Drivers of Firm Innovation: The Role of Overconfidence and Gender in the C-Suite

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Abstract

Prevailing research suggests that firms led by female executives tend to be more risk-averse, a characteristic often linked to reduced corporate risk-taking. Given the critical role of risk-taking in fostering innovation, it would be natural to infer that such firms may lag in innovative pursuits. Challenging this oversimplification, I analyze the overlooked dimension of overconfidence among female executives. I find that firms with a larger share of overconfident females in the C-suite are more innovative – securing more patents, earning more citations, and increasing the monetary value of their patent portfolios. This effect is accentuated in innovation-driven industries. These results underscore the need for a more nuanced approach to examining how executive personal characteristics like overconfidence intersect with gender in shaping corporate innovation.

1. Introduction

In a world characterized by rapid technological advancements and shifting consumer preferences, innovation serves as the critical driver that can either propel firms forward or leave them falling behind. It is more than just the introduction of a novel idea; it's a mechanism that propels business growth, captures market share, and ensures sustained relevance in a competitive landscape. However, the road to innovation is fraught with risk. Investment in unproven technologies or strategies requires substantial resources and comes with no guarantee of return. In this high-stakes, high-reward environment, understanding the drivers of innovation becomes crucial. In light of the risk inherent in innovative activities, understanding the risk-taking behaviors of key decision-makers becomes especially salient. Consequently, Upper Echelons Theory serves as a useful framework, suggesting that the personalities, experiences, and characteristics of a firm's top management team can be predictive of its strategic and innovative pursuits (Hambrick and Mason, 1984).

The corporate world's executive landscape has, however, undergone a seismic shift over the last few decades. Increasingly, we observe the ascent of women to the pinnacles of corporate leadership, a movement that holds profound implications for organizational strategy and outcomes. With the rising prevalence of women in C-suite roles, academic interest has grown in understanding how their leadership styles, decision-making processes, and propensities for risk-taking influence firm behavior. A narrative has emerged from this body of research: firms with pronounced female leadership seem to display a more conservative risk profile (Huang and Kisgen, 2013; Faccio, Marchica, and Mura, 2016; Madaleno, Teodósio, and Vieira, 2021).

However, a limitation in much of this existing research is its implicit assumption that all female executives are homogenous when it comes to risk-taking behaviors. While many studies do not explicitly state this, the empirical frameworks mechanistically treat all women as identical in their risk profiles. Considering the pioneering nature of the research and the limited availability of data, this approach is understandable. However, it does not capture the full spectrum of individual attributes that shape decision-

making in both men and women. As women continue to become more represented in top management positions, grasping the nuanced differences in individual attributes, like divergent attitudes toward risk, becomes increasingly important for a comprehensive understanding of organizational leadership.

Another factor shaping executive risk-taking is overconfidence. This psychological trait leads individuals to overestimate their abilities and the probability of favorable outcomes. Overconfidence in executives has a dual-edged impact on corporate strategies. On one hand, it can result in excessive risk-taking, culminating in overinvestment and potentially value-destructive mergers and acquisitions (Malmendier and Tate, 2005; 2008). On the other hand, overconfidence can stimulate innovation and prevent potential underinvestment problems, thereby aligning corporate strategies with optimal risk levels (Goel and Thakor, 2008; Campbell et al., 2011). Although male executives are more likely to be overconfident relative to female executives, overconfidence manifests itself in both men and women influencing corporate risk profiles in ways that are not solely attributable to gender differences. Therefore, overlooking overconfidence as an individual attribute in discussions of executive risk-taking could yield incomplete and potentially misleading conclusions.

Though overconfidence is often attributed to male executives, its influence among female leaders is underexplored. Given that innovation inherently involves risk—something female executives generally shy away from but overconfident executives embrace—the impact of overconfident female leaders on firm innovation becomes a compelling question. This study aims to elucidate the distinct effects of overconfident and non-overconfident female executives on firm innovation. By doing so, it adds a nuanced layer to our understanding of executive diversity, recognizing multidimensional traits that span both gender and psychological factors like overconfidence.

To investigate the relationship between overconfidence, gender, and firm innovation, I study S&P 1500 firms from 1996 to 2019. I explore how the firm's innovative activities—measured through patent counts, citation counts, and dollar value of innovation—are influenced by the overconfidence and gender traits of the top 5 executives in the C-suite. Utilizing the option-based measure for overconfidence proposed

by Malmendier and Tate (2005), I identify an executive as overconfident if they refrain from exercising deep in-the-money options. I then sort each executive into one of four exclusive categories: 1) overconfident male, 2) non-overconfident male, 3) overconfident female, and 4) non-overconfident female. My categorization reveals that male executives are more likely to exhibit overconfidence, aligning with existing literature on gender disparities. However, a notable percentage of female executives also delay option-exercising, indicating that gender alone is not a sufficient indicator of overconfidence.

My empirical analysis presents a nuanced understanding of executive risk-taking behaviors and its impact on firm innovation across multiple dimensions. First, I find that firms with a larger proportion of overconfident female executives exhibit a notably higher level of patent activity, challenging existing assumptions about risk-averse female leadership. Similarly, these firms also yield higher citation counts, indicative of the substantial impact and recognition of their innovations in the broader industry. Furthermore, when assessing the real dollar value generated from innovation, I find that firms led by overconfident female executives again outperform their counterparts. These results substantiate my hypothesis that the effects of female executives on innovation are divergent, contingent on their levels of overconfidence. Importantly, after accounting for the influence of overconfident CEOs – whether they are male or female – overconfident female executives maintain a significant positive effect on innovation outcomes. Similarly, this finding holds after controlling for the influence of female board members. That is, overconfident female executives appear to have a positive impact on firm innovation in addition to, and independent of, the effects from the CEO and board of directors.

Yet, the influence of overconfident female executives on innovation is not uniform across all firms; rather, it varies significantly depending on what industry they operate in and the firm's own orientation toward innovation. First, I find that the effect that overconfident female executives have on innovation is pronounced in firms operating within innovative industries. In these sectors, a higher proportion of overconfident female executives significantly boosts measures of innovation such as patent acquisition, citation counts, and the dollar value of patents. The impact is notably diminished in less innovative

industries. Moreover, when examining firms based on their individual track record for innovation, I find that overconfident female executives serve as key drivers of patent activity in firms that are themselves highly innovative. Conversely, the value derived from innovation is notably enhanced by overconfident female executives in less innovative firms. Interestingly, there is also preliminary evidence to suggest that non-overconfident female executives could negatively impact innovation outcomes in highly innovative firms. These findings underscore that the impact of executive traits on innovation is contingent on the innovative standing of the firm and the specific measure of innovation, suggesting a multifaceted interplay between executive overconfidence, gender, and organizational context.

Further bolstering the robustness of these findings, Instrumental Variable (IV) analysis is employed to address potential endogeneity issues. Adapting Adams and Ferreira's (2009) instrument, the first IV is the fraction of board members with past negative experiences with overconfident female executives at other firms. Second, similar to Huang and Kisgen's (2013) instrument, the second IV is the total number of females with at least a master's degree in the state where the firm is incorporated. Both IVs are aimed at isolating the effect of overconfident female executives on firm innovation. This analysis confirms the primary results, lending credence to the argument that the impact of overconfident female executives on firm innovation is not merely a result of omitted variables or reverse causality.

