in its Fama-French 49 industry classification at the beginning year of the sample[3].

[3]The innovation ranking of each appointing firm is fixed at the beginning year of the sample to make sure the change of a CEO's weighted number of directorships will be fully owing to new appointment or quit.

3.5 Control variables

We first control for several firm characteristics that prior research suggests as factors affecting the number of outside directorships held by CEOs. Booth and Deli (1996) argue that larger firms have more external contracting relationships and thus will benefit more from building well-bonded relationships through sending their CEOs to other firms' boards. In addition, from the demand side, CEOs of large firms can bring higher certification effect to the appointing firms. As a result, CEOs from large firms should hold more outside directorships. They also find that that CEOs of firms with more growth opportunities hold fewer outside directorships because their time are more valuable. Fich (2005) presents similar empirical results to support this view. Similar to this finding, it is reasonable to expect that CEOs of firms investing more on capital expenditures and with higher sales growth are less likely to accept outside directorships. However, the value of high growth potential firms is highly relied on realising their future opportunities, this may impose more pressure on the CEO to certify their ability. Based on the career concern hypothesis, CEOs of these firms are more likely to accept external directorships as the certification of their ability. Fama and Jensen (1983) posit that individuals obtain outside directorships when the external labour market for directors recognizes their valuable decision making skills in their own firms. Therefore, CEOs of well-performing firms are more likely to be appointed as outside directors. Ferris et al. (2003) and Fich (2005) find empirical evidence to support this view. Furthermore, Fahlenbrach et al. (2010) argue that CEOs working at older and more mature firms who have delegated more of their authority to younger managers are more likely to accept outside directorships. Therefore, we control for firm size, firm age, capital expenditures, sales growth, market-to-book and return on assets. In addition, Knyazeva et al. (2013) demonstrate that the local supply of prospective directors has an important effect on a firm's director appointment process. We further include the local director pool variable to control for the local supply of directors, this variable can reflect the local competitiveness of outside directorship market and thus affect the number of directorships held by a CEO. We also control for other firm characteristics including cash, leverage, dividend and capital intensity to rule out possible effect on the number of directorships held by CEOs.

Next, we control for CEO characteristics that are shown to affect their attractiveness on the directorship market or affect their willingness to accept outside directorships. CEO age and education could proxy for CEO knowledge and experience. CEO tenure reflects the cost to the sender firm[4] of a CEO accepting outside directorships. For CEOs with longer tenure, this cost decreases because they have transfer more decision rights to younger managers or their eventual successors (Booth and Deli 1996).

Last, we also include several board characteristics in our analysis. Following Booth and Deli (1996), we control for board size, director ownership, CEO duality and number of board interlocks. Board size reflects the complexity of a firm's external contracting relationships, thus firms with larger boards will benefit more from outside directorships CEOs hold. In addition, large boards may have less intensive monitoring, thus decreasing CEOs' cost of holding outside directorships. Higher director ownership increases the board monitoring, therefore it increases CEO's cost of holding outside directorships. CEOs who are also chairmen have more control power so that they have more freedom to accept outside directorships, and external firms are more willing to build better relationships with them because of their importance in the firms. Consequently, CEO duality increases the number of directorships a CEO holds. As the number of board interlocks reflects a firm's tendency to build bonded relationships with other firms, it is positively related with the number of directorships held by its CEOs.

In the BoardEX database, a firm's new directors will be added in its board profile at the end of the fiscal year. To make sure that all explanatory variables capture the information before the director appointment or leave, we measure the number of directorships a CEO holds at year t and measure all explanatory variables at year t-1. Furthermore, we winsorize all non-binary variables at 1% level for both tails in case that the outliers drive our results. All variable definitions are presented in the Appendix.

[4]Sender firm refers to a CEO's primary employing firm.

3.6 Descriptive statistics

Table 1 reports descriptive statistics for variables used in our analysis. We categorize sender firms into two groups, one is the innovative firm (defined as the firm with at least one patent outcome during the sample period), the other is the non-innovative firm (defined as the firm with no patent outcome during the sample period). To further distinguish the level of innovativeness, we sort all innovative firms into quartile groups on the basis of their patent outcome. Our sample shows consistent results of the proposed hypotheses. CEOs of more innovative firms significantly hold more outside directorships, and the appointing firms they serve in are also more innovative. The mean number of outside directorships held by CEOs of innovative firms in the sample is 0.41. In contrast, CEOs of non-innovative firms in the sample hold 0.26 outside directorships on average. Furthermore, CEOs in the top quartile hold 0.30 more outside directorships than CEOs in the bottom quartile. Meanwhile, the appointing firms that innovative CEOs serve in receive 59.05 patents with 15.65 citations per patent averagely, and the appointing firms that non-innovative CEOs serve in only generate 9.12 patents with 8.70 citations per patent on average. Both of mean and median differences between two groups are significant at conventional levels. The descriptive statistics suggest that CEOs of more innovative firms hold more outside directorships. However, at this stage, we cannot attribute this pattern just to firm innovativeness, as other factors could potentially explain the number of outside directorships held by CEOs.

Our results also show that CEOs holding more outside directorships are younger but have better education background, they have been CEO for shorter years and work in larger firms that have more growth opportunities, hold more cash and invest more in R&D expenses. The firms they work in also have more board members and are more likely to build bonding relationships with other firms through interlocking. To sum up, our descriptive statistics yield evidence similar to previous studies on the driven factors of the number of directorships held by CEOs.

4 Innovation performance and CEO outside directorships

In this section, we empirically test whether firm innovativeness determines the number of outside directorships held by a CEO.

4.1 Instrumental variables

One possible concern is that the association between firm innovativeness and the number of outside directorships held by CEOs is the result of endogeneity. If there are omitted variables or unobservables that affect firm innovativeness as well as the number of outside directorships, then the estimation will be biased. For example, recent studies find that CEOs with better managerial ability produce better innovation outcomes (Chemmanur et al. 2014, Cho et al. 2016, Custódio et al. 2017), although we control for several factors that can reflect a CEO's managerial ability, there is still a chance that the association between firm innovativeness and the number of outside directorships held by CEOs is driven by other unobserved managerial ability which is not related to innovation leadership. To address this endogeneity, we use the following two instruments: *ln(CP ratio)* is the natural logarithm of one plus the ratio of Catholic residents over Protestant residents in the county where the firm is headquartered; *Urban industrial diversity* is defined as one minus the Herfindahl index of local employment across two-digit industries in the county where the firm is headquartered.

4.1.1 Relevance of instruments

For the instruments to be valid, they must strongly affect firm innovativeness. Prior literature has confirmed that these two instruments are relevant to a firm's innovation performance. For our first instrument *ln(CP ratio)*, Chen et al. (2014) show that local gambling preference, measured by a county's Catholics-to-Protestants ratio, has a great impact on local firms' innovation outcome. The association between religious belief and the risk attitudes of individuals has been well established in prior studies (i.e., Hilary and Hui (2009), Kumar et al. (2011), and Shu et al. (2012)). In particular, Catholics tend to be less risk averse while Protestants exhibit more risk averse than the average population. Therefore, a higher Catholics-to-Protestants ratio in a county reflects higher degrees of local preference for risk taking. Firms located in such counties tend to invest more in innovation, take more radical innovation projects, and experience better innovation performance.

In terms of our second instrument *Urban industrial diversity*, existing studies find that most innovations are made and spread in cities since the flow of ideas and information is easier. The diversification of industries in urban area facilitates knowledge spillovers across industries by reducing searching costs of cross-industry inspirations and expertise, as well as provision of alternative components on their new products. Glaeser et al. (1992) find that local diversification of industries and local competition, rather than local specialization, can encourage employment growth in industries. This finding suggests that within-industry knowledge spillovers are not as important as cross-industry knowledge spillovers for urban growth. Duranton and Puga (2001) build a theoretical model to explain how urban industrial diversity can help foster innovation. They show that, because of the uncertainty of innovation, a firm needs to experiment to find out the full potential of their innovation projects. This process may need knowledge across industries. A firms located in the area with diversified industries can reduce their searching costs of cross-industry knowledge, for example, it is easier to find industrial experts to hire or to try different components on their new products, and therefore enhance a firm's ability to generate better innovation outcomes.

Consistent with the economic rationale, the regression estimates of the instruments on different firm innovativeness measures demonstrate that both of two instruments have a strong association with a firm's innovation performance. As presented in Panel B of Table 2, both *ln(CP ratio)* and *Urban industrial diversity* have significantly positive impact on patent counts and citation counts. However, we do not observe significant association between *ln(CP ratio)* and patent quality, which is measured by citations per patent. A possible explanation is that firms located in gambling-prone counties tend to undertake riskier innovation projects. Such projects have greater potential to generate high-impact innovation outcome but also experience lower level of successful rate, which in turn lowers the average patent quality.

4.1.2 The exclusion restriction condition

Valid instruments also need to satisfy the exclusion restriction. That is, the instruments should not affect CEO outside directorship measures other than their effect on firm innovativeness. Economically, we do not observe any clear rationale for how our instruments can directly affect CEO outside directorships. However, there are potential indirect channels through which the instruments may affect CEO outside directorships. Hirshleifer et al. (2012) and Galasso and Simcoe (2011) report a positive relation between CEO overconfidence and firm innovativeness. Together with the findings in Beavers and Mobbs (2015) suggesting that overconfident CEOs tend to accept more outside board seats, the potential overlap between CEO overconfidence and gambling preferences may lead to invalidity of the exclusion restriction condition of *ln(CP ratio)* as an instrument. We argue that such overlap is trivial. As discussed in Chen et al. (2014), local gambling preference can affect degrees of risk averse at all levels of the organization while CEO overconfidence is only at individual level. Yet no clear evidence documented in previous studies has shown a direct link between local gambling preference and CEO overconfidence. To further alleviate this concern, we also control for CEO overconfidence in the robustness tests.

For the other instrument *Urban industrial diversity*, we are not aware of any prior literature suggesting a direct link between it and CEO outside directorships. However, one possible concern is that if the industrial diversity in a county is correlated with its size, it may affect CEO outside directorships simply because the larger counties are more likely to have greater demand for outside directors. To deal with this issue, we also control for the local demand for outside directors in our regressions. Meanwhile, the prior studies on urban diversity (e.g., Duranton and Puga (2000)) only show a weak correspondence between type of specilisation and city size, which also alleviates the validity concern on the instrument.

Empirically, although it is not possible to directly test the exclusion restriction, we run a placebo test by including the instruments in the second stage regressions. If the exclusion restriction is violated, the instruments could affect the dependent variable through channels other than influencing firm innovativeness and we would observe statistically significant coefficients on the instruments. For brevity, we do not report the results of the placebo test, but the results are consistent with the notion that that the instruments we choose only affects the dependent variable through their impact on firm innovativeness.

4.2 Main analysis

4.2.1 Are CEOs of innovative firms more likely to hold outside directorships?

We begin our analysis by investigating how a firm's innovativeness affects its CEO's probability of being an outside director in other firms. To answer this question, we use a probit model where the dependent variable is equal to 0 if a CEO does not hold any outside directorships, and 1 if a CEO holds at least one outside directorship.

Model (1)−(3) of Table 2 present the results of the probit regressions. All regressions include controls for firm characteristics, CEO characteristics and other factors highlighted in prior literature that can affect a CEO's probability of holding outside directorships through both supply and demand sides. We also include year and industry dummies (using Fama-French 49 industry classifications) to control for potential time trends and time-invariant industry heterogeneity. The results confirm our conjecture, the coefficients on all three firm innovativeness measures are positive and significant at the conventional level, suggesting that CEOs of more innovative firms are more likely to hold outside directorships. We also observe that CEOs holding outside directorships are older, better educated, and from larger and more mature firms who prefer to build bonding relationships with other firms through board interlocking, consistent with findings in prior literature. Our results still hold after correcting potential endogeneity. As shown in Model (4)−(6) of Table 2, we continue to find significantly positive effect of firm innovativeness on a CEO's probability of holding outside directorships.

We next ask how the appointing firms' innovativeness can affect an innovative CEO's probability of holding outside directorships. Based on our supply and demand analysis of innovative CEO-directors, we conjecture that innovative CEOs are more likely to hold outside directorships in innovative firms. To examine this prediction, we estimate a set of multinomial regression models where the dependent variable (Y) is a categorical variable constructed by a CEO's different choices of holding outside directorships. First, we sort our sample into two groups, one includes CEOs who do not hold any outside directorships (non-director group, Y=0), the other consists of CEOs holding at least one outside directorships (CEO-director group, Y=1 or Y=2). We then sort the CEO-director sample by the appointing firms' innovativeness (measured by citation counts), and further divide the sample into two sub-groups (i.e., high innovative appointing firms group (Y=2) and low innovative appointing firms group (Y=1)) based on the sample median. We report the regression estimates in Panel A of Table 3. We observe that CEOs of more innovative firms prefer to hold outside directorships in high innovative firms, which is in line with our prediction. In addition, besides splitting appointing firms by their innovativeness, we sort the CEO-director sample by the appointing firms' R&D as well. As presented in Panel B of Table 3, we find that innovative CEOs are more likely to join the board of R&D-intensive firms.

Last, we assess the technological proximity between the sender firm and the appointing firm. The technological proximity is particularly of interest because it can reflect the matching of the appointing firm's advisory needs and the innovative CEO-director's expertise. The prior literature suggests that directors are particularly sought after when they can provide valuable expertise that can match the appointing firm's advisory needs[5].

[5]See Coles et al. (2008), Dass et al. (2014), Güner et al. (2008), Masulis et al. (2012), Meyerinck et al.

Therefore, we should observe that innovative CEO-directors hold outside directorships in firms with high technology proximity to their own firms. To examine this prediction, we estimate the similar multinomial probit regression where we divide the CEO-director sample by the technological proximity between the sender firm and the appointing firm. In Panel C of Table 3, our results confirm the prediction. We show that CEOs of more innovative firms are less likely to serve as outside director in firms with low technological proximity to their own firms, and they tend to hold outside directorships in firms with high technological proximity to their own firms. We can also interpret this finding using the theory suggested by Fahlenbrach et al. (2010). CEO-directors face high opportunity cost of time and high reputation cost. If they join boards of firms that they are familiar with, the required workload and potential reputation risk would be less. Therefore, innovative CEO-directors are likely to join firms with high technological proximity to their own firms.

4.2.2 Innovativeness and the number of outside directorships held by a CEO

In this subsection, we directly test how a firm's innovativeness affects the number of outside directorships held by its CEO, Because the number of outside directorships is left censored, Tobit models are utilized in our regression analysis. As discussed in the earlier section, we use two different measures of outside directorships, one is the actual number of outside directorships, the other is the weighted number of outside directorships.

Panel A of Table 4 reports the results estimated by using the actual number of outside directorships as the dependent variable. Consistent with our theoretical prediction and univariate analysis, firm innovativeness is associated with significantly more number of directorships held by a CEO. The coefficients of all three firm innovativeness measures are significantly positive, both before and after correcting potential endogeneity. The coefficients associated with control variables are also economically and statistically in line with prior studies and our prediction. We observe that CEOs of larger and older

(2015), Wang et al. (2015)

firms hold more outside directorships, and these firms are more likely to build bonding relationship with other firms through director interlocking, which is consistent with the idea in Booth and Deli (1996) demonstrating that large and established firms face more complex external contracting relationships and thus will benefit more from sending their CEOs to serve on other firms' board. Similar to Ferris et al. (2003), the coefficient on CEO age is significantly positive. We further find significantly positive effect of CEO education on number of outside directorships held by a CEO. This suggests that CEOs with more experience and better knowledge background are more popular on the directorship market.

We now turn to the regression analysis using the weighted number of outside directorships as the dependent variable. Our purpose here is not only to examine whether innovative CEOs hold more outside directorships, but also to take into account the matching of a CEO-director's expertise and the appointing firm's advisory needs. Using our weighting method, one outside directorship in more innovative appointing firms will weigh more in the total number of outside directorships, it therefore captures both the number and the quality of outside directorships held by a CEO. As shown in Panel B of Table 4, the effect of firm innovativeness remains qualitatively unchanged and becomes more pronounced. The coefficients on all firm innovativeness measures are significantly positive at the 1% level. This finding is consistent with our supply and demand analysis of innovative CEO-directors. From the supply side, innovative CEO-directors' expertise are especially valuable for innovative appointing firms. From the demand side, CEOs of innovative firms can also benefit more from serving as outside directors in innovative firms.

Overall, our regression analysis is in line with our theoretical prediction, suggesting that CEOs of more innovative firms hold more outside directorships and this pattern is more pronounced when the appointing firms are innovative.

4.3 Robustness tests

The results presented above provide empirical evidence of a strong causal relation between a firm's innovativeness and the number of outside directorships held by its CEO.

In this section, we conduct several additional tests to examine the robustness of this finding.

4.3.1 Addressing reverse causality

One possible concern is that if a firm becomes more innovative because its CEO enhances her ability through seating on other firms' boards, the effect of firm innovativeness on the outside directorships we observed could be attributable to reverse causality. To alleviate this concern, rather than use the innovation outcome at $t-1$, we use the the innovation outcome at $t-3$ instead. As presented in Panel A of Table 8, the significantly positive coefficients associated with the lagged innovation outcome confirm that our main finding are unlikely to be driven by reverse causality.

4.3.2 Self-citations

Hall et al. (2005) contends that self-citations are more valuable than external citations. They suggest that self-citations could reflect the strong competitiveness of a firm in a particular technology class and a firm's ability to internalize the knowledge spillovers rather than to acquire externally. Based on this suggestion, we do not exclude self-citations when we assess the impact of patents. However, much of the innovation literature, such as Chemmanur et al. (2014), Hirshleifer et al. (2013) and Faleye et al. (2014), use non-self-citations to measure the impact of patents. To examine whether our findings are sensitive to self-citations, we further exclude self-citations in our analysis and the results remain similar (see Panel B of Table 8).

4.3.3 CEO overconfidence, CEO ownerships and board ownerships

The prior studies provide evidence to suggest that CEO overconfidence can affect firm innovativeness and his willingness to accept outside directorship(Hirshleifer et al. 2012, Galasso and Simcoe 2011, Beavers and Mobbs 2015). In addition, much of research

(Booth and Deli 1996, Fahlenbrach et al. 2010, Perry and Peyer 2005) contends that CEO and board ownership could affect the number of directorships held by CEOs. CEOs with low ownership may have poor incentives to maximize shareholder value, thus could be more willing to accept outside directorships. Moreover, high board ownership could increase the intensity of board monitoring, so they are less likely to allow CEOs to spend their time on outside directorship jobs. Motivated by these findings, we further control for CEO overconfidence[6], CEO ownership and board ownership. As presented in Panel C of Table 8, the results remain largely consistent.

4.3.4 Firm random effect

In this subsection, we estimate firm-level random effects Tobit models to check whether our results are driven by time-invariant unobservable firm characteristics. We employed random effects rather than fixed effects due to the use of maximum likelihood in estimating the Tobit model. According to the results presented in Panel D of Table 8, using firm random effect weakens our results, this is not surprising as the number of outside directorships held by CEOs is sticky at the firm level over time.

4.4 Further Extensions

4.4.1 Innovation efficiency

Patent counts and citation counts only capture the outcome of a firm's innovation activities, it is also interesting to assess the impact of a firm's innovation input and innovation efficiency on the number of outside directorships held by its CEO because such efficiency can reflect a CEO's ability of producing innovation outcome with a reasonable cost. Following innovation literature, we construct three measures of a firm's innovation efficiency by scaling a firm's patent count, citation count and citations per patent by its R&D capital, which is the cumulative R&D expenses over the preceding 5 years with

[6]We follow Malmendier and Tate (2008) to define a CEO as overconfident if he once postpones the exercise of vested options that are at least 67% in the money.

an annual depreciation rate of 20% [7]. In Table 5, we report the regression estimates of Tobit models further including corresponding innovation efficiency measures and R&D intensity. We continue observing significantly positive coefficients on innovation outcome measures in most of the regressions. In some regressions, the coefficients on innovation efficiency measures are significantly positive as well. However, we do not find significant relation between R&D intensity and the number of outside directorships. Together these results suggest that innovation outcome is more important than innovation efficiency and innovation input for deciding the number of outside directorships held by a CEO.

4.4.2 High-impact innovation

A growing academic literature has shown that outside directors who develop reputations as skillful monitors might acquire additional directorships in other firms. Here we tend to examine whether the success of producing high-impact innovations helps a CEO acquire additional board seats in other firms. Following the specification in ?, I regress the one-year change in outside directorships against a firm's high-impact innovation outcome in the previous year. The high-impact innovation outcome is measured as the natural logarithm of one plus a firm's total number of patents that are in the top 10% group of the distribution of its economic value (Kogan et al. 2017) in a given 3-digit class and application year.

Estimates in Table 7 show that there is no association between the company's high-impact innovation outcome and the raw number of outside directorships subsequently obtained by a CEO. However, when we regress the change of the weighted number of outside directorships on the high-impact innovation outcome, we find a strong positive association. The results suggest that if a CEO successfully leads the firm to produce patents with high economic value, the external labour market will reward such superior performance, particularly by more innovative firms.

[7] This approach of adjusting R&D expenses is suggested in many finance and accounting studies such as Chan et al. (2001), Lev et al. (2005) and Hirshleifer et al. (2013).

4.4.3 Exploitative and explorative innovation

Jansen et al. (2006) argue that exploitative and explorative innovation are both keen on a firm's success in technological innovation. Exploitative innovations build on a firm's existing knowledge base and extend its existing product lines and reinforce its product-market competitiveness. Exploitative innovations are cumulative innovations reflecting a firm's establishment of a strong competitive position in particular technological classes which enables it to internalize its knowledge accumulation and create knowledge spillovers by itself sequentially. Pursuing exploitative innovation is shown to be more profitable in more competitive environments. It embodies a process in which successive inventors compete away each other's excess returns (Scotchmer 1991).

On the other hand, explorative innovations reflect a firm's activities in searching for new knowledge and developing new products for emerging customers and markets. This type of innovation strategy is more radical and requires to acquire new knowledge or departure from existing knowledge (Benner and Tushman 2003). Jansen et al. (2006) assert that explorative innovations are more effective in dynamic environments, which is characterized by instability of technology trends, customer preferences, product demand, or supply of key materials.

In this subsection, we further examine the reputational impact of exploitative and explorative innovation strategies for CEOs in the labour market for outside directors. Table 7 reports the regression estimates of Probit and Tobit models. We do not observe any significant effect of either exploitative or explorative innovations on a CEO's probability of holding outside directorships and the raw number of outside directorships. However, when using the weighted number of outside directorships as the dependent variable, we find a significantly positive coefficient on exploitative innovations. This evidence suggests that not only the overall innovation performance but also the specific innovation strategy affect a CEO's attractiveness in the external labour market, particularly driven by the appointing firms who are also innovative. In addition, we show that innovative firms tend to take advice from CEOs of firms that have developed and well utilised its existing knowledge base rather than from CEOs of firms taking more aggressive innovation strategies.

5 Impact of innovative CEO-directors on firm performance

5.1 Innovation performance

In this section, we examine whether the presence of innovative CEO-directors on the board can impact a firm's innovation performance. To assess this effect, we exploit a difference-in-difference regression using a panel data set that contains information of firms in the treatment group and control group during three pre-appointment years and three post-appointment years. We allow a two-year gap between the pre-appointment years and the post-appointment years since it takes time for a firm to convert innovation input to patenting output. We construct a treatment sample including CEO-director appointments in which an innovative firm (firms with non-zero patent outcome during the sample period) appointing an innovative CEO-director (CEOs of firms with non-zero patent outcome during the sample period), and a control sample including CEO-director appointments in which an innovative firm appointing a non-innovative CEO-director (CEOs of firms with zero patent outcome during the sample period). In this way, we can rule out the performance change due to the appointment of any type of CEO-directors and allow us to attribute the performance change to the innovativeness of CEO-directors. We apply the similar regression specification used in Bena and Li (2014) and Seru (2014) as follows[8]

$$
\begin{aligned}
\text{Innovation outcome}_{i,t} = & \alpha + \beta_1 \text{After}_{i,t} + \beta_2 \text{After}_{i,t} \times \text{Treat}_{i,t} \\
& + \beta_3 \text{Controls}_{i,t} + \text{Firm FE}_i + \text{Year FE}_t + \epsilon_{i,t}
\end{aligned}
\tag{3}
$$

[8]We cannot estimate the coefficients on $Treat_{i,t}$ or $Treat_{i,t} \times$ *High Innovativeness/Proximity/R&D*$_{i,t}$ as both terms are subsumed by firm fixed effects.

where the subscripts refer to firm i and year t. *After* is an indicator variable that equals one for all the years after the appointment and zero otherwise. *Treat* is an indicator variable that equals one for firms in the treatment group and zero for firms in the control group. We include firm fixed effect in the specification to control for any time-invariant heterogeneity among firms. We also include year fixed effects to control for possible common trend affecting innovation output in both the treatment and control groups.