This study offers several contributions to existing research on executive behavior, gender, and corporate innovation. Firstly, it challenges the prevailing narrative that firms led by female executives are inherently risk-averse by isolating the effects of overconfidence among female leaders. This nuanced analysis reveals that overconfident female executives significantly drive innovation in firms, thereby enriching our understanding of the multi-faceted relationship between gender, psychological traits, and corporate outcomes. My research also underscores the need for a more granular approach that considers the interplay between multiple executive attributes rather than treating them as monolithic categories. Additionally, I show that the impact of overconfident female executives on firm innovation is both additive to and independent of the influence exerted by CEOs and boards. This finding broadens the scope of inquiry

into corporate governance, suggesting that researchers should pay closer attention to the entire executive team when examining drivers of innovation. Lastly, my findings offer preliminary evidence that the relationship between executive traits and firm innovation is moderated by the firm's industry and its own innovative orientation, opening up avenues for future research to explore these interactions more deeply.

2. Motivation and Hypothesis Development

In the dynamic corporate environment, the role that executive behavioral characteristics have in influencing decision-making processes cannot be overstated. Specifically, characteristics that affect risk-taking behavior, which tend to vary across genders, often result in distinct decision-making patterns that shape the strategic direction of firms, particularly for firm innovation – an endeavor marked by high uncertainty and potential for substantial returns. My study examines how executive overconfidence and gender influences the degree and quality of firm innovation. In this section, I will discuss how executive overconfidence and gender are likely to affect firm innovation.

2.1. The C-suite and Firm Innovation

Neoclassical economic theory suggests that firm outcomes are independent of the firm's managers. That is, firm decision-makers are utility-maximizers and homogenous across their abilities and attitudes, thus, in equilibrium they are inconsequential to firm outcomes. Conversely, Upper Echelons Theory has emerged as a critical framework in understanding how a firm's top managers, particularly executives, shape its course and performance. It postulates that the personal traits, characteristics, beliefs, and biases of top managers guide the firm's strategic direction. In essence, the firm becomes a reflection of its leadership (Hambrick and Mason, 1984). Empirical evidence reinforces the connection between managers' attributes and corporate behavior. Bertrand and Schoar (2003) find that managerial fixed effects play a significant role in explaining the differences in investment, financial, and organizational practices across firms, suggesting that managerial heterogeneity can lead to variations in firm behavior and outcomes. Recent studies further confirm the influence of managerial attributes, with firms displaying strategies and policies

that are closely aligned with the individual characteristics of their top managers (Kaplan, Klebanov, and Sorensen, 2012; Custodio, and Metzger, 2014; Bernile, Bhagwat, and Rau, 2016).

Innovation necessitates the willingness to pursue novel concepts, assume risks, and, at times, challenge conventional norms. Thus, top executives' risk-taking preferences, inclinations, and behaviors become the primary mechanism through which their personal characteristics shape the firm's innovative direction. That is, the very nature of innovation requires the embrace of uncertainty and comfort with failure, making the connection between personal risk preferences and organizational innovation particularly pronounced. An executive with a high propensity for risk-taking might foster a workplace culture that encourages bold and ambitious efforts, aiming not for modest gains but for transformative breakthroughs potentially leading to the development of disruptive new technologies. In contrast, an executive with a low propensity for risk-taking may guide the firm towards incremental progress, maintaining a stable and predictable growth trajectory. This relationship between individual executive risk preferences and firm innovation underscores why managerial idiosyncrasies are especially consequential in the innovative process.

The role of CEOs in shaping corporate strategy and outcomes is well-documented and often the focal point of managerial studies. However, a nuanced understanding of firm behavior necessitates a broader perspective that includes other C-suite executives. Individual CFOs, CTOs, and CIOs possess considerable decision-making power in their own right, contributing unique expertise and insights that enhance the strategic choices of the firm (Huang and Kisgen, 2013; Wu, Dbouk, Hasan, Kobeissi, and Zheng, 2021). These non-CEO executives often collaborate with and, at times, challenge the CEO's direction, reflecting their value in steering corporate strategies.

In addition to their individual influence, the collective decision-making power of all non-CEO C-suite members is increasingly acknowledged as a potent force. Their cumulative knowledge and varied perspectives can foster a more robust and adaptive approach to innovation. While the CEO may be the most influential individual, the combined input of the entire C-suite can at times wield more significant sway,

reflecting a complex and dynamic interplay within the executive team (Quintana-García and Benavides-Velasco, 2016; Hyun, Kim, Han, and Anderson, 2022). This perspective resonates with recent research that adopts a more holistic approach by examining the cumulative effects of the entire executive team on firm outcomes, rather than focusing solely on individual roles.

2.2. Executive Overconfidence and Firm Innovation

Among various executive characteristics that impact corporate decision-making, behavioral biases – particularly overconfidence – have attracted substantial attention. Overconfidence, defined as a systematic overestimation of one's abilities or the precision of one's knowledge (Kahneman and Tversky, 1979; Moore and Healy, 2008), has been extensively studied in psychology and behavioral sciences. Research in these fields illustrates the individual variations in overconfidence, including gender differences, and establishes the positive correlation between overconfidence and risk-taking (Langer and Roth, 1975; Weinstein, 1980; Barber and Odean, 2001). The ramifications of overconfidence become especially pronounced in financial decision-making, where individuals must formulate expectations about the future (Odean 1998; Benos 1998; Daniel, Hirshleifer, and Subrahmanyam, 1998).

Executives within firms are not exempt from overconfidence and may be particularly prone to it (Goel and Thakor, 2008). Their overconfidence holds significant implications for shareholders, as it leads them to overestimate potential investment returns and underestimate associated risks. Consequently, overconfident executives are more likely to overinvest compared to their rational counterparts, all else held equal. This behavioral pattern influences various firm outcomes. For example, firms led by overconfident CEOs exhibit larger investment–cash flow sensitivities, engage in more value-destroying mergers and acquisitions, and carry more short-term debt (Malmendier and Tate, 2005; Malmendier and Tate, 2008; Huang, Tan, and Faff, 2016).

The persistence of employing overconfident executives prompts the question: Why do firms continue to hire leaders whose irrationality distorts decision-making? One theory suggests that overconfidence effectively counterbalances risk aversion, guiding executives toward an optimal investment

strategy (Goel and Thakor, 2008; Campbell, Gallmeyer, Johnson, Rutherford, and Stanley, 2011). Herein lies the intriguing intersection between overconfidence and innovation: While overconfidence can lead to certain pitfalls, it may also be beneficial in a high-risk, high-reward environment, such as firm innovation. Innovation requires comfort with uncertainty, a trait that overconfident executives might exhibit through underestimating the risks involved. Moreover, the impact of overconfidence might be more pronounced for innovative activities, given the complexity and delayed feedback associated with such endeavors (Einhorn, 1980; Griffin and Tversky, 1992). Research confirms the connection between overconfidence and enhanced innovation, with firms led by overconfident CEOs securing more patents and citations, especially in innovation-intensive industries (Hirshleifer, Low, and Teoh, 2012).

2.3. Executive Gender and Firm Innovation

The relationship between gender, particularly female leadership, and risk-taking in corporate environments has been a subject of extensive investigation. This inquiry is grounded in a broader understanding of decision-making differences between men and women. Experts across various disciplines, especially in psychology and behavioral science, have demonstrated distinct gender-based decision-making patterns. These differences not only manifest themselves in general behaviors but also notably in financial decision-making. Sapienza, Zingales, and Maestripieri (2009) find that, owing to differences in testosterone, male MBA students are inclined to choose riskier careers in the financial industry. Conversely, Powell and Ansic (1997) determine through experimentation that males employ riskier strategies in financial environments, although these strategies do not significantly impact performance. Further corroborating this theme, Meng, Tang, and Xu (2014) provide a comprehensive review, documenting that firms with female management are associated with a reduction in corporate risk-taking. The synthesis of these studies forms the foundational understanding that female leadership is generally characterized by less risk-taking, which likely impacts firm innovation.

Firms that embrace risk are often more inclined to invest in research and development, explore new markets, and pursue disruptive technologies, leading to increased patents and citations (Hirshleifer et al.,

2012). Further, as established in the preceding section, female executives tend to exhibit lower levels of risk-taking behavior. This has profound implications for firms led by female managers. Drawing on the well-documented negative association between female leadership and risk-taking, it can be inferred that firms with a greater proportion of female leadership may be characterized by less aggressive innovation strategies. However, relevant literature documents the opposite effect. That is, firms with a female CTO as well as firms with a larger proportion of female board members attain more patents and citations, implying a positive relationship between female leadership and firm innovation (Wu, Dbouk, Hasan, Kobeissi, and Zheng, 2021; Chen, Lueng, and Evans, 2018; Griffin, Li, and Xu, 2021). Although these studies attribute their findings to psychological and behavioral difference between men and women, differences in risk-taking is not discussed. This connection between gender, risk-taking, and innovation provides a complex and multifaceted landscape that warrants deeper examination, especially in light of conflicting findings in existing literature, as will be explored further.

2.4. Hypothesis Development

The positive relationship between executive overconfidence and firm innovation is a well-established concept in the existing literature. Overconfident executives, driven by a self-assured belief in their judgments, are more likely to undertake risky projects resulting in increased firm innovation. However, the relationship between gender and risk-taking presents a more complex and nuanced picture. On the one hand, theoretical perspectives suggest that female executives exhibit more risk-averse behavior, leading to a negative relationship between female executives and firm innovation. On the other hand, recent empirical studies have reported a positive relationship between female executives and firm innovation without considering risk-taking characteristics. Importantly, these studies assume that all females share identical psychological and behavioral traits, including those that affect risk-taking. This assumption overlooks the fact that individuals, irrespective of their gender, may vary significantly in their attitudes towards risk. That is, the positive relationship between female executives and firm innovation may not be wholly attributed to managerial styles. Instead, this effect might be a consequence of variations in risk-taking behavior among

female executives, indicating that risk-taking could be a crucial underlying factor driving innovation – for both male and female executives.

In light of these discrepancies, my study offers an alternative explanation by examining the interplay between gender and overconfidence in relation to risk-taking. While overconfidence consistently leads to increased risk-taking, and being female is associated with decreased risk-taking, the effect of these factors on firm innovation is more complex. The well-established positive relationship between overconfidence and innovation contrasts with the ambiguous findings concerning the role of female executives in innovation. By distinguishing between overconfident and non-overconfident female executives, I intend to explore this complexity, shedding light on the underlying risk-taking behaviors that may reconcile these conflicting effects. Thus, I predict that overconfident female executives and non-overconfident female executives will have differential effects on firm innovation, as measured by the attainment of patents, citations on those patents, the quality of patents, and the value realized from those patents. This hypothesis underscores the importance of considering individual variations in risk-taking behavior and avoids simplifying the complex interplay between gender and overconfidence. It provides a novel perspective that can help reconcile the conflicting findings in the existing literature and offers a promising avenue for future research on executive behavior and firm innovation.

3. Data and Methods

3.1. Data

I construct my sample by integrating data from various sources. My starting point is firm-level accounting data for all S&P1500 firms, obtained from Compustat, coupled with stock return data from CRSP. This dataset excludes financial firms and utilities. For my overconfidence measure, I collate executive compensation data from Execucomp. Firm innovation is gauged using patent and citation data from Kogan et al. (2017), available on Noah Stoffman's academic website. I integrate this data with the firm's accounting records, preserving all firm-year observations that have corresponding accounting data available, even when the firm-year recorded zero patents and/or citations. I derive governance metrics from

ISS Risk Metrics, while institutional ownership data is extracted from 13F-HR filings via the SEC's Edgar database. Consequently, the sample consists of 11,379 firm-year observations spanning the period from 1996 to 2019.

3.2. Measuring Overconfidence and Gender

3.2.1. Executive-level Measure of Overconfidence

A widely utilized proxy for executive overconfidence relies on the premise that executives are subject to a substantial amount of firm-specific risk. Conventional wisdom suggests they should mitigate this risk as much as possible. First introduced by Malmendier and Tate (2005), Holder67 leverages this idea, classifying an executive as overconfident if they neglect to exercise an 'in-the-money' option that is priced at least 67% above the exercise price. The underlying rationale is that a risk-averse executive would exercise these options to secure a guaranteed return and diversify their portfolio.

The 67% threshold originates from the model developed by Hall and Murphy (2002), which assumes a constant relative risk aversion (CRRA) coefficient of 3. To be included in this categorization, an executive must demonstrate such behavior at least twice, and the exercisable options they hold must constitute a minimum of 50% of their total annual compensation, as per Execucomp's TDC1. Because overconfidence is perceived as a persistent trait, an executive is labeled as overconfident from their first instance of such behavior.

In the absence of detailed information on each executive's option package, I apply the methodology from Campbell et al. (2011) to compute the average moneyness of all exercisable options in each executive's portfolio. This involves scaling the average realizable value per option by the average exercise price. The average realizable value per option is derived by dividing the total realizable value of exercisable options (as indicated by the Execucomp variable OPT_UNEX_EXER_EST_VAL) by the total number of these options (OPT_UNEX_EXER_NUM). The resultant figure is then reduced by the stock price at the close of the fiscal year (PRCCF). This approach effectively omits unexercisable options, averting any risk of misclassifying an executive who possesses high moneyness options but lacks the ability to cash them in.

3.2.2. Firm-Level Measure of Executive Overconfidence and Gender

My study investigates the interplay between executive overconfidence and gender and its effects on firm innovation. Because of this, I establish several firm-level variables that measure the overconfidence and gender characteristics of the firm's C-suite. In doing so, I first categorize each individual executive as either male or female according to their GENDER designation in Execucomp. Next, for each executive-year I use Holder67 to classify each executive as either overconfident or not overconfident. This classification scheme creates four mutually exclusive groups. Namely, each executive is either an overconfident male, non-overconfident male, overconfident female, or non-overconfident female in any given year. Subsequently, I form binary measures I(Overconfident-Male)-CEO, I(Overconfident-Female)-CEO, and I(Non-Overconfident-Female)-CEO that signify whether a firm-year had an overconfident male CEO, an overconfident female CEO, or a non-overconfident female CEO, respectively. Furthermore, I generate firm-level metrics of gender and overconfidence based on the top 5 C-suite executives ranked by total compensation. P(Overconfident-Male)-top 5, P(Overconfident-Female)-top 5, and P(Non-Overconfident-Female)-top 5 are metrics denoting the proportion of overconfident male, overconfident female, and non-overconfident female executives, respectively.[1]

3.3. Measuring Innovation

I follow prior relevant literature and employ several proxies for firm innovation based on patent and citation data (Hirshleifer et al., 2012; Chen et al., 2018; Wu et al., 2021). I begin with the entire history of U.S. patent data collected via Google Patents. Using this data, I assign each individual patent application to public firm-years in the Compustat database dropping the patent applications for which I do not have firm accounting data. Then, I construct several proxies for firm innovation, all of which are aggregated at the firm-year level using individual patent data. Patent Count is the total number of patent applications that

[1] As a robustness test, I use the binary measures of these same variables. These measures begin with a prefix "I" rather than "P". For example, I(Overconfident-Female)-top 5 is binary and indicates that a particular firm-year had at least one overconfident female in the C-suite. The descriptions of other proportion measures are analogous to indicators described above. A detailed description of all variables is available in the Appendix.

eventually approved. I match using the submission year rather than the granting year as it is a more accurate measure of the firm's innovativeness for the current C-suite.