Before the formal analysis, we first explain the sample construction of the treatment and control groups. In our whole sample, there are 550 unique CEOs who hold outside directorships during the sample period. We use the BoardEX database to find out all appointing firms and the time when they appointed outside CEOs as directors, and then remove the appointing firms that do not have enough data around the appointment. Next, we further remove the appointing firms receiving zero patent over the sample period to make sure that all appointing firms are actively involved in technology innovation. This results in 205 appointing firms remaining in our sample. To examine whether the innovativeness of CEO-directors can affect the appointing firm's post-appointment innovation performance, we select 132 out of 205 appointments in which the CEO-directors are from innovative firms (defined as firms received at least one patent during the sample period) as the treatment sample. The control sample consists of 73 appointments in which the CEO-directors are from non-innovative firms.

We now turn to explain the results of our difference-in-difference analysis. Panel A of Table 9 reports the OLS regression estimates of Equation (4). We show that the coefficients on the interaction term $After \times Treat_{i,t}$ is positive and significant at the 5% level in the regressions on citation counts and expected citations per patent. The results are still robust when we include several firm characteristic variables in the regressions. Although we fail to observe similar effect in the regressions on patent counts, our results suggest that appointing innovative-CEO directors leads to significant improvement of a firm's innovation quality.

To further assess how much of the observed improvement in the treatment group can be attributed to different characteristics of both the sender firm and the appointing firm, we use a difference-in-difference-in-difference specification. First, we sort all sender firms in the treatment group into high innovativeness group and low innovativeness group by the sample median of sender firm's pre-appointment innovation outcomes. In Panel B of Table 9, we add interaction term $After_{i,t} \times Treat_{i,t} \times High\ Innovativeness_{i,t}$ to the specification above. The significantly positive coefficients on this interaction term indicate that the observed effect in the treatment group is largely driven by the level of a CEO-director's innovativeness, which suggests that appointing an outside CEO from high innovative firms as a director can significantly increase both patent counts and citation counts generated in the post-appointment years.

Next, we move to explore how technological proximity between the appointing firm and the sender firm can affect the innovation performance of the appointing firm. High technological proximity between two firms suggests that their innovation activities are overlapping to some certain degree. Such overlap can help fill the information gap between directors and incumbent managers, leading to more valuable advices provided by directors. In Panel C of Table 9, we add interaction term $After_{i,t} \times Treat_{i,t} \times High\ Proximity_{i,t}$ to the specification mentioned in Equation (4). *High Proximity* is an indicator variable that takes value one if the technological proximity between the sender firm and the appointing firm is larger than the sample median of the treatment group and zero otherwise. We only observe significantly positive coefficients on the interaction term $After_{i,t} \times Treat_{i,t} \times High\ Proximity_{i,t}$ when we use citation counts and citations per patent to measure a firm's innovation outcomes, suggesting that the impact of CEO-directors from firms with high technological proximity is mainly on the quality of patents.

Finally, we examine how much of the improvement of innovation outcomes in the treatment group is due to the level of appointing firm's R&D intensity. Similarly, we split the treatment sample into two groups by the sample median R&D intensity and include $After_{i,t} \times Treat_{i,t} \times High\ R\&D_{i,t}$ in the specification. As can be observed in Panel D of Table 9, only the increase of citations per patent can be attributed to the level of appointing firm's R&D intensity.

In summary, we conclude that the presence of innovative CEO-directors on a firm's board can significantly improve its innovation performance in the post-appointment years. In addition, we find that the degree of improvement depends on the level of the sender firm's innovativeness, the technological proximity between two firms, and the level of the appointing firm's R&D intensity.

5.2 Operating performance

We have shown that the presence of innovative CEO-directors on a firm's board can significantly improve the firm's innovation performance in the post-appointment years. In this section, we examine whether this improved innovation performance can be converted to better operating performance. We use the same sample of 205 CEO-director appointments in the post-appointment innovation performance test and investigate the post-appointment operating performance of the firms in the treat sample and the control sample separately. The treat sample includes CEO-director appointments in which an innovative firm (firms with non-zero patent outcome during the sample period) appointed an innovative CEO-director (CEOs of firms with non-zero patent outcome during the sample period), while the control sample includes CEO-director appointments in which an innovative firm appointed a non-innovative CEO-director (CEOs of firms with zero patent outcome during the sample period). We apply the similar regression specification used in Healy et al. (1992) and Harford (1999) as follows:

$$\begin{aligned}\text{Post-appointment operating performance}_i =& \alpha + \beta \text{ Pre-appointment operating performance}_i \\ &+ \theta \text{ Year Dummies}_i + \gamma \text{ Industry Dummies}_i + \epsilon_i\end{aligned} \tag{4}$$

where i indexes firms; *Pre-appointment operating performance* is the average operating performance over 3 years before the appointment. *Post-appointment operating performance* is the average operating performance over event years +2 to +4 (or +2 to +6) after the appointment.[9] *Year Dummies* is a vector of binary variables indicating event years. *Industry Dummies* is a vector of binary variables indicating industries defined using Fama-French 49 industries. β captures the persistence of pre-appointment operating performance. α captures any abnormal operating performance improvements between the pre-appointment and post-appointment periods.

Barber and Lyon (1996) point out that when studying operating performance, it is important to control for abnormal firm characteristics. This adjustment will remove the effects of several firm characteristics on post-event abnormal operating performance, and attributes any post-event abnormal operating performance to the event itself. Following Barber and Lyon (1996), we use return on assets (ROA) to measure operating performance and then adjust ROA by two methods. First, we adjust a firm's ROA by the median ROA of firms in the same Fama-French 49 industry and size decile. Second, we adjust a firm's ROA by the ROA of a matched firm that is from the same Fama-French 49 industry with ROA in event year -3 that is within $\pm$ 10% of the appointing firm and closest in size to the appointing firm.

In Panel A of Table 10, we report the regression estimates of post-appointment operating performance using post-appointment 3-year (event year +2 to +4) average operating performance. As reported in Model (1) and (2), the regressions using unadjusted ROA show that the abnormal operating performance associated with the appointment is significantly positive for both the treat sample and the control sample. However, the constant term for the treat firms is more significant (at the 1% level) than that for the control firms (at the 10% level), and its magnitude is larger as well, which indicates the treat firms outperform the control firms in terms of the abnormal operating performance. When we further adjust the ROA by firm characteristics including size, industry and past performance, the discrepancy of abnormal operating performance between the treat groups and the control groups becomes more pronounced. Specifically, as shown in Model (5) and (6), the treat firms on average have a significantly positive abnormal operating

[9] As mentioned earlier, we allow a two-year gap between the pre-appointment years and the post-appointment years since it takes time for a firm to convert innovation input to patenting output.

performance of 10.3% a year. In contrast, the control firms on average have a significant negative abnormal operating performance of -4.2% a year. The difference between two groups is both statistically and economically significant. Further, we also observe that the coefficient on pre-event operating performance for the treat firms is much smaller than that for the control firms, suggesting that appointing an innovative CEO-director brings more dramatic change on a firm's operating performance than appointing an non-innovative CEO-director. In addition, the estimates of similar regressions using 5-year (event year +2 to +6) average operating performance are reported in Panel B of Table 10, where we find very similar results.

Overall, our results show that the presence of innovative CEO-directors on the board not only improve a firm's innovation performance but also enhance its financial performance, which further suggests that enhanced innovation capacity translates to value enhancement for shareholders.

6 Conclusion

In this paper, we investigate whether a CEO's proven ability of cultivating and promoting innovation in their own firm can be recognized by the outside directorship market, and whether this expertise and ability enables the appointing firms to improve their innovation and financial performance. We find that CEOs of innovative firms are particularly sought after as outside directors. They are more likely to hold outside directorships than CEOs of non-innovative firms and the number of outside directorships held by them is positively associated with their own firm's innovation performance.

Theories suggest that innovative CEO-directors should be particularly sought after for advice when their expertise are valuable for the appointing firms. Meanwhile, CEOs of innovative firms are more likely to join firms that can provide them prestige, network and knowledge that enhance their career and performance of their own firms. We provide evidence consistent with this prediction. In our performance analysis, we further demonstrate that innovative CEO-director appointment significantly improves the appointing firms innovation and financial performance.

We conclude that the skill of cultivating and promoting innovation is an attribute highly valued in the outside director market. Further, the supply of innovative CEO-directors provides an important conduit for knowledge transmission across innovative firms.

References

Adams, R. B. and Ferreira, D. (2007), 'A theory of friendly boards', *The Journal of Finance* **62**(1), 217–250.

Adams, R. B., Hermalin, B. E. and Weisbach, M. S. (2010), 'The role of boards of directors in corporate governance: A conceptual framework and survey', *Journal of Economic Literature* pp. 58–107.

Aghion, P., Van Reenen, J. and Zingales, L. (2013), 'Innovation and institutional ownership', *The American Economic Review* **103**(1), 277–304.

Barber, B. M. and Lyon, J. D. (1996), 'Detecting abnormal operating performance: The empirical power and specification of test statistics', *Journal of Financial Economics* **41**(3), 359–399.

Beavers, R. and Mobbs, S. (2015), 'Director overconfidence', *Working Paper* .

Bena, J. and Li, K. (2014), 'Corporate innovations and mergers and acquisitions', *The Journal of Finance* **69**(5), 1923–1960.

Benner, M. J. and Tushman, M. L. (2003), 'Exploitation, exploration, and process management: The productivity dilemma revisited', *Academy of management review* **28**(2), 238–256.

Booth, J. R. and Deli, D. N. (1996), 'Factors affecting the number of outside directorships held by ceos', *Journal of Financial Economics* **40**(1), 81–104.

Brickley, J. A., Linck, J. S. and Coles, J. L. (1999), 'What happens to ceos after they retire? new evidence on career concerns, horizon problems, and CEO incentives', *Journal of Financial Economics* **52**(3), 341–377.

Chan, L. K., Lakonishok, J. and Sougiannis, T. (2001), 'The stock market valuation of research and development expenditures', *The Journal of Finance* **56**(6), 2431–2456.

Chemmanur, T. J., Loutskina, E. and Tian, X. (2014), 'Corporate venture capital, value creation, and innovation', *Review of Financial Studies* p. hhu033.

Chen, Y., Podolski, E. J., Rhee, S. G. and Veeraraghavan, M. (2014), 'Local gambling preferences and corporate innovative success', *Journal of Financial and Quantitative Analysis* **49**(1), 77–106.

Cho, C., Halford, J. T., Hsu, S. and Ng, L. (2016), 'Do managers matter for corporate innovation?', *Journal of Corporate Finance* **36**, 206–229.

Coles, J. L., Daniel, N. D. and Naveen, L. (2008), 'Boards: Does one size fit all?', *Journal of Financial Economics* **87**(2), 329–356.

Custódio, C., Ferreira, M. A. and Matos, P. (2017), 'Do general managerial skills spur innovation?', *Management Science* .

Dalton, D. R., Daily, C. M., Johnson, J. L. and Ellstrand, A. E. (1999), 'Number of directors and financial performance: A meta-analysis', *Academy of Management journal* **42**(6), 674–686.

Dass, N., Kini, O., Nanda, V., Onal, B. and Wang, J. (2014), 'Board expertise: Do directors from related industries help bridge the information gap?', *Review of Financial Studies* **27**(5), 1533–1592.

Duranton, G. and Puga, D. (2000), 'Diversity and specialisation in cities: why, where and when does it matter?', *Urban studies* **37**(3), 533–555.

Duranton, G. and Puga, D. (2001), 'Nursery cities: Urban diversity, process innovation, and the life cycle of products', *American Economic Review* pp. 1454–1477.

Fahlenbrach, R., Low, A. and Stulz, R. M. (2010), 'Why do firms appoint ceos as outside directors?', *Journal of Financial Economics* **97**(1), 12–32.

Faleye, O., Hoitash, R. and Hoitash, U. (2013), 'Advisory directors', *Available at SSRN 1866166* .

Faleye, O., Kovacs, T. and Venkateswaran, A. (2014), 'Do better-connected CEOs innovate more?', *Journal of Financial and Quantitative Analysis* **49**(5-6), 1201–1225.