In addition to raw patent counts, I employ several other measures of innovation that aim to capture the quality of the patent. Patent Value – Nominal is the value of innovation in millions of nominal dollars. Patent Value – Real is the value of innovation in millions of real dollars deflated to 1982. Another common measure that captures the quality of a patent is the patent's citation count. However, using a simple citation count induces truncation bias. That is, recently approved patents have not had an equivalent amount of time to accumulate citations compared to older patents, despite potentially being higher quality. To address this issue, I follow Hirshleifer et al. (2012) in developing two measures. For the first correction, the citation count for each patent is normalized by comparing it to the average citation count of all patents in its respective technology class and year of application. I then define TTcitation which represents the aggregate of the adjusted citation counts for all the patents that the company has applied for within that specific year. For the second correction, every patent's citation count is weighted in accordance with the index proposed by Hall, Jaffe, and Trajtenberg (2001, 2005). Subsequently, Qcitation represents the collective total of these corrected citation counts from all patents filed within that particular year.

3.4. Control Variables

To isolate the effect of executive overconfidence and gender on innovation, several control variables come into play, based on the approach of Hirshleifer et al. (2012). For firm-level controls, firm size, calculated as the natural log of total sales, and capital intensity, calculated as the natural log of net property, plant, and equipment scaled by total employees, are included (Hall and Ziedonis, 2001).

The firm's buy-and-hold annual stock return serves as a control, as large past returns can result in high moneyness options for the firm's executives, potentially correlating with the proxies for firm innovation. The percentage of shares held by financial institutions, averaged over the fiscal year, factors into this analysis as well, following the "lazy managers" hypothesis proposed by Aghion, Van Reenen, and

Zingales (2009).

Characteristics of the firm's managers also play a significant role. Tenure-CEO measures the years the CEO has served in their current role within the firm. To account for the financial incentives of the executives, 'Delta' and 'Vega' are calculated. 'Delta' reflects the dollar change in each executive's stock and option portfolio for a 1% fluctuation in the firm's stock price. 'Vega' captures the dollar change in an executive's option holdings for a 1% shift in the firm's stock return volatility. These measures help gauge an executive's motivation to boost the firm's stock price and take on greater risks. Delta-top 5 and Vega-top 5 serve as the averages of Delta and Vega, respectively, for the firm's top 5 highest-paid executives.

Board of directors' attributes also factor into the analysis. Sierra-Morán, Cabeza-García, González-Álvarez, and Botella (2021) link governance quality and firm innovation closely, prompting the inclusion of the size of the board of directors as a proxy for governance quality. P(Independent)-Board and P(Female)-Board are calculated to reflect the fraction of the firm's directors with independent appointments and the proportion of the firm's directors who are female, respectively (Chen, Leung, and Evans, 2018).

3.5. Descriptive Statistics

Table 2 outlines the descriptive statistics for the sample used to explore the relationship between executive overconfidence, executive gender, and firm innovation. Initial observations reveal that around 7% of top 5 executives, on average, are females. Overconfident and non-overconfident females constitute about 3.3% and 3.7% of this group, respectively. Yet, non-reported statistics indicate that approximately 23% of all firm-years feature at least one female executive. A deeper dive shows that about 11.3% of firm-years include at least one overconfident female executive, and 13.4% of firm-years have at least one non-overconfident female executive. When focusing on the CEO position, data reveals that around 3.3% of firm-years have a female CEO, 2.1% feature an overconfident female CEO, and 1.1% have a non-overconfident female CEO.

Turing to the patent data, the mean number of patents per year is about 44 with a median of just 1 indicating substantial positive skewness. In fact, about 49% of firm-years have zero patents. Similarly,

about 52% of firm-years have zero citations, with a mean of 478 citations in a given firm-year. Further, the average patent receives about 10.8 citations, although this is also highly skewed. Lastly, the average patent garners roughly $1.5M in value for the firm.

3.6. Empirical Methodology

My objective is to explore the interaction between executive overconfidence and gender at the firm level, examining the relationship of the C-suite's personal characteristics with the firm's innovation propensity, as indicated by its achievement of patents and citations. My empirical specification, therefore, takes the following general form:

$$(1)\ Innovation_{i,t} = f\big(Overconfidence\ \&\ Gender\ Characteristics_{i,t} + Firm\ Characteristics_{i,t} + Executive\ Characteristics_{i,t} + Board\ Characteristics_{i,t} + Ownership\ Characteristics_{i,t} + Year\ Effect_t + Firm\ Effect_i\big)$$

where equation (1) is OLS. $Innovation_{i,t}$ is a proxy for firm innovation (e.g., Patent Count), and $Overconfidence\ \&\ Gender\ Characteristics_{i,t}$ are firm-level measures of the overconfidence and gender characteristics of the C-suite. $Firm\ Characteristics_{i,t}$ encompass the natural log of sales, the natural log of property plant and equipment scaled by total employees, and the previous year's stock return. $Executive\ Characteristics_{i,t}$ include the tenure of the CEO, the natural log of one plus the average Delta for the top 5 executives, and the natural log of one plus the average Vega for the top 5 executives. $Board\ Characteristics_{i,t}$ account for the natural log of the board of directors' size, the proportion of the board of directors with independent seats, and the proportion of the board of directors who are female. Lastly, $Ownership\ Characteristics_{i,t}$ refer to institutional ownership, expressed as a percentage of total stockholder's equity.

In exploring the impact of executive overconfidence and gender on firm innovation, endogeneity issues can arise due to unobserved firm characteristics. There might be omitted variables that affect both

the likelihood of hiring or promoting overconfident and female executives and the firm's innovation. For example, some firms might have a more progressive or risk-embracing culture, thereby hiring more overconfident and female executives, and promoting innovation. To address this, I include firm fixed effects to control for any time-invariant unobserved firm characteristics, such as corporate culture. I underscore only the results that remain consistent when I incorporate these fixed effects.

However, there may still be time-variant unobservable variables that affect both innovation and the firm's propensity to employ overconfident female executives. Another concern is reverse causality. That is, innovative firms might naturally attract or promote executives based on their overconfidence and gender characteristics. To ensure I am identifying the correct direction of the relationship, I use two instrumental variables (IV). The first, inspired by Adams and Ferreira (2009), is the fraction of board members that have had at least one negative experience working with an overconfident female executive at another firm that isn't the focal firm. A director has a 'negative experience' when the firm falls beneath the 25th percentile of industry-adjusted annual return. This IV, denoted as P(Overconfident-Female-Connection)-Board, assumes that board members are inclined to avoid working with similar executives following an unfavorable outcome.

My second IV, inspired by Huang and Kisgen's (2013) instrument, is the total number of females (in millions) that have earned a masters, professional, or doctoral degree in the state where the firm is incorporated. I denote this variable N(Female)-Higher Education. This instrument assumes the number of highly educated women in the vicinity impacts a firm's likelihood of having female C-suite members but is unlikely to correlate with firm innovation other than thought its effect on the proportion of the firm's C-suite comprised of overconfident women. I get education data from U.S. Census Bureau API.

I use these IVs to instrument for the proportion of overconfident female executives in the C-suite. I focus on overconfident female executives for two reasons. First, all variables that capture executive overconfidence and gender characteristics are endogenous. Thus, for brevity I instrument for P(overconfident-Female)-top 5 and omit P(Overconfident-Male)-top 5 and P(Non-Overconfident-Female)-

top 5 from the analysis. Second, P(Overconfident-Male)-top 5, P(Non-Overconfident-Male)-top 5, P(Overconfident-Female)-top 5, and P(Non-Overconfident-Female)-top 5 must sum to 1 by design. Thus, if I employ the full model in the first stage, the F-statistic would be artificially inflated to a large degree.

4. Empirical Analysis and Results

4.1. Executive Overconfidence, Executive Gender, and Firm Innovation

This section presents my empirical findings, focusing on the nuanced relationship between executive overconfidence, executive gender, and the level of innovation within firms. Unique to this study is the nuanced approach that allows for within-gender variation in levels of overconfidence. I hypothesize that both gender and overconfidence serve as co-determinants of a firm's inclination towards innovation. More pointedly, the impact on innovation varies not only between male and female executives but also within these gender categories based on the degree of overconfidence exhibited.

4.1.1. Patent and Citation Activity

To assess the divergent impacts of overconfident and non-overconfident female executives on firm innovation, I scrutinize patent acquisition and subsequent citations as proxies. I introduce firm-level variables capturing the C-suite's gender and confidence traits: specifically, P(Overconfident-Male)-Top 5, P(Overconfident-Female)-Top 5, and P(Non-Overconfident-Female)-Top 5.[2] .

Table 2 outlines the results. In column (1), the dependent variable is the natural logarithm of one plus the total number of patents applied for in a given year that were eventually granted.[3] First, I find that firms with a larger proportion of overconfident male executives attain more patents; however, this finding is only significant at the 10% level. To test my first hypothesis explicitly, I examine the effects of overconfident and non-overconfident female executives separately. I find that non-overconfident female

[2] Because these variables must sum to 1, P(Non-Overconfident-Male)-top 5 is omitted and serves as a baseline for interpretation of results.

[3] Patents applied for but never granted are not included in the sample. Using the year in which the firm applied for the patent is a more accurate measure of current innovation activity compare to using the year in which the patent was eventually granted.

executives have no significant effect on a firm's propensity to attain patents. Conversely, firms with a larger proportion of overconfident female executives attain significantly more patents, even after controlling for the effect of overconfident male executives and other determinants of firm innovation.

Next, I investigate the firm's propensity to attain citations on their patents, with the results shown in columns (2) and (3) of Table 2. Firms with a larger proportion of overconfident female executives attain significantly more patent citations after adjusting for truncation bias. In columns (4) and (5), I use total nominal value and total real value as dependent variables, respectively. Firms with a larger proportion of overconfident female executives achieve significantly higher returns in the form of total value from patents, supplementing the positive effect from overconfident male executives. Economically speaking, adding a single overconfident female to the C-suite results in an increase roughly three times that of adding an overconfident male executive. This finding is significant at the 1% level across all proxies for firm innovation.

While Table 2 assumes equal decision-making power among all C-suite members, the role of the CEO is notably distinct. CEOs wield greater influence, particularly in shaping the firm's innovation strategies. Hirshleifer et al. (2012) substantiate this by showing that overconfident CEOs significantly drive innovation. Therefore, it is crucial to examine the CEO's impact separately. In Table 3 I consider differential effects between the CEO and the rest of the C-suite.[4] Interestingly, consistent with related literature, I find that overconfident CEOs have a pronounced positive effect on firm innovation across all innovation proxies. Turning to my variables interest, I find that firms with a greater proportion of overconfident female executives are associated with increased innovative activities across all five proxies for innovation in addition to, and independent of, the CEO. Lastly, I find that firms with a non-overconfident female CEO attain significantly less patents and patent citations, although this effect is estimated using a relatively small

[4] P(Overconfident-Male)-top 5, P(Overconfident-Female)-top 5 and P(Non-Overconfident-Female)-top 5 only include the non-CEO C-suite members in the top 4 non-CEO members.

sample of non-overconfident female CEOs.[5]

Together, these results substantiate my hypothesis that overconfidence serves as a distinguishing factor in the impact of female executives on firm innovation. Specifically, firms with a greater proportion of overconfident female executives not only exhibit enhanced innovation but also realize tangible value from such innovative activities. Conversely, non-overconfident female executives do not yield a significant influence on innovation outcomes. Interestingly, these effects are independent of, and in addition to the positive impact of overconfident male executives – especially an overconfident male CEO. Lastly, after controlling for the proportion of female board members—a factor previously linked to increased firm innovation in the literature (Chen, Lueng, and Evans, 2018; Griffin, Li, and Xu, 2021)—I find that overconfident female executives still significantly contribute to greater innovation in their firms. This underscores the importance of considering individual risk-taking traits, like overconfidence, when evaluating the role of female executives in firm innovation, instead of treating all female executives as a homogenous group influenced solely by gender-based managerial styles.

4.1.2. Patent and Citation Activity for Firms in Innovative Industries

Building upon established literature, this subsection probes the nuanced interplay between executive overconfidence, gender, and firm innovation across firms in differing industries. Given that innovation often correlates with a higher appetite for risk, one might anticipate a more substantial influence of overconfident executives—regardless of gender—on firm innovation in industries with elevated levels of innovative activity.

To distinguish between innovative and non-innovative industries, I employ a metric grounded in patent citation statistics. An industry is classified as innovative if its prior-year average Qcitation count per patent surpasses the median Qcitation count calculated across all industry categories. For the purposes of

[5] Although this sample is relatively small, relevant literature has derived results from smaller samples. For example, Lee and James (2007) find that the market tends to react negatively to female CEOs using a sample of just 17 female CEOs. This is in comparison to my sample of 84 female CEOs and 240 female CEO firm-years.

this categorization, industry classifications are based on their two-digit SIC codes.

To test this hypothesis, I partition the sample into firms operating in innovative and non-innovative industries and present the corresponding outcomes in Tables 4A and 4B. My findings underscore that the relationship between a higher proportion of overconfident female executives and enhanced firm innovation is primarily observed within firms operating in innovative industries. Specifically, in these sectors, firms with a higher proportion of overconfident female executives significantly outperform in terms of patent acquisition, citation counts, and the monetary value derived from patents. Conversely, their influence appears muted in less innovative industry contexts.

To bolster these findings, in Table 4C I interact all executive overconfidence and gender metrics with a binary variable indicating whether a firm is part of an innovative industry. This analysis corroborates the previous results, reinforcing that the positive impact of overconfident female executives on firm innovation is accentuated in innovative industries. Interestingly, column (2) also suggests that non-overconfident female executives are associated with a significantly reduced number of citations within these innovative industries, although this finding is only significant at 10%.

4.1.3. Patent and Citation Activity for Innovative Firms

In extending our understanding of the complex interplay between executive traits and firm innovation, this subsection explores whether the observed effects hold true when the firms themselves are segmented based on their innovative track record, rather than the industries they operate in. Specifically, I classify a firm as 'innovative' if its average Qcitation count per patent during a given year surpasses the industry average for the same period.

In Tables 5A and 5B I split up the firms into innovative firms and non-innovative firms and rerun regressions on several proxies for firm innovation. The analysis reveals a complex landscape. Looking first at patent counts, overconfident female executives are key drivers of innovation in highly innovative firms. In contrast, in firms with less of an innovation focus, overconfident male executives drive patent activity. When turning to TTcitation an interesting pattern emerges. Non-overconfident female executives negatively

impact this metric in innovative firms, while none of the variables of interest are significant for non-innovative firms, suggesting that the relationship between executive characteristics and TTcitation is more nuanced in these settings.

In Table 5B I find that in innovative firms, overconfident female executives positively influence Qcitation while non-overconfident female executives negatively influence Qcitation, although both are significant at only 10% significance level. In non-innovative firms, overconfident male executives are associated with higher Qcitation levels, albeit again only at the 10% level. Finally, when assessing the real dollar value of patents, neither male nor female executives significantly impact this measure in innovative firms, regardless of their level of overconfidence. Interestingly, in non-innovative firms, both overconfident female and male executives contribute positively and significantly to the real dollar value of patents.

In Table 5C I repeat these tests in a different empirical setting. That is, I interact all measures of executive overconfidence and gender with a binary variable that indicates an innovative firm. Results paint a clearer picture. That is, the positive effect that overconfident female executives have on firm innovation is pronounced for firms that are especially innovative for patent counts, Qcitation, and the real dollar value of patents. On the other hand, this effect appears to be pronounced in non-innovative firms for TTcitation.

Overall, these results suggest that the impact of executive overconfidence and gender on firm innovation is conditional on both the firm's innovative standing and the specific measure of innovation considered. It underlines the need for a multifaceted approach when studying these complex dynamics.