Fama, E. F. and Jensen, M. C. (1983), 'Separation of ownership and control', *The Journal of Law & Economics* **26**(2), 301–325.

Ferris, S. P., Jagannathan, M. and Pritchard, A. C. (2003), 'Too busy to mind the business? monitoring by directors with multiple board appointments', *The Journal of Finance* **58**(3), 1087–1111.

Fich, E. M. (2005), 'Are some outside directors better than others? evidence from director appointments by fortune 1000 firms*', *The Journal of Business* **78**(5), 1943–1972.

Galasso, A. and Simcoe, T. S. (2011), 'Ceo overconfidence and innovation', *Management Science* **57**(8), 1469–1484.

Glaeser, E. L., Kallal, H. D., Scheinkman, J. A. and Shleifer, A. (1992), 'Growth in cities', *Journal of Political Economy* pp. 1126–1152.

Güner, A. B., Malmendier, U. and Tate, G. (2008), 'Financial expertise of directors', *Journal of Financial Economics* **88**(2), 323–354.

Hall, B. H., Jaffe, A. B. and Trajtenberg, M. (2001), The nber patent citation data file: Lessons, insights and methodological tools, Technical report, National Bureau of Economic Research.

Hall, B. H., Jaffe, A. and Trajtenberg, M. (2005), 'Market value and patent citations', *RAND Journal of Economics* pp. 16–38.

Harford, J. (1999), 'Corporate cash reserves and acquisitions', *The Journal of Finance* **54**(6), 1969–1997.

Healy, P. M., Palepu, K. G. and Ruback, R. S. (1992), 'Does corporate performance improve after mergers?', *Journal of Financial Economics* **31**(2), 135–175.

Hermalin, B. E. and Weisbach, M. S. (1988), 'The determinants of board composition', *The RAND Journal of Economics* pp. 589–606.

Hilary, G. and Hui, K. W. (2009), 'Does religion matter in corporate decision making in america?', *Journal of Financial Economics* **93**(3), 455–473.

Hirshleifer, D., Hsu, P.-H. and Li, D. (2013), 'Innovative efficiency and stock returns', *Journal of Financial Economics* **107**(3), 632–654.

Hirshleifer, D., Low, A. and Teoh, S. H. (2012), 'Are overconfident ceos better innovators?', *The Journal of Finance* **67**(4), 1457–1498.

Holmström, B. (1999), 'Managerial incentive problems: A dynamic perspective', *The Review of Economic Studies* **66**(1), 169–182.

Jaffe, A. B. (1986), 'Technological opportunity and spillovers of R&D: Evidence from firms' patents, profits, and market value', *The American Economic Review* pp. 984–1001.

Jansen, J. J., Van Den Bosch, F. A. and Volberda, H. W. (2006), 'Exploratory innovation, exploitative innovation, and performance: Effects of organizational antecedents and environmental moderators', *Management science* **52**(11), 1661–1674.

Jensen, M. C. (1993), 'The modern industrial revolution, exit, and the failure of internal control systems', *The Journal of Finance* **48**(3), 831–880.

Kang, J.-K., Liu, W.-L., Low, A. and Zhang, L. (2014), 'Friendly boards and innovation', *Working Paper* .

Knyazeva, A., Knyazeva, D. and Masulis, R. W. (2013), 'The supply of corporate directors and board independence', *Review of Financial Studies* **26**(6), 1561–1605.

Kogan, L., Papanikolaou, D., Seru, A. and Stoffman, N. (2017), Technological innovation, resource allocation, and growth, Technical Report 2.

Kumar, A., Page, J. K. and Spalt, O. G. (2011), 'Religious beliefs, gambling attitudes, and financial market outcomes', *Journal of Financial Economics* **102**(3), 671–708.

Lev, B., Sarath, B. and Sougiannis, T. (2005), 'R&D reporting biases and their consequences', *Contemporary Accounting Research* **22**(4), 977–1026.

Malmendier, U. and Tate, G. (2008), 'Who makes acquisitions? CEO overconfidence and the market's reaction', *Journal of Financial Economics* **89**(1), 20–43.

Manso, G. (2011), 'Motivating innovation', *The Journal of Finance* **66**(5), 1823–1860.

Masulis, R., Ruzzier, C., Xiao, S. and Zhao, S. (2012), 'Do independent expert directors matter?', *Working Paper* .

Masulis, R. W. and Mobbs, S. (2014), 'Independent director incentives: Where do talented directors spend their limited time and energy?', *Journal of Financial Economics* **111**(2), 406–429.

Meyerinck, F., Oesch, D. and Schmid, M. (2015), 'Is director industry experience valuable?', *Financial Management* .

Perry, T. and Peyer, U. (2005), 'Board seat accumulation by executives: A shareholder's perspective', *The Journal of Finance* **60**(4), 2083–2123.

Scotchmer, S. (1991), 'Standing on the shoulders of giants: cumulative research and the patent law', *The journal of economic perspectives* **5**(1), 29–41.

Seru, A. (2014), 'Firm boundaries matter: Evidence from conglomerates and R&D activity', *Journal of Financial Economics* **111**(2), 381–405.

Shu, T., Sulaeman, J. and Yeung, P. E. (2012), 'Local religious beliefs and mutual fund risk-taking behaviors', *Management Science* **58**(10), 1779–1796.

Wang, C., Xie, F. and Zhu, M. (2015), 'Industry expertise of independent directors and board monitoring', *Journal of Financial and Quantitative Analysis* **50**(05), 929–962.

Weisbach, M. S. (1988), 'Outside directors and CEO turnover', *Journal of Financial Economics* **20**, 431–460.

Young, J. (1990), 'Pawns or potentates: The reality of america's corporate boards', *The Academy of Management Perspectives* **4**(4), 85.

Table 1: **Summary statistics**

This table reports summary statistics for the variables used in our analysis. Panel A reports the summary statistics for the panel data used to estimate the effect of innovativeness on the number of outside directorships held by a CEO. Panel B reports the summary statistics of the panel data used in the analysis of the impact of innovative CEO-directors on firm performance. In panel A, dependent variables are measured at year t, and all independent variables are measured at year t-1. The summary statistics are reported for two different types of sender firms (i.e., the CEO's own firm). One is the firms without any innovation outcome during our sample period, the other consists of the firms with at least one innovation outcome during our sample period. We further sort sender firms with innovation outcome into quartile groups by patent counts. In panel B, all variables are measured at the end of the fiscal year. In both panel A and panel B, All non-binary independent variables are winsorized at the 1st and 99th percentile. Variable definitions are in Appendix. Two sample t-test (Wilcoxon-Mann-Whitney tests) are conducted to test whether the means (medians) of the firms in the group A are significantly different from that of the firms in the group B (in both panel A and panel B), and whether the firms in the 4th quartile group are significantly different from the firms in the 1st quartile group (only in panel A). Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively.

Panel A: Data used for analysing the effect of innovativeness on the number of outside directorships held by a CEO

	A: Sender firms without any patent outcome		B: Sender firms with at least 1 patent				B: Sender firms with at least 1 patent outcome									
					Difference		Q1 Low		Q2		Q3		Q4 High		Q4 High − Q1 Low	
	Mean	Median	Mean	Median	t-stat	Z-stat	Mean	Median	Mean	Median	Mean	Median	Mean	Median	t-stat	Z-stat
Dependent variable																
Number of outside directorships (actual)	0.26	0.00	0.41	0.00	0.15***	0.00***	0.29	0.00	0.33	0.00	0.47	0.00	0.59	0.00	0.30***	0.00***
Number of directorships (weighted)	0.03	0.00	0.07	0.00	0.04***	0.00***	0.03	0.00	0.04	0.00	0.07	0.00	0.18	0.00	0.15***	0.00***
Innovation outcome																
Patent counts	–	–	27.54	6.00	–	–	1.14	1.00	4.45	4.00	15.14	14.00	107.96	73.00	106.82***	72.00***
Citation counts	–	–	710.75	124.92	–	–	28.60	15.18	115.84	83.88	426.23	312.64	2746.81	2010.35	2718.21***	1995.17***
Citations per patent	–	–	2.88	3.06	–	–	2.35	2.66	3.04	3.04	3.17	3.13	3.24	3.27	0.89***	0.61***
Innovation efficiency																
Patent counts/R&D Capital	–	–	0.14	0.04	–	–	0.04	0.01	0.21	0.04	0.19	0.08	0.18	0.09	0.14***	0.08***
Citation counts /R&D Capital	–	–	4.25	0.71	–	–	1.35	0.09	6.77	0.63	4.91	1.63	5.35	1.95	4.00***	1.86***
Citations per patent /R&D Capital	–	–	0.08	0.01	–	–	0.10	0.01	0.15	0.03	0.04	0.02	0.01	0.00	−0.09***	−0.01***
Firm characteristic																
Total Assets (millions $)	3779.76	1052.27	8045.12	1639.74	4265.36***	587.47***	4005.04	1005.09	5147.57	1062.76	6918.10	1585.43	18798.66	7063.40	14793.62***	6058.31***
Market-to-book	2.04	1.64	2.43	1.95	0.39***	0.31***	2.22	1.85	2.40	1.89	2.49	1.97	2.71	2.24	0.49***	0.39***
R&D	0.02	0.00	0.06	0.04	0.04***	0.04***	0.05	0.03	0.06	0.04	0.06	0.05	0.08	0.06	0.03***	0.03***
Return on assets	0.18	0.17	0.16	0.16	−0.02***	−0.01***	0.16	0.16	0.16	0.15	0.15	0.15	0.17	0.16	0.01	0.00
Cash	0.13	0.07	0.20	0.13	0.07***	0.06***	0.17	0.10	0.21	0.13	0.20	0.14	0.22	0.16	0.05***	0.06***
Leverage	0.17	0.16	0.15	0.14	−0.02***	−0.02***	0.16	0.13	0.15	0.13	0.17	0.14	0.14	0.14	−0.02*	0.01
Capital expenditures	0.07	0.04	0.05	0.04	−0.02***	0.00***	0.05	0.04	0.05	0.03	0.05	0.04	0.05	0.04	0.00	0.00
Dividend	0.06	0.00	0.07	0.00	0.01*	0.00***	0.06	0.00	0.06	0.00	0.08	0.00	0.09	0.07	0.03***	0.07***
Sales growth	0.15	0.11	0.14	0.10	−0.01	−0.01***	0.15	0.11	0.17	0.12	0.14	0.09	0.12	0.08	−0.03**	−0.03***
Capital intensity	0.42	0.18	0.26	0.18	−0.16***	0.00	0.29	0.17	0.24	0.17	0.24	0.19	0.26	0.21	−0.03*	0.04***
Firm age	23.42	18.00	28.34	23.00	4.92***	5.00***	26.32	20.50	26.69	20.00	28.19	23.00	33.49	33.00	7.17***	12.50***
Number of local firms	151.19	113.00	189.63	158.50	38.44***	45.50***	172.06	125.50	173.32	127.50	202.98	201.00	219.71	256.00	47.65***	130.50***
CEO characteristics																
CEO age	54.93	55.00	54.36	55.00	−0.57***	0.00**	54.44	54.00	54.15	54.00	54.77	55.00	53.97	55.00	−0.47	1.00
CEO tenure	11.33	8.80	8.71	6.40	−2.62***	−2.40***	9.61	7.30	9.15	7.00	8.15	5.90	7.43	5.40	−2.18***	−1.90***
CEO education	1.69	2.00	2.07	2.00	0.38***	0.00***	1.94	2.00	2.00	2.00	2.15	2.00	2.27	2.00	0.33***	0.00***
Board characteristics																
Board size	8.88	9.00	9.27	9.00	0.39***	0.00***	8.89	9.00	8.93	9.00	9.21	9.00	10.29	10.00	1.40***	1.00***
CEO duality	0.72	1.00	0.72	1.00	0.00	0.00	0.69	1.00	0.69	1.00	0.73	1.00	0.78	1.00	0.09***	0.00***
Interlock	0.06	0.00	0.10	0.00	0.04***	0.00***	0.07	0.00	0.13	0.00	0.09	0.00	0.13	0.00	0.06***	0.00***
Obs	3,325		2,090				688		470		495		437			