4.1.4. Patent Quality

To complement my analysis on the quantity of patents, this subsection scrutinizes their quality. Specifically, the quality is evaluated based on citations per patent (TTcitation and Qcitation) and the realized dollar value per patent. These additional measures allow for a more nuanced understanding of the multifaceted impact of executive traits on innovation. Results are outlined in Table 6A and 6B.

In Table 6A, I find mixed results depending on the quality metric considered. For TTcitation per patent, overconfident executives—regardless of gender—have no significant effect. Interestingly, the

presence of non-overconfident female executives is negatively associated with this measure, albeit only significantly at the 10% level. For Qcitation per patent, female executives—whether overconfident or not—do not significantly influence the metric, while overconfident male executives do, positively. Lastly, when assessing the real dollar value per patent, both overconfident male and overconfident female executives have a positive impact.

In Table 6B I examine the effects that executive overconfidence and gender have on patent quality in innovative vs. non-innovative industries. First, in column (1), I find that the negative effect that non-overconfident female executives have on TTcitation per patent is pronounced for firms in innovative industries. This finding is now significant at 5%. In column (2) I find that the positive impact that overconfident male executives have on Qcitation per patent is concentrated in innovative industries. Finally, in column (3) I find that the positive effect that both overconfident male and female executives have on patent value in real dollars per patent is driven by firms in innovative industries. These findings are consistent with the overarching idea that the impacts of executive overconfidence and gender, both of which influence risk-taking behavior, are most pronounced in firms within innovative industries. While previous sections focused on the quantity of innovation, this section substantiates that the quality of innovation is similarly influenced by these complex dynamics.

4.1.5. Instrumental Variables Approach

To further validate the robustness of my findings and mitigate potential endogeneity issues, I employ an instrumental variables (IV) approach. Given that executives are not randomly assigned to firms, there are unobserved factors that could be influencing both the firm's propensity for innovation and its likelihood of hiring executives based on their overconfidence and gender traits.

For the IV analysis, I make use of two instruments. The first instrument, consistent with my Empirical Methodology section, is the proportion of board members who have had a negative experience with an overconfident female executive at another firm, denoted as P(Overconfident-Female-Connection)-Board. The second instrument is the total number of females (in millions) who have earned a master's,

professional, or doctoral degree from a university located in the state where the firm is incorporated.

I employ a two-stage process for the IV analysis. In the first stage, a Tobit model with censoring at 0 and 1 is used to predict the proportion of overconfident female executives. The Tobit model is chosen to account for the censored nature of the proportion variable. In the second stage, I use OLS to predict various measures of firm innovation. In both stages, I focus solely on P(Overconfident-Female)-top 5, omitting P(Overconfident-Male)-top 5 and P(Non-Overconfident-Female)-top 5. I do this for two reasons. First, despite all overconfidence and gender variables being endogenous, my primary interest lies in P(Overconfident-Female)-top 5. Second, the proportions of overconfident male, overconfident female, non-overconfident male, and non-overconfident female executives must sum to one, by construction. Thus, focusing on overconfident female executives allows me to mitigate concerns related to the other proportions that are essentially determined by the focus variable.

The results of this IV analysis are presented in Table 7. I report the first-stage results in column (1). Satisfying the relevance restriction, both P(Overconfident-Female-Connection)-Board and N(Female)-Higher Education are significantly related to the endogenous variable P(Overconfident-Female)-top 5 and display the expected signs. Moreover, an F-statistic value of 13.2, well above commonly accepted thresholds, alleviates concerns about weak instruments. I then perform four second-stage regressions on proxies of firm innovation, with results shown in columns (2) through (5). Across all tests, the results consistently support the notion that firms with a greater proportion of overconfident female executives tend to be more innovative, achieving more patents and citations and realizing higher value from innovative activities.

5. Conclusion

In the fast-paced landscape of modern business, the role of innovation has become indispensable. Executive leadership, particularly the C-suite, often spearheads—or stifles—innovation within firms. This study adds depth to the growing body of literature on executive behavior and corporate innovation by offering a nuanced understanding of how overconfidence and gender, specifically among female executives,

influence a firm's innovation outcomes. Importantly, this study challenges the existing narrative that suggests female executives are universally risk-averse, revealing that levels of overconfidence can significantly modify this general trend.

My research makes several contributions that challenge and enrich existing literature. First, it refutes the conventional wisdom that gender alone dictates risk-taking and, by extension, innovation. My findings reveal that firms with a higher proportion of overconfident female executives display increased patent activity, higher citation counts, and greater innovation value. Notably, the influence of these overconfident female executives enhances—rather than merely echoes—the impact of CEOs and board directors. This underscores the need for future research to broaden its focus beyond just the CEO and the board, examining the role of the entire executive team in shaping organizational outcomes.

Moreover, my study adds nuanced layers to our understanding of how specific executive traits interact with different firm contexts. Rather than treating traits like overconfidence or risk-aversion as universally beneficial or detrimental, my results indicate that their impact is contingent upon the firm's innovative orientation and industry environment. In essence, this suggests there's no one-size-fits-all approach to evaluating executive traits; their effectiveness depends on the specific circumstances and needs of the firm.

As the number of female executives continues to rise, this demographic shift holds dual significance—both academic and practical. First, with more females ascending to upper management roles, it becomes increasingly impractical to sustain monolithic views about female risk-taking behavior, highlighting the need for a more nuanced understanding that incorporates traits such as overconfidence. Second, the expanded pool of female executives provides a robust sample size for future research, thereby enhancing the statistical power needed to draw more definitive conclusions about the intricate interplay of executive traits, gender, and organizational outcomes. In the context of ever-evolving executive leadership, ongoing exploration of these variables is not just enlightening but also critical, paving the way for meaningful avenues of future research.

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Appendix A: Variable Description

Variable	Description
P(Overconfident-Male)-top 5	The proportion of non-CEO executives that are overconfident males
P(Overconfident-Female)-top 5	The proportion of non-CEO executives that are overconfident females
P(Non-Overconfident-Female)-top 5	The proportion of non-CEO executives that are female and not overconfident
I(Overconfident-Male)-top 5	Indicator that equals one if there is at least one overconfident non-CEO male executive in the top five executives for a given firm-year
I(Overconfident-Female)-top 5	Indicator that equals one if there is at least one overconfident non-CEO female executive in the top five executives for a given firm-year
I(Non-Overconfident-Female)-top 5	Indicator that equals one if there is at least one non-CEO female executive who is not overconfident in the top five executives for a given firm-year
I(Overconfident-Male)-CEO	Indicator for firm-year in which the CEO is an overconfident male
I(Overconfident-Female)-CEO	Indicator for firm-year in which the CEO is an overconfident female
I(Non-Overconfident-Female)-CEO	Indicator for firm-year in which the CEO is a non-overconfident female
Patent Count	Number of patents applied for during the year
Citation Count	Total number of citations summed across all patents applied for during the year.
TTcitation	Total number of citations summed across all patents applied for during the year. Each patent's number of citations is divided by the average citation count of all patents in the same technology class and applied in the same year.
Qcitation	Total number of citations summed across all patents applied for during the year. Each patent's number of citations is multiplied by the weighting index from Hall, Jaffe, and Trajtenberg (2001, 2005).
Patent Quality	Average number of citations per patent summed across all patents granted during the year
Patent Value – Nominal	Value of innovation in millions of nominal dollars
Patent Value – Real	Value of innovation deflated to 1982 (million) dollars using the CPI
Sales	Firm sales (in millions)
PPE/EMP	Net property, plant, and equipment (in thousands) per employee
Stock Return	Buy-and-hold return over the fiscal year
Tenure-CEO	Tenure of the CEO
Delta – top 5	Dollar change (in thousands) in executive's stock and option portfolio for 1% change in stock price averaged across the top 5 executives
Vega – top 5	Dollar change (in thousands) in executive's options holdings for 1% change in stock price averaged across the top 5 executives
Institutional Ownership	Percentage of shares held by financial institutions, averaged over the fiscal year
Board Size	Natural log of the total number of members on the board of directors
P(Female)-Board	Proportion of the board of directors made up of females
P(Independent)-Board	Proportion of independent appointments on the board of directors

Appendix B: Primary Analysis

Table 1: Summary Statistics

This table provides summary statistics for variables used to predict the firm innovation. P(Overconfident-Male)-top 5 is the proportion of the top 5 executives who are overconfident males. P(Overconfident-Female)-top 5 is the proportion of the top 5 executives who are overconfident females. P(Non-Overconfident-Female)-top 5 is the proportion of the top 5 executives who are female and not overconfident. I(Overconfident-Male)-CEO is an indicator for an overconfident male CEO. I(Overconfident-Female)-CEO is an indicator for an overconfident female CEO. I(Non-Overconfident-Feale)-CEO is an indicator for a non-overconfident female CEO. Patent Count is the total number of patents applied for during the year. Citation Count is the total number of citations summed across all patents applied for during the year. TTcitation is the total number of citations divided by the average citation count of all patents in the same technology class and applied in the same year. Qcitation is the total number of citations multiplied by the weighting index from Hall, Jaffe, and Trajtenberg (2001, 2005). Patent Quality is the number of patents applied for during the year. Patent Value-Nominal is the value of innovation in millions of nominal dollars. Patent Value-Real is the value of innovation in millions of real dollars deflated using CPI. Sales is firm sales (in millions) PPE/EMP is net property, plant, and equipment (in thousands) per employee. Stock Return is buy-and-hold return over the fiscal year. Tenure-CEO is the tenure (in years) of the CEO. Delta-top 5 is the dollar change (in thousands) in executive's stock and option portfolio for 1% change in stock price averaged across the top 5 executives. Vega-top 5 is the dollar change (in thousands) in executive's options holdings for 1% change in stock price averaged across the top 5 executives. Institutional Ownership is the percentage of shares held by financial institutions, averaged over the fiscal year.

Statistic	N	Mean	Min	25%	Median	75%	Max	St. Dev.
P(Overconfident-Male)-top 5	11,379	0.519	0	0.200	0.500	0.800	1	0.359
P(Overconfident-Female)-top 5	11,379	0.033	0	0	0	0	1	0.102
P(Non-Overconfident-Female)-top 5	11,379	0.037	0	0	0	0	1	0.103
I(Overconfident-Male)-CEO	11,379	0.667	0	0	1	1	1	0.471
I(Overconfident-Female)-CEO	11,379	0.021	0	0	0	0	1	0.144
I(Non-Overconfident-Female)-CEO	11,379	0.011	0	0	0	0	1	0.103
Patent Count	11,379	44.29	0	0	1	14	8,890	242
Citation Count	11,379	478.1	0	0	0	83	130,331	3,390
TTcitation	11,379	48.38	0	0	0	12.78	7,147	249
Qcitation	11,379	102.2	0	0	1	26.58	42,719	791
Patent Value – Nominal	11,379	1,562	0	0	2.320	270.9	189,788	6,558
Patent Value – Real	11,379	657.1	0	0	1.041	118.5	63,866	2,730
Sales	11,379	5,906	0.317	632.9	1,741	5,185	53,370	11,078
PPE/EMP	11,379	208.3	0.361	24.12	44.504	89.26	10,022	920.9
Stock Return	11,379	0.116	-0.918	-0.152	0.070	0.301	8.948	0.481
Tenure-CEO	11,379	7.853	0.000	3	6	11	50	7.185
Delta-top 5	11,379	468.5	0.346	70.73	157.2	354.2	134,423	3,206
Vega-top 5	11,379	95.77	0	21.72	49.50	111.4	5,367	183.9
Institutional Ownership	11,379	0.663	0	0.521	0.654	0.805	1	0.210
P(Female)-Board	11,379	0.125	0	0	0.111	0.200	0.667	0.106
P(Independent)-Board	11,379	0.724	0	0.667	0.778	0.875	1	0.201
Board Size	11,379	9.018	4	7	9	10	23	2.172

Table 2: Executive Overconfidence, Gender, and Firm Innovation

This table provides summary statistics for variables used to predict the firm innovation. P(Overconfident-Male)-top 5 is the proportion of the top 5 executives who are overconfident males. P(Overconfident-Female)-top 5 is the proportion of the top 5 executives who are overconfident females. P(Non-Overconfident-Female)-top 5 is the proportion of the top 5 executives who are female and not overconfident. Patent Count is the total number of patents applied for during the year. Citation Count is the total number of citations summed across all patents applied for during the year. TTcitation is the total number of citations divided by the average citation count of all patents in the same technology class and applied in the same year. Qcitation is the total number of citations multiplied by the weighting index from Hall, Jaffe, and Trajtenberg (2001, 2005). Patent Quality is the number of patents applied for during the year. Patent Value-Nominal is the value of innovation in millions of nominal dollars. Patent Value-Real is the value of innovation in millions of real dollars deflated using CPI. Sales is firm sales (in millions). PPE/EMP is net property, plant, and equipment (in thousands) per employee. Stock Return is buy-and-hold return over the fiscal year. Tenure-CEO is the tenure (in years) of the CEO. Delta-top 5 is the dollar change (in thousands) in executive's stock and option portfolio for 1% change in stock price averaged across the top 5 executives. Vega-top 5 is the dollar change (in thousands) in executive's options holdings for 1% change in stock price averaged across the top 5 executives. Institutional Ownership is the percentage of shares held by financial institutions, averaged over the fiscal year. P-values are calculated using robust standard errors and are shown in parenthesis.

	Log(1+Patents)	Log(1+ TTcitation)	Log(1+ Qcitation)	Log(1+Patent Value - Nominal)	Log(1+Patent Value - Real)
P(Overconfident-Male)-top 5	0.047*	0.032	0.059*	0.193***	0.173***
	(0.072)	(0.292)	(0.058)	(0.000)	(0.000)
P(Overconfident-Female)-top 5	0.276***	0.317***	0.318***	0.633***	0.569***
	(0.001)	(0.001)	(0.002)	(0.000)	(0.000)
P(Non-Overconfident-Female)-top 5	0.048	-0.076	0.017	0.087	0.063
	(0.493)	(0.365)	(0.839)	(0.529)	(0.593)
Log(Sales)	0.300***	0.266***	0.301***	0.603***	0.549***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log(PPE/EMP)	0.046**	0.075***	0.053**	0.021	0.034
	(0.011)	(0.000)	(0.013)	(0.547)	(0.258)
Stock Return	-0.002	0.008	-0.000	0.034	0.029
	(0.858)	(0.618)	(0.976)	(0.187)	(0.179)
Log(1+Tenure-CEO)	-0.006	-0.037***	-0.021*	-0.011	-0.012
	(0.541)	(0.001)	(0.064)	(0.557)	(0.447)
Log(1+Delta-top 5)	0.011	0.022*	0.024*	0.097***	0.092***
	(0.313)	(0.096)	(0.079)	(0.000)	(0.000)
Log(1+Vega-top 5)	0.005	-0.004	-0.001	-0.022	-0.017
	(0.558)	(0.691)	(0.934)	(0.219)	(0.262)
Institutional Ownership	-0.037	-0.037	-0.050	-0.150**	-0.116*
	(0.315)	(0.399)	(0.262)	(0.038)	(0.060)
P(Female)-Board	0.360***	0.334***	0.451***	0.701***	0.620***
	(0.000)	(0.006)	(0.000)	(0.000)	(0.000)
P(Independent)-Board	-0.086	-0.039	-0.069	-0.187*	-0.143
	(0.115)	(0.544)	(0.286)	(0.079)	(0.115)
Log(Board Size)	-0.026	-0.048	-0.064	-0.189**	-0.170**
	(0.593)	(0.407)	(0.271)	(0.048)	(0.037)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	11,379	11,379	11,379	11,379	11,379
Adjusted R^2	0.912	0.893	0.901	0.883	0.906