Table 1—Continued

	A: Sender firms without any patent outcome		B: Sender firms with at least 1 patent				B: Sender firms with at least 1 patent outcome									
					Difference		Q1 Low		Q2		Q3		Q4 High		Q4 High − Q1 Low	
	Mean	Median	Mean	Median	t-stat	Z-stat	Mean	Median	Mean	Median	Mean	Median	Mean	Median	t-stat	Z-stat
Appointing firm characteristics																
Patent counts	9.12	0.00	59.05	4.00	49.93***	4.00***	55.24	0.00	26.48	2.00	49.92	6.00	91.32	15.00	36.08**	15.00***
Citation counts	239.73	0.00	1445.80	83.95	1206.07***	83.95***	1243.04	0.00	576.99	34.27	1285.51	146.02	2313.94	391.97	1070.90***	391.97***
Citations per patent	8.70	0.00	15.65	11.67	6.95***	11.67***	12.19	0.00	11.88	7.28	18.07	13.73	18.71	16.97	6.52***	16.97***
Total Assets (millions $)	20005.60	4774.07	32656.46	8429.05	12650.86***	3654.98***	29335.21	5716.20	24770.58	6550.00	33496.69	9125.00	39755.19	11551.00	10419.98*	5834.80***
Market-to-book	1.80	1.53	2.08	1.79	0.28***	0.26***	1.91	1.59	1.87	1.57	2.07	1.86	2.37	2.16	0.46***	0.57***
Obs	722		672				164		127		182		199			

Panel B: Variables used for analysing the impact of innovative CEO-directors on firms performance

	A: Treatment sample		B: Control sample		Difference	
	Mean	Median	Mean	Median	t-stat	Z-stat
Before the CEO-director appointment						
ln(1 + Patent counts)	3.11	3.16	3.00	3.09	−0.67	−0.66
ln(1 + Citation counts)	5.75	6.34	5.55	6.05	−0.85	−1.04
ln(1 + Citations per patent)	2.81	2.92	2.71	2.91	−1.04	−0.83
After the CEO-director appointment						
ln(1 + Patent counts)	2.82	2.80	2.46	2.20	−2.03**	−2.17**
ln(1 + Citation counts)	5.18	5.73	4.53	5.20	−2.42**	−2.02**
ln(1 + Citations per patent)	2.49	2.90	2.19	2.81	−2.66***	−2.02**
Obs	396		219			
Firms	132		73			
Firm characteristics						
Total Assets (millions $)	48162.20	6376.57	53815.45	6373.60	0.51	−1.66*
Leverage	0.22	0.21	0.24	0.23	3.25***	3.26***
Cash	0.12	0.07	0.10	0.05	−2.99***	−3.57***
Market-to-book	2.61	1.984	2.13	1.69	−3.91***	−4.77***
R&D	0.05	0.03	0.04	0.02	−3.78***	−5.43***
Return on assets	0.19	0.18	0.17	0.16	−4.07***	−3.57***
Obs	792		438			
Firms	132		73			

	A: Treatment sample		B: Control sample		Difference	
	Mean	Median	Mean	Median	t-stat	Z-stat
Pre-event average operating performance						
ROA	0.176	0.195	0.207	0.174	−1.98**	−1.77*
Size, industry adjusted ROA	0.054	0.029	0.036	0.025	−1.38	−1.03
Size, performance, industry-adjusted ROA	0.034	0.025	0.023	0.013	−1.34	−0.93
Post-event 3-year average operating performance						
ROA	0.176	0.166	0.156	0.150	−1.56	−1.45
Size, industry-adjusted ROA	0.032	0.021	0.023	0.010	−0.83	−0.95
Size, performance, industry-adjusted ROA	0.028	0.029	0.028	0.018	0.01	−0.41
Post-event 5-year average operating performance						
ROA	0.173	0.166	0.159	0.151	−1.16	−1.01
Size, industry-adjusted ROA	0.030	0.020	0.024	0.012	−0.58	−0.40
Size, performance, industry-adjusted ROA	0.027	0.025	0.028	0.017	0.04	−0.15
Obs (for ROA and size, industry-adjusted ROA)	132		73			
Obs (for size, performance, industry-adjusted ROA)	125		66			

Table 2: **Innovativeness and a CEO's probability of holding outside directorships**
This table reports probit regression estimates of the effect of firm innovativeness on a CEO's probability of being outside directors in other firms. Panel A reports the results of Probit and instrumental variable regressions. The dependent variable equals 1 if a CEO holds at least one outside directorship at year t, 0 if not. All independent variables are measured at year t-1. Panel B reports the first-stage regression estimates of the instrumental variable analysis. Variable definitions are in Appendix. Standard errors are robust to heteroskedasticity and within industry and year clustering. Industry classification is based on the Fama-French 49-industry classification. The p-values are in parentheses. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively.

Panel A: Probit and instrumental variable regressions

				Instrumented		
	(1)	(2)	(3)	(4)	(5)	(6)
ln(1 + Patent counts)	0.038*			0.424***		
	(0.065)			(0.009)		
ln(1 + Citation counts)		0.027**			0.210***	
		(0.017)			(0.007)	
ln(1 + Citations per patent)			0.044**			0.323**
			(0.017)			(0.011)
ln(Total assets)	0.220***	0.218***	0.224***	0.055	0.080	0.130***
	(0.000)	(0.000)	(0.000)	(0.476)	(0.217)	(0.010)
Market-to-book	0.042*	0.039*	0.042*	−0.024	−0.019	−0.001
	(0.075)	(0.092)	(0.070)	(0.478)	(0.536)	(0.958)
Return on assets	−0.240	−0.224	−0.232	0.078	0.096	0.037
	(0.387)	(0.420)	(0.402)	(0.801)	(0.757)	(0.901)
Cash	−0.067	−0.077	−0.067	−0.312	−0.321	−0.259
	(0.715)	(0.675)	(0.711)	(0.145)	(0.130)	(0.191)
Leverage	−0.359**	−0.366**	−0.371**	−0.310*	−0.358**	−0.392**
	(0.037)	(0.033)	(0.030)	(0.078)	(0.036)	(0.018)
CAPEX	0.270	0.255	0.280	−0.344	−0.311	−0.154
	(0.548)	(0.570)	(0.533)	(0.513)	(0.549)	(0.754)
Dividend	−0.241	−0.237	−0.221	−0.261	−0.189	−0.095
	(0.263)	(0.271)	(0.304)	(0.224)	(0.371)	(0.656)
Sales growth	0.124	0.120	0.113	0.188*	0.146	0.105
	(0.270)	(0.286)	(0.314)	(0.086)	(0.181)	(0.343)
Capital intensity	−0.106	−0.101	−0.106	0.052	0.038	−0.003
	(0.108)	(0.127)	(0.110)	(0.627)	(0.700)	(0.974)
ln(Firm age)	0.263***	0.262***	0.262***	0.226***	0.229***	0.230***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln(CEO age)	0.597***	0.594***	0.595***	0.667***	0.655***	0.639***
	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
ln(CEO tenure)	0.018	0.019	0.019	0.037*	0.036*	0.030
	(0.394)	(0.357)	(0.369)	(0.091)	(0.094)	(0.148)
CEO education	0.129***	0.128***	0.129***	0.092***	0.095***	0.102***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Board size	−0.006	−0.006	−0.006	−0.005	−0.003	−0.001
	(0.573)	(0.580)	(0.597)	(0.626)	(0.749)	(0.902)
CEO duality	0.062	0.063	0.063	0.057	0.065	0.070
	(0.206)	(0.204)	(0.202)	(0.224)	(0.167)	(0.138)
Interlock	0.884***	0.880***	0.879***	0.836***	0.829***	0.833***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln(1+Number of local firms)	0.033*	0.033*	0.033*	0.022	0.023	0.025
	(0.059)	(0.061)	(0.062)	(0.202)	(0.183)	(0.155)
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry effect	Yes	Yes	Yes	Yes	Yes	Yes
Obs	5,415	5,415	5,415	5,415	5,415	5,415

Table 2−Continued

Panel B: First-stage regressions			
Dependent Variable:	ln(1 + Patent counts)	ln(1 + Citation counts)	ln(1 + Citations per patent)
	(1)	(2)	(3)
ln(CP ratio)	0.083***	0.115***	0.025
	(0.000)	(0.000)	(0.198)
Urban industrial diversity	3.540***	9.418***	6.689***
	(0.000)	(0.000)	(0.000)
ln(Total assets)	0.370***	0.637***	0.267***
	(0.000)	(0.000)	(0.000)
Market-to-book	0.158***	0.297***	0.139***
	(0.000)	(0.000)	(0.000)
Return on assets	−0.689***	−1.516***	−0.850***
	(0.000)	(0.000)	(0.000)
Cash	0.655***	1.382***	0.726***
	(0.000)	(0.000)	(0.000)
Leverage	−0.097	−0.004	0.089
	(0.418)	(0.986)	(0.509)
CAPEX	1.496***	2.914***	1.445***
	(0.000)	(0.000)	(0.000)
Dividend	0.136	−0.104	−0.354*
	(0.402)	(0.751)	(0.077)
Sales growth	−0.177***	−0.147	0.037
	(0.004)	(0.216)	(0.625)
Capital intensity	−0.388***	−0.726***	−0.352***
	(0.000)	(0.000)	(0.000)
ln(Firm age)	0.061**	0.126**	0.083***
	(0.013)	(0.011)	(0.007)
ln(CEO age)	−0.254**	−0.454*	−0.232
	(0.042)	(0.072)	(0.138)
ln(CEO tenure)	−0.057***	−0.103***	−0.046***
	(0.000)	(0.000)	(0.008)
CEO education	0.062***	0.117***	0.061***
	(0.000)	(0.000)	(0.000)
Board size	0.015**	0.021	0.007
	(0.037)	(0.127)	(0.406)
CEO duality	0.003	−0.033	−0.039
	(0.932)	(0.588)	(0.345)
Interlock	0.081*	0.232***	0.154***
	(0.055)	(0.005)	(0.004)
Local director pool	−0.052***	−0.094***	−0.045***
	(0.000)	(0.000)	(0.007)
Year effect	Yes	Yes	Yes
Industry effect	Yes	Yes	Yes
Obs	5,409	5,409	5,409

Table 3: **Innovativeness and a CEO's probability of holding outside directorship: the impact of appointing firms' innovativeness**
This table reports multinomial probit regression estimates of how appointing firms' innovativeness can affect a CEO's probability of holding outside directorship. In panel A, panel B and panel C, the dependent variable equals 0 if a CEO does not hold any outside directorship. In panel A, the dependent variable equals 1 if a CEO holds outside directorships in firms whose citation counts are smaller than the sample median, 2 if a CEO holds outside directorships in firms whose citation counts are larger than the sample median. In panel B, the dependent variable equals 1 if a CEO holds outside directorships in firms whose technological proximity to the CEO's own firm is smaller than the sample median, 2 if a CEO holds outside directorships in firms whose technological proximity to the CEO's own firm is larger than the sample median. In panel C, the dependent variable equals 1 if a CEO holds outside directorships in firms whose R&D intensity is smaller than the sample median, 2 if a CEO holds outside directorships in firms whose R&D intensity is larger than the sample median. In all panels, the dependent is measured at year t and all independent variables are measured at year t-1. Control variables included in the regressions but unreported for brevity are ln(Total assets), Market-to-book, Return on assets, Cash, Leverage, CAPEX, Dividend, Sales growth, Capital intensity, ln(Firm age), ln(CEO age), ln(CEO tenure), CEO education, Board size, CEO duality, Interlock, and ln(1 + Number of local firms). Variable definitions are in Appendix. Standard errors are robust to heteroskedasticity and within industry and year clustering. Industry classification is based on the Fama-French 49-industry classification. The p-values are in parentheses. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively.

							Instrumented					
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
	Y=1	Y=2	Y=1	Y=2	Y=1	Y=2	Y=1	Y=2	Y=1	Y=2	Y=1	Y=2
Panel A: The effect of appointing firm's innovativeness												
ln(1 + Patent counts)	−0.024	0.100***					0.148	1.046***				
	(0.420)	(0.002)					(0.656)	(0.009)				
ln(1 + Citation counts)			−0.010	0.074***					0.103	0.354**		
			(0.537)	(0.000)					(0.486)	(0.030)		
ln(1 + Citations per patent)					−0.010	0.127***					0.220	0.419*
					(0.689)	(0.000)					(0.343)	(0.073)
Panel B: The effect of appointing firm's R&D intensity												
ln(1 + Patent counts)	0.022	0.089***					0.170	0.053				
	(0.522)	(0.003)					(0.307)	(0.698)				
ln(1 + Citation counts)			0.004	0.066***					0.100	0.009		
			(0.807)	(0.000)					(0.198)	(0.893)		
ln(1 + Citations per patent)					−0.013	0.116***					0.212	−0.012
					(0.663)	(0.000)					(0.114)	(0.914)
Panel C: The effect of technological proximity between the sender firm and the appointing firm												
ln(1 + Patent counts)	−0.160***	0.145***					−0.495***	0.545***				
	(0.000)	(0.000)					(0.001)	(0.001)				
ln(1 + Citation counts)			−0.076***	0.105***					−0.210***	0.249***		
			(0.000)	(0.000)					(0.002)	(0.001)		
ln(1 + Citations per patent)					−0.106***	0.184***					−0.305***	0.418***
					(0.000)	(0.000)					(0.010)	(0.001)
Control variables	Yes		Yes		Yes		Yes		Yes		Yes	
Year effect	Yes		Yes		Yes		Yes		Yes		Yes	
Industry effect	Yes		Yes		Yes		Yes		Yes		Yes	
Obs	5,415		5,415		5,415		5,415		5,415		5,415	

Table 4: **Firm innovativeness and the number of outside directorships held by a CEO**
This table reports Tobit regression estimates of the effect of firm innovativeness on the number of outside directorships held by a CEO. The dependent variable is the actual number of outside directorships a CEO holds at year t in panel A, and the weighted number of outside directorships held by a CEO at year t in panel B. All independent variables are measured at year t-1. Variable definitions are in Appendix. Standard errors are robust to heteroskedasticity and within industry and year clustering. Industry classification is based on the Fama-French 49-industry classification. The p-values are in parentheses. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively.

Panel A: The actual number of outside directorships						
Dependent variable	The number of outside directorships (actual)					
				Instrumented		
	(1)	(2)	(3)	(4)	(5)	(6)
ln(1 + Patent counts)	0.064**			0.650**		
	(0.012)			(0.015)		
ln(1 + Citation counts)		0.043***			0.322**	
		(0.002)			(0.010)	
ln(1 + Citations per patent)			0.071***			0.498**
			(0.003)			(0.012)
ln(Total assets)	0.290***	0.287***	0.297***	0.065	0.101	0.175***
	(0.000)	(0.000)	(0.000)	(0.531)	(0.231)	(0.003)
Market-to-book	0.053*	0.050	0.053*	−0.042	−0.035	−0.009
	(0.088)	(0.109)	(0.078)	(0.415)	(0.442)	(0.824)
Return on assets	−0.300	−0.275	−0.290	0.153	0.184	0.097
	(0.429)	(0.468)	(0.443)	(0.738)	(0.683)	(0.822)
Cash	−0.091	−0.102	−0.085	−0.480	−0.492	−0.396
	(0.699)	(0.664)	(0.716)	(0.137)	(0.120)	(0.171)
Leverage	−0.421*	−0.430*	−0.437*	−0.378	−0.446*	−0.494**
	(0.079)	(0.071)	(0.066)	(0.138)	(0.072)	(0.041)
CAPEX	0.032	0.013	0.064	−0.860	−0.810	−0.562
	(0.959)	(0.983)	(0.918)	(0.279)	(0.295)	(0.436)
Dividend	−0.308	−0.303	−0.275	−0.359	−0.249	−0.101
	(0.281)	(0.289)	(0.336)	(0.247)	(0.401)	(0.730)
Sales growth	0.166	0.158	0.147	0.272*	0.205	0.140
	(0.257)	(0.278)	(0.313)	(0.082)	(0.173)	(0.350)
Capital intensity	−0.120	−0.113	−0.121	0.110	0.090	0.029
	(0.176)	(0.203)	(0.171)	(0.482)	(0.528)	(0.819)
ln(Firm age)	0.335***	0.334***	0.333***	0.302***	0.303***	0.302***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln(CEO age)	0.925***	0.923***	0.925***	1.083***	1.056***	1.027***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln(CEO tenure)	0.031	0.033	0.032	0.062*	0.060*	0.052*
	(0.258)	(0.226)	(0.239)	(0.059)	(0.056)	(0.085)
CEO education	0.187***	0.186***	0.188***	0.146***	0.149***	0.157***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Board size	−0.009	−0.009	−0.008	−0.011	−0.008	−0.005
	(0.539)	(0.541)	(0.561)	(0.496)	(0.606)	(0.759)
CEO duality	0.057	0.056	0.057	0.056	0.067	0.075
	(0.394)	(0.398)	(0.393)	(0.416)	(0.330)	(0.275)
Interlock	1.086***	1.080***	1.078***	1.067***	1.041***	1.036***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln(1+Number of local firms)	0.035	0.035	0.035	0.026	0.027	0.029
	(0.133)	(0.140)	(0.139)	(0.288)	(0.270)	(0.233)
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry effect	Yes	Yes	Yes	Yes	Yes	Yes
Obs	5,415	5,415	5,415	5,415	5,415	5,415

Tabel 4−Continued

Panel B: The weighted number of outside directorships						
Dependent variable	The number of outside directorships (weighted)					
				Instrumented		
	(1)	(2)	(3)	(4)	(5)	(6)
ln(1 + Patent counts)	0.036***			0.145***		
	(0.000)			(0.000)		
ln(1 + Citation counts)		0.015***			0.072***	
		(0.000)			(0.000)	
ln(1 + Citations per patent)			0.013***			0.110***
			(0.000)			(0.001)
ln(Total assets)	0.052***	0.058***	0.065***	0.011	0.020	0.038***
	(0.000)	(0.000)	(0.000)	(0.487)	(0.137)	(0.000)
Market-to-book	0.007	0.009*	0.012***	−0.010	−0.008	−0.002
	(0.129)	(0.063)	(0.008)	(0.182)	(0.237)	(0.783)
Return on assets	−0.016	−0.021	−0.040	0.067	0.071	0.046
	(0.783)	(0.717)	(0.492)	(0.332)	(0.305)	(0.492)
Cash	−0.010	−0.003	0.011	−0.083	−0.084	−0.062
	(0.805)	(0.942)	(0.784)	(0.126)	(0.120)	(0.213)
Leverage	−0.100***	−0.104***	−0.104***	−0.091**	−0.106***	−0.117***
	(0.004)	(0.003)	(0.003)	(0.015)	(0.004)	(0.001)
CAPEX	0.082	0.103	0.139	−0.082	−0.063	−0.003
	(0.366)	(0.267)	(0.146)	(0.483)	(0.592)	(0.980)
Dividend	−0.014	−0.006	0.003	−0.025	0.003	0.040
	(0.733)	(0.888)	(0.935)	(0.604)	(0.953)	(0.404)
Sales growth	0.006	−0.000	−0.003	0.025	0.009	−0.005
	(0.798)	(0.995)	(0.882)	(0.307)	(0.701)	(0.834)
Capital intensity	−0.012	−0.016	−0.024*	0.031	0.025	0.010
	(0.378)	(0.237)	(0.071)	(0.212)	(0.264)	(0.615)
ln(Firm age)	0.047***	0.048***	0.049***	0.041***	0.042***	0.042***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln(CEO age)	0.119***	0.120***	0.122***	0.148***	0.147***	0.145***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
ln(CEO tenure)	0.007	0.006	0.005	0.013**	0.012**	0.010**
	(0.114)	(0.139)	(0.263)	(0.015)	(0.015)	(0.046)
CEO education	0.025***	0.026***	0.027***	0.017***	0.018***	0.020***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Board size	−0.002	−0.002	−0.002	−0.003	−0.002	−0.001
	(0.277)	(0.342)	(0.422)	(0.212)	(0.336)	(0.544)
CEO duality	0.013	0.014	0.014	0.013	0.016	0.018
	(0.200)	(0.195)	(0.182)	(0.242)	(0.166)	(0.114)
Interlock	0.147***	0.147***	0.150***	0.142***	0.137***	0.137***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln(1+Number of local firms)	0.005	0.005	0.005	0.003	0.004	0.005
	(0.191)	(0.189)	(0.162)	(0.359)	(0.322)	(0.238)
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry effect	Yes	Yes	Yes	Yes	Yes	Yes
Obs	5,415	5,415	5,415	5,415	5,415	5,415

Table 5: **Innovation efficiency and the number of outside directorships**
This table reports Tobit regression estimates of the effect of innovation efficiency on the number of outside directorships held by a CEO. The dependent variable is the actual number of outside directorships held by a CEO in panel A, and the weighted number of outside directorships held by a CEO in panel B. All independent variables are measured at year t-1. Control variables included in the regressions but unreported for brevity are ln(Total assets), Market-to-book, Return on assets, Cash, Leverage, CAPEX, Dividend, Sales growth, Capital intensity, ln(Firm age), ln(CEO age), ln(CEO tenure), CEO education, Board size, CEO duality, Interlock, and ln(1 + Number of local firms). Variable definitions are in Appendix. Standard errors are robust to heteroskedasticity and within industry and year clustering. Industry classification is based on the Fama-French 49-industry classification. The *p*-values are in parentheses. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively.

				Instrumented		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Dependent variable = the number of outside directorships (actual)						
ln(1 + Patent counts)	0.013			1.025*		
	(0.642)			(0.061)		
ln(1 + Patent counts/R&D Capital)	1.077***			−4.631		
	(0.000)			(0.143)		
ln(1 + Citation counts)		0.012			0.440*	
		(0.516)			(0.061)	
ln(1 + Citation counts/R&D Capital)		0.159***			−0.745	
		(0.005)			(0.146)	
ln(1 + Citations per patent)			0.076***			0.554**
			(0.002)			(0.041)
ln(1 + Citations per patent/R&D Capital)			−0.350			−2.033*
			(0.399)			(0.069)
R&D	0.476	0.343	0.225	−3.690	−2.628	−2.228
	(0.522)	(0.651)	(0.768)	(0.129)	(0.144)	(0.162)
Panel B: Dependent variable = the number of outside directorships (weighted)						
ln(1 + Patent counts)	0.032***			0.197**		
	(0.000)			(0.019)		
ln(1 + Patent counts/R&D Capital)	0.076			−0.853*		
	(0.184)			(0.081)		
ln(1 + Citation counts)		0.011***			0.086**	
		(0.000)			(0.018)	
ln(1 + Citation counts/R&D Capital)		0.022**			−0.137*	
		(0.020)			(0.082)	
ln(1 + Citations per patent)			0.013***			0.113***
			(0.000)			(0.009)
ln(1 + Citations per patent/R&D Capital)			−0.088			−0.438**
			(0.252)			(0.021)
R&D	0.097	0.143	0.207*	−0.581	−0.379	−0.303
	(0.394)	(0.218)	(0.079)	(0.117)	(0.178)	(0.236)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry effect	Yes	Yes	Yes	Yes	Yes	Yes
Obs	5,415	5,415	5,415	5,415	5,415	5,415

Table 6: **High-impact innovations and CEO outside directorships**
This table reports OLS regression estimates of the effect of a firm's high-impact innovation outcome on the change of number of outside directorships held by a CEO. The dependent variable is the annual change of the actual number of outside directorships held by a CEO in Model (1), and the the annual change of the weighted number of outside directorships held by a CEO in Model (2). All independent variables are measured at year t-1. Variable definitions are in Appendix. Standard errors are robust to heteroskedasticity and within industry and year clustering. Industry classification is based on the Fama-French 49-industry classification. The *p*-values are in parentheses. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively.

Dependent variable:	Δ number of outside directorships (actual)	Δ number of outside directorships (weighted)
	(1)	(2)
ln(Top10% patent count)	0.001	0.013**
	(0.941)	(0.029)
ln(Total assets)	0.008**	0.001
	(0.049)	(0.601)
Market-to-book	0.010***	0.002
	(0.006)	(0.242)
Return on assets	0.022	−0.005
	(0.554)	(0.542)
Cash	−0.025	−0.007
	(0.381)	(0.371)
Leverage	−0.009	−0.001
	(0.761)	(0.867)
CAPEX	−0.064	−0.010
	(0.300)	(0.452)
Dividend	−0.064	−0.026**
	(0.149)	(0.013)
Sales growth	0.011	0.001
	(0.547)	(0.679)
Capital intensity	0.008	0.003*
	(0.405)	(0.099)
ln(Firm age)	0.007	0.002
	(0.301)	(0.150)
ln(CEO age)	−0.025	−0.005
	(0.381)	(0.550)
ln(CEO tenure)	−0.012***	−0.002*
	(0.006)	(0.051)
CEO education	0.006	−0.000
	(0.110)	(0.640)
Board size	0.001	0.000
	(0.476)	(0.861)
CEO duality	0.002	−0.002
	(0.864)	(0.420)
Interlock	−0.065***	−0.001
	(0.000)	(0.837)
ln(1+Number of local firms)	−0.000	−0.000
	(0.985)	(0.797)
Year effect	Yes	Yes
Industry effect	Yes	Yes
Obs	5,415	5,415

Table 7: **Exploitative and explorative innovations**
This table reports regression estimates of the effect of exploitative and explorative innovations on the number of outside directorships held by a CEO. All independent variables are measured at year t-1. Variable definitions are in Appendix. Standard errors are robust to heteroskedasticity and within industry and year clustering. Industry classification is based on the Fama-French 49-industry classification. The *p*-values are in parentheses. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively.

Dependent variable:	Outside directorship dummy		Number of outside directorships		Number of outside directorships (weighted)	
	(1)	(2)	(3)	(4)	(5)	(6)
Exploitative patents	−0.185		−0.329		0.279***	
	(0.484)		(0.297)		(0.000)	
Explorative patents		−0.001		0.019		−0.009
		(0.995)		(0.882)		(0.618)
ln(Total assets)	0.238***	0.235***	0.321***	0.315***	0.063***	0.068***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Market-to-book	0.049**	0.049**	0.066**	0.065**	0.014***	0.014***
	(0.031)	(0.032)	(0.028)	(0.030)	(0.003)	(0.002)
Return on assets	−0.269	−0.275	−0.350	−0.361	−0.063	−0.054
	(0.331)	(0.320)	(0.354)	(0.339)	(0.277)	(0.359)
Cash	−0.026	−0.038	−0.024	−0.043	−0.000	0.018
	(0.887)	(0.833)	(0.918)	(0.852)	(0.990)	(0.650)
Leverage	−0.363**	−0.360**	−0.425*	−0.422*	−0.097***	−0.102***
	(0.035)	(0.036)	(0.074)	(0.078)	(0.005)	(0.004)
CAPEX	0.337	0.332	0.162	0.149	0.144	0.156
	(0.455)	(0.462)	(0.794)	(0.811)	(0.129)	(0.105)
Dividend	−0.225	−0.226	−0.269	−0.275	−0.001	0.003
	(0.293)	(0.291)	(0.342)	(0.333)	(0.974)	(0.949)
Sales growth	0.112	0.117	0.145	0.153	0.006	−0.002
	(0.316)	(0.296)	(0.321)	(0.294)	(0.804)	(0.921)
Capital intensity	−0.125*	−0.123*	−0.151*	−0.148*	−0.026*	−0.029**
	(0.060)	(0.064)	(0.086)	(0.095)	(0.051)	(0.027)
ln(Firm age)	0.266***	0.266***	0.340***	0.338***	0.049***	0.050***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln(CEO age)	0.597***	0.600***	0.921***	0.927***	0.127***	0.123***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
ln(CEO tenure)	0.016	0.015	0.027	0.026	0.003	0.004
	(0.463)	(0.472)	(0.333)	(0.342)	(0.469)	(0.405)
CEO education	0.132***	0.132***	0.192***	0.192***	0.028***	0.028***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Board size	−0.006	−0.006	−0.008	−0.008	−0.002	−0.002
	(0.610)	(0.604)	(0.592)	(0.587)	(0.406)	(0.453)
CEO duality	0.062	0.063	0.057	0.059	0.016	0.014
	(0.212)	(0.206)	(0.389)	(0.378)	(0.127)	(0.173)
Interlock	0.887***	0.887***	1.089***	1.091***	0.152***	0.152***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln(1+Number of local firms)	0.034*	0.033*	0.037	0.036	0.005	0.005
	(0.056)	(0.057)	(0.117)	(0.123)	(0.177)	(0.141)
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry effect	Yes	Yes	Yes	Yes	Yes	Yes
Obs	5,415	5,415	5,415	5,415	5,415	5,415

Table 8: **Robustness tests**

This table reports Tobit regression estimates of a set of robustness tests of the effect of firm innovativeness on the number of outside directorships held by a CEO. The dependent variable is the actual number of directorships a CEO holds in model (1)−(6), and the weighted number of directorships a CEO holds in model (7)−(12). All independent variables, except in panel A, are measured at year t-1. The firm innovativeness measure is ln(1 + Patent counts) in the model (1), (4), (7), and (10), ln(1 + Citation counts) in the model (2), (5), (8), and (11), ln(1 + Citations per patent) in the model (3), (6), (9), and (12), respectively. Control variables included in the regressions but unreported for brevity are ln(Total assets), Market-to-book, Return on assets, Cash, Leverage, CAPEX, Dividend, Sales growth, Capital intensity, ln(Firm age), ln(CEO age), ln(CEO tenure), CEO education, Board size, CEO duality, Interlock, and ln(1 + Number of local firms). Variable definitions are in Appendix. Standard errors are robust to heteroskedasticity and within industry and year clustering. Industry classification is based on the Fama-French 49-industry classification. The p-values are in parentheses. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively.

	Dependent variable = number of directorships (actual)						Dependent variable = number of directorships (weighted)					
				instrumented						instrumented		
Firm innovativeness measure	Patent counts	Citation counts	Citations per patent	Patent counts	Citation counts	Citations per patent	Patent counts	Citation counts	Citations per patent	Patent counts	Citation counts	Citations per patent
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: Addressing reverse causality												
Firm innovativeness at t-3	0.072***	0.056***	0.103***	0.687**	0.291**	0.456**	0.038***	0.018***	0.017***	0.135**	0.060***	0.097***
	(0.005)	(0.000)	(0.000)	(0.049)	(0.043)	(0.037)	(0.000)	(0.000)	(0.000)	(0.011)	(0.007)	(0.005)
Obs	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415
Panel B: Remove self-citations												
Firm innovativeness	–	0.039***	0.065***	–	0.314**	0.474**	–	0.017***	0.012***	–	0.065***	0.101***
	–	(0.007)	(0.009)	–	(0.038)	(0.034)	–	(0.000)	(0.002)	–	(0.005)	(0.004)
Obs	–	5,415	5,415	–	5,415	5,415	–	5,415	5,415	–	5,415	5,415
Panel C: Control for CEO ownership, board ownership and CEO overconfidence												
Firm innovativeness	−0.019	−0.003	0.008	2.692***	0.885***	1.140***	0.019***	0.007**	0.004	0.434***	0.143***	0.186***
	(0.585)	(0.882)	(0.801)	(0.010)	(0.002)	(0.001)	(0.002)	(0.014)	(0.344)	(0.005)	(0.001)	(0.000)
CEO overconfidence	−0.150**	−0.148**	−0.146**	0.179	0.060	−0.016	−0.013	−0.014	−0.016	0.037	0.018	0.005
	(0.039)	(0.042)	(0.044)	(0.357)	(0.625)	(0.863)	(0.219)	(0.197)	(0.153)	(0.205)	(0.336)	(0.730)
CEO ownership	−0.212	−0.212	−0.205	−0.010	0.307	0.457	−0.031	−0.028	−0.030	0.001	0.053	0.078
	(0.839)	(0.839)	(0.843)	(0.994)	(0.786)	(0.672)	(0.831)	(0.847)	(0.838)	(0.995)	(0.745)	(0.615)
Board ownership	−1.149	−1.143	−1.139	−0.097	−0.551	−0.807	−0.146	−0.149	−0.153	0.014	−0.060	−0.101
	(0.136)	(0.138)	(0.139)	(0.928)	(0.529)	(0.321)	(0.173)	(0.168)	(0.159)	(0.932)	(0.639)	(0.389)
Obs	2,890	2,890	2,890	2,890	2,890	2,890	2,890	2,890	2,890	2,890	2,890	2,890
Panel D: Firm random-effect												
Innovation outcome	0.103***	0.043***	0.029	0.602	0.233	0.335	0.032***	0.011***	0.005	0.070	0.027	0.039
	(0.000)	(0.004)	(0.171)	(0.319)	(0.319)	(0.319)	(0.000)	(0.000)	(0.252)	(0.529)	(0.529)	(0.529)
Obs	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 9: Post-appointment innovation performance

This table reports the estimates of the effect of an innovative CEO-director appointment on the appointing firm's innovation performance. The estimates from OLS regression using a difference-in-difference specification are presented in this table. The dependent variable is the appointing firm's annual innovation outcome from *t*-3, skipping year *t* and *t*+1, to *t*+4, where *t* is the year of appointment. The unit of observation is a firm-year. *After* is a dummy variable that equals 1 after the appointment and 0 otherwise. *Treat* is a dummy variable that equals 1 for the treatment group (sender firm has non-zero innovation outcomes) and 0 for the control group (sender firm has zero innovation outcomes). *High Innovativeness* is a dummy variable that equals 1 if the sender firm's innovation outcomes over three years prior to the appointment are larger than the median value of all sender firms in the treatment group and 0 otherwise. *High proximity* is a dummy variable that equals 1 if the technological proximity between the sender firm and the appointing firm is larger than the sample median of the treatment group and 0 otherwise. *High R&D* is a dummy variable that equals 1 if the appointing firm's R&D intensity over three years prior to the appointment are larger than the median value of all appointing firms in the treatment group and 0 otherwise. Control variables included in the regressions but unreported for brevity are ln(Total assets), Market-to-book, Return on assets, Cash, Leverage, and R&D. Variables are defined in Appendix. Standard errors are robust to heteroskedasticity and within firm and year clustering. Industry classification is based on the Fama-French 49-industry classification. The *p*-values are in parentheses. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively.

Dependent variable:	ln(1+Patent counts)	ln(1+Citations counts)	ln(1+Citations per patent)	ln(1+Patent counts)	ln(1+Citations counts)	ln(1+Citations per patent)
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: The impact of innovative CEO-directors on the appointing firm's innovation performance						
After × Treat	0.122*	0.333**	0.209**	0.099	0.319**	0.218**
	(0.075)	(0.010)	(0.030)	(0.147)	(0.015)	(0.024)
After	−0.062	−0.337	−0.337**	−0.058	−0.329	−0.332**
	(0.588)	(0.124)	(0.042)	(0.603)	(0.133)	(0.044)
Constant	3.706***	7.749***	3.921***	1.549**	6.894***	5.414***
	(0.000)	(0.000)	(0.000)	(0.042)	(0.000)	(0.000)
Adj. R^2	0.919	0.875	0.592	0.924	0.875	0.595
Panel B: Sender firm's innovativeness and post-appointing innovation performance						
After × Treat × High Innovativeness	0.403***	0.741***	0.395***	0.343***	0.736***	0.448***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
After × Treat	−0.059	−0.001	0.031	−0.053	−0.008	0.020
	(0.468)	(0.995)	(0.803)	(0.516)	(0.961)	(0.877)
After	−0.085	−0.379*	−0.360**	−0.079	−0.374*	−0.359**
	(0.450)	(0.078)	(0.029)	(0.473)	(0.082)	(0.028)
Constant	3.577***	7.511***	3.795***	1.516**	6.824***	5.371***
	(0.000)	(0.000)	(0.000)	(0.045)	(0.000)	(0.000)
Adj. R^2	0.921	0.878	0.597	0.925	0.878	0.601
Panel C: Technological proximity and post-appointing innovation performance						
After × Treat × High Proximity	−0.072	0.291*	0.409***	0.064	0.368**	0.350***
	(0.414)	(0.053)	(0.000)	(0.457)	(0.018)	(0.003)
After × Treat	0.158**	0.189	0.007	0.067	0.135	0.044
	(0.046)	(0.229)	(0.953)	(0.391)	(0.408)	(0.728)
After	−0.061	−0.340	−0.340**	−0.059	−0.335	−0.337**
	(0.592)	(0.120)	(0.038)	(0.597)	(0.124)	(0.039)
Constant	3.687***	7.828***	4.033***	1.498**	6.601***	5.136***
	(0.000)	(0.000)	(0.000)	(0.049)	(0.000)	(0.000)
Adj. R^2	0.919	0.875	0.597	0.924	0.876	0.598
Panel D: Appointing firm's R&D intensity and post-appointing innovation performance						
After × Treat × High R&D	0.072	0.253*	0.278**	0.034	0.248	0.312***
	(0.421)	(0.097)	(0.011)	(0.699)	(0.109)	(0.004)
After × Treat	0.089	0.215	0.080	0.084	0.205	0.075
	(0.249)	(0.173)	(0.512)	(0.283)	(0.196)	(0.538)
After	−0.066	−0.350	−0.351**	−0.060	−0.342	−0.349**
	(0.567)	(0.109)	(0.033)	(0.592)	(0.116)	(0.033)
Constant	3.707***	7.751***	3.923***	1.557**	6.954***	5.490***
	(0.000)	(0.000)	(0.000)	(0.041)	(0.000)	(0.000)
Adj. R^2	0.919	0.877	0.605	0.924	0.875	0.597
Control variables	No	No	No	Yes	Yes	Yes
Firm effect	Yes	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
No. of Treatment Events	132	132	132	132	132	132
No. of Control Events	73	73	73	73	73	73
Obs	1,230	1,230	1,230	1,230	1,230	1,230

Table 10: **Post-appointment operating performance**
This table reports regression estimates of a firm's post-appointment abnormal operating performance. The dependent variable is the average annual operating performance over 3 years or 5 years skipping a gap of two years after the appointment of an innovative CEO-director. The independent variable is the average annual operating performance over 3 years before the appointments. In model (1) and (2), a firm's operating performance is measured by unadjusted ROA (defined in Appendix). In model (3) and (4), a firm's operating performance is measured by ROA adjusted by the median ROA of firms in the same Fama-French 49 industry and size decile. In model (5) and (6), a firm's operating performance is measured by ROA adjusted by the ROA of a matched firm that is from the same Fama-French 49 industry with an ROA in event year −3 that is within ± 10% of the appointing firm and that is closet in size. We also report p-values of Chow tests comparing the structural difference and statistical equality of the constant term across the treat group regression and the control group regression. Standard errors are robust to heteroskedasticity and within year and industry clustering. Industry classification is based on the Fama-French 49-industry classification. The p-values are in parentheses. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively.

Measure of operating performance:	ROA		Size, industry-adjusted ROA		Size, performance, industry-adjusted ROA	
	(1) Treat	(2) Control	(3) Treat	(4) Control	(5) Treat	(6) Control
Panel A: Post-appointment 3-year average operating performance						
Constant	0.189***	0.059*	0.048*	−0.063***	0.103***	−0.042***
	(0.000)	(0.082)	(0.054)	(0.000)	(0.001)	(0.002)
Pre-event operating performance	0.345***	0.676***	0.301***	0.613***	0.626***	0.841**
	(0.001)	(0.000)	(0.004)	(0.001)	(0.003)	(0.011)
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry effect	Yes	Yes	Yes	Yes	Yes	Yes
Obs	132	73	132	73	125	66
Adj. R^2	0.473	0.465	0.738	0.563	0.359	0.396
Test of equality across two regressions (Chow test)						
Structural difference	(0.000)***		(0.000)***		(0.000)***	
Equality of the constant term	(0.000)***		(0.000)***		(0.000)***	
Panel B: Post-appointment 5-year average operating performance						
Constant	0.207***	0.061*	0.081***	−0.066***	0.105***	−0.038***
	(0.000)	(0.080)	(0.001)	(0.000)	(0.002)	(0.001)
Pre-event operating performance	0.285***	0.552***	0.242**	0.512***	0.530**	0.985***
	(0.007)	(0.001)	(0.019)	(0.008)	(0.023)	(0.001)
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry effect	Yes	Yes	Yes	Yes	Yes	Yes
Obs	132	73	132	73	125	66
Adj. R^2	0.462	0.512	0.719	0.603	0.214	0.440
Test of equality across two regressions (Chow test)						
Structural difference	(0.000)***		(0.000)***		(0.000)***	
Equality of the constant term	(0.000)***		(0.000)***		(0.029)**	

Table A1: Correlation matrix

Variable	Number of directorships	Weighted number of	ln(1+Patent counts)	ln(1+Citation counts)	ln(1+Citations per patent)	ln(1+Patent counts/RDC	ln(1+Citation counts/RDC	ln(1+Citations per patent/ RDC	R&D	ln(Total assets)	Market-to-book
Number of directorships	1.000										
Weighted number of directorships	0.750	1.000									
ln(1 + Patent counts)	0.162	0.380	1.000								
ln(1 + Citation counts)	0.143	0.315	0.957	1.000							
ln(1 + Citations per patent)	0.108	0.209	0.800	0.938	1.000						
ln(1 + Patent counts/R&D capital)	0.045	0.122	0.584	0.579	0.504	1.000					
ln(1 + Citation counts/R&D capital)	0.047	0.153	0.704	0.741	0.686	0.906	1.000				
ln(1 + Citations per patent/R&D capital)	−0.029	−0.030	0.102	0.184	0.264	0.330	0.312	1.000			
R&D	−0.072	0.029	0.343	0.386	0.391	0.213	0.312	0.043	1.000		
ln(Total assets)	0.313	0.352	0.300	0.243	0.151	−0.064	−0.039	−0.145	−0.239	1.000	
Market-to-book	−0.049	0.009	0.162	0.176	0.167	0.147	0.193	0.096	0.369	−0.211	1.000
Return on assets	−0.004	−0.003	−0.065	−0.077	−0.084	−0.042	−0.061	0.038	−0.171	−0.012	0.385
Cash	−0.122	−0.045	0.182	0.219	0.229	0.162	0.237	0.065	0.574	−0.327	0.434
Leverage	0.057	0.008	−0.064	−0.080	−0.086	−0.070	−0.108	−0.039	−0.237	0.300	−0.301
CAPEX	−0.034	−0.044	−0.117	−0.128	−0.129	−0.019	−0.049	0.039	−0.096	−0.010	0.065
Dividend	0.087	0.097	0.058	0.033	0.003	−0.033	−0.047	−0.032	−0.167	0.191	−0.012
Sales growth	−0.042	−0.050	−0.033	−0.012	0.009	0.052	0.056	0.112	0.159	−0.097	0.231
Capital intensity	0.003	−0.024	−0.119	−0.137	−0.141	−0.070	−0.104	−0.039	−0.131	0.175	−0.142
ln(Firm age)	0.236	0.215	0.139	0.109	0.072	−0.068	−0.072	−0.073	−0.214	0.421	−0.231
ln(CEO age)	0.126	0.080	−0.033	−0.043	−0.047	−0.048	−0.059	−0.047	−0.156	0.122	−0.167
ln(CEO tenure)	0.025	−0.010	−0.133	−0.132	−0.118	−0.067	−0.084	−0.007	−0.051	−0.105	−0.006
CEO education	0.151	0.145	0.187	0.183	0.162	0.097	0.109	0.049	0.127	0.148	0.027
Board size	0.207	0.207	0.158	0.116	0.059	−0.065	−0.067	−0.087	−0.188	0.601	−0.131
CEO duality	0.091	0.087	0.029	0.007	−0.015	−0.017	−0.038	−0.044	−0.099	0.135	−0.015
Interlock	0.332	0.244	0.072	0.069	0.058	0.020	0.024	−0.009	−0.033	0.160	−0.035
Local director pool	−0.002	0.050	0.172	0.174	0.154	0.080	0.113	0.003	0.198	0.060	0.085

Table A1−Continued

	Return on assets	Cash	Leverage	CAPEX	Dividend	Sales growth	Capital intensity	ln(Firm age)	ln(CEO age)	ln(CEO tenure)	CEO education	Board size	CEO duality	Interlock	Local director pool
Return on assets	1.000														
Cash	−0.117	1.000													
Leverage	−0.093	−0.382	1.000												
CAPEX	0.333	−0.122	0.046	1.000											
Dividend	0.025	−0.136	−0.013	−0.133	1.000										
Sales growth	0.279	0.116	−0.028	0.238	−0.184	1.000									
Capital intensity	−0.023	−0.166	0.291	0.544	0.005	0.071	1.000								
ln(Firm age)	−0.038	−0.283	0.102	−0.102	0.384	−0.233	0.012	1.000							
ln(CEO age)	−0.011	−0.202	0.040	−0.005	0.065	−0.068	0.026	0.190	1.000						
ln(CEO tenure)	0.038	0.002	−0.020	0.076	−0.061	0.047	0.043	0.007	0.369	1.000					
CEO education	−0.075	0.039	0.030	−0.049	−0.016	0.027	0.018	0.061	0.015	−0.080	1.000				
Board size	−0.008	−0.306	0.205	−0.043	0.260	−0.124	0.054	0.401	0.104	−0.145	0.107	1.000			
CEO duality	0.058	−0.073	−0.003	0.030	0.016	−0.007	−0.006	0.098	0.190	0.294	−0.010	0.090	1.000		
Interlock	−0.010	−0.082	0.044	0.003	0.035	−0.029	0.029	0.099	0.074	0.049	0.086	0.154	0.068	1.000	
Local director pool	−0.089	0.220	−0.089	−0.112	−0.075	0.028	−0.085	−0.078	−0.022	−0.049	0.025	−0.013	−0.023	−0.046	1.000

Table A2: Variable definition

Variable	Definition
The number of outside directorships (actual)	Total number of outside directorships held by a CEO in S&P 1500 firms during the year.
The number of outside directorships (weighted)	$\sum_1^n 1_i/\text{Ranking}_{it}$ where 1_{it} refers to one outside directorship held by a CEO in firm i at time t, Ranking_i is the decile ranking of the appointing firm sorted by its patent counts in the same Fama-French 49 industry, and n is the total number of directorships a CEO holds.
Patent counts	Number of patents applied for and eventually granted during the year.
Citation counts	Total number of citations summed across all patents applied for and eventually granted during the year. For each patent, citation count is multiplied by the weighting index estimated by the empirical citation-lag distribution.
Citations per patent	Patent counts/Citation counts
Technological proximity	$T_i T_j'/(T_i T_i')^{1/2}(T_j T_j')^{1/2}$ where T_i=(T_{i1}, T_{i2},..., T_{i426}) and $T_{i\tau}$ is the average share of patents of firm i in technology class τ over 30 years prior to the appointment.
Top10% patent count	A firm's total number of patents that are in the top 10% category of the economic value (following the measure in Kogan et al. (2017)) in a given 3-digit class and application year.
Exploitative patents	The percentage of a firm's exploitative patents to its total number of patents filed in a given year. A patent is defined as an exploitive patent if at least 80% of the citations it refers are from existing knowledge, which includes all the patents that the firm produced and all the patents that were cited by the firm's patents filed over the past five years.
Explorative patents	The percentage of a firm's explorative patents to its total number of patents filed in a given year. A patent is defined as an explorative patent if at least 80% of the citations it refers and not from existing knowledge, which includes all the patents that the firm produced and all the patents that were cited by the firm's patents filed over the past five years.
R&D	R&D expenditures/lagged assets. Missing values are substituted with zero.
R&D Capital	$R\&D_{i,t-1} + 0.8 \times R\&D_{i,t-2} + 0.6 \times R\&D_{i,t-3} + 0.4 \times R\&D_{i,t-4} + 0.2 \times R\&D_{i,t-5}$
Return on assets (ROA)	Operating income before depreciation/lagged assets
Sales growth	Current sales/lagged sales − 1
Cash	Cash/assets
Dividend payout ratio	Dividends paid to common and preferred shareholders/operating income before depreciation
Leverage	(long-term debt+short-term debt)/assets
CAPEX	Capital expenditures/lagged assets
Capital intensity	Net property, plant, and equipment/sales
Market-to-book	(total assets − book equity + market value of equity − deferred taxes) / total assets
Firm age	Years in CRSP-Compustat merged database.
CEO age	−
CEO education	Number of qualifications a CEO has.
Board size	Number of directors on the CEO's own board.
CEO duality	Binary variable taking a value of one if a CEO is also chairman of the board, zero otherwise.
Interlock	Number of board interlocks the firm has with other firms.
CEO ownership	Percentage of common stock owned by a CEO.
Board ownership	Percentage of common stock owned by the officers and directors of the firm (including CEO onwership).
CEO overconfidence	Indicator variable equals 1 for all years after a CEO holds options that are at least 67% in the money, and 0 otherwise.
Number of local firms	The number of U.S. nonfinancial and nonutility firms headquartered within sixty miles of the firm's headquarters, excluding firms in the same 4-digit SIC industry.
CP ratio	The Catholics-to-Protestants ratio in the county where a firm is headquartered.
Urban industrial diversity	One minus the Herfindahl index of local employment across two-digit industries in the county where a firm is headquartered.