Table 3: Executive Overconfidence, Gender, and Firm Innovation – Control for CEO characteristics

This table provides summary statistics for variables used to predict the firm innovation. P(Overconfident-Male)-top 5 is the proportion of the top 5 executives who are overconfident males. P(Overconfident-Female)-top 5 is the proportion of the top 5 executives who are overconfident females. P(Non-Overconfident-Female)-top 5 is the proportion of the top 5 executives who are female and not overconfident. I(Overconfident-Male)-CEO is an indicator for an overconfident male CEO. I(Overconfident-Female)-CEO is an indicator for an overconfident female CEO. I(Non-Overconfident-Feale)-CEO is an indicator for a non-overconfident female CEO. Patent Count is the total number of patents applied for during the year. Citation Count is the total number of citations summed across all patents applied for during the year. TTcitation is the total number of citations divided by the average citation count of all patents in the same technology class and applied in the same year. Qcitation is the total number of citations multiplied by the weighting index from Hall, Jaffe, and Trajtenberg (2001, 2005). Patent Quality is the number of patents applied for during the year. Patent Value-Nominal is the value of innovation in millions of nominal dollars. Patent Value-Real is the value of innovation in millions of real dollars deflated using CPI. Sales is firm sales (in millions). PPE/EMP is net property, plant, and equipment (in thousands) per employee. Stock Return is buy-and-hold return over the fiscal year. Tenure-CEO is the tenure (in years) of the CEO. Delta-top 5 is the dollar change (in thousands) in executive's stock and option portfolio for 1% change in stock price averaged across the top 5 executives. Vega-top 5 is the dollar change (in thousands) in executive's options holdings for 1% change in stock price averaged across the top 5 executives. Institutional Ownership is the percentage of shares held by financial institutions, averaged over the fiscal year. P-values are calculated using robust standard errors and are shown in parenthesis.

	Log(1+Patents)	Log(1+ TTcitation)	Log(1+ Qcitation)	Log(1+Patent Value - Nominal)	Log(1+Patent Value - Real)
I(Overconfident-Male)-CEO	0.099***	0.066***	0.104***	0.226***	0.203***
	(0.000)	(0.006)	(0.000)	(0.000)	(0.000)
I(Overconfident-Female)-CEO	0.027	-0.020	0.029	0.221*	0.195*
	(0.692)	(0.801)	(0.720)	(0.095)	(0.085)
I(Non-Overconfident-Female)-CEO	-0.184**	-0.251***	-0.216**	-0.208	-0.201
	(0.024)	(0.009)	(0.027)	(0.190)	(0.138)
P(Overconfident-Male)-top 5	-0.022	-0.006	-0.012	0.039	0.037
	(0.297)	(0.826)	(0.643)	(0.358)	(0.296)
P(Overconfident-Female)-top 5	0.151**	0.202***	0.179**	0.393***	0.352***
	(0.013)	(0.005)	(0.014)	(0.001)	(0.001)
P(Non-Overconfident-Female)-top 5	0.025	-0.040	0.006	0.061	0.047
	(0.627)	(0.509)	(0.917)	(0.539)	(0.583)
Log(Sales)	0.300***	0.266***	0.301***	0.603***	0.549***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log(PPE/EMP)	0.046**	0.075***	0.053**	0.021	0.034
	(0.011)	(0.000)	(0.013)	(0.547)	(0.258)
Stock Return	-0.002	0.008	-0.000	0.034	0.029
	(0.858)	(0.618)	(0.976)	(0.187)	(0.179)
Log(1+Tenure-CEO)	-0.006	-0.037***	-0.021*	-0.011	-0.012
	(0.541)	(0.001)	(0.064)	(0.557)	(0.447)
Log(1+Delta-top 5)	0.011	0.022*	0.024*	0.097***	0.092***
	(0.313)	(0.096)	(0.079)	(0.000)	(0.000)
Log(1+Vega-top 5)	0.005	-0.004	-0.001	-0.022	-0.017
	(0.558)	(0.691)	(0.934)	(0.219)	(0.262)
Institutional Ownership	-0.037	-0.037	-0.050	-0.150**	-0.116*
	(0.315)	(0.399)	(0.262)	(0.038)	(0.060)
P(Female)-Board	0.360***	0.334***	0.451***	0.701***	0.620***
	(0.000)	(0.006)	(0.000)	(0.000)	(0.000)
P(Independent)-Board	-0.086	-0.039	-0.069	-0.187*	-0.143
	(0.115)	(0.544)	(0.286)	(0.079)	(0.115)
Log(Board Size)	-0.026	-0.048	-0.064	-0.189**	-0.170**
	(0.593)	(0.407)	(0.271)	(0.048)	(0.037)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	11,379	11,379	11,379	11,379	11,379
Adjusted R^2	0.913	0.883	0.906	0.893	0.901

Table 4A: Executive Overconfidence, Gender, and Firm Innovation – Innovative Industries

This table provides summary statistics for variables used to predict the firm innovation. P(Overconfident-Male)-top 5 is the proportion of the top 5 executives who are overconfident males. P(Overconfident-Female)-top 5 is the proportion of the top 5 executives who are overconfident females. P(Non-Overconfident-Female)-top 5 is the proportion of the top 5 executives who are female and not overconfident. Patent Count is the total number of patents applied for during the year. Citation Count is the total number of citations summed across all patents applied for during the year. TTcitation is the total number of citations divided by the average citation count of all patents in the same technology class and applied in the same year. Qcitation is the total number of citations multiplied by the weighting index from Hall, Jaffe, and Trajtenberg (2001, 2005). Patent Quality is the number of patents applied for during the year. Patent Value-Nominal is the value of innovation in millions of nominal dollars. Patent Value-Real is the value of innovation in millions of real dollars deflated using CPI. Sales is firm sales (in millions). PPE/EMP is net property, plant, and equipment (in thousands) per employee. Stock Return is buy-and-hold return over the fiscal year. Tenure-CEO is the tenure (in years) of the CEO. Delta-top 5 is the dollar change (in thousands) in executive's stock and option portfolio for 1% change in stock price averaged across the top 5 executives. Vega-top 5 is the dollar change (in thousands) in executive's options holdings for 1% change in stock price averaged across the top 5 executives. Institutional Ownership is the percentage of shares held by financial institutions, averaged over the fiscal year. P-values are calculated using robust standard errors and are shown in parenthesis.

	Log(1+Patents)		Log(1+ TTcitation)	
	Innovative Industries	Non-Innovative Industries	Innovative Industries	Non-Innovative Industries
P(Overconfident-Male)-top 5	0.092**	-0.052	0.067	-0.053
	(0.011)	(0.138)	(0.123)	(0.137)
P(Overconfident-Female)-top 5	0.394***	-0.007	0.445***	0.002
	(0.001)	(0.904)	(0.001)	(0.976)
P(Non-Overconfident-Female)-top 5	-0.008	0.060	-0.153	-0.025
	(0.942)	(0.340)	(0.199)	(0.724)
Log(Sales)	0.372***	0.058***	0.333***	0.064***
	(0.000)	(0.005)	(0.000)	(0.009)
Log(PPE/EMP)	0.051*	-0.021	0.090***	-0.018
	(0.069)	(0.202)	(0.008)	(0.272)
Stock Return	-0.008	-0.007	0.005	0.008
	(0.640)	(0.700)	(0.809)	(0.719)
Log(1+Tenure-CEO)	-0.020	0.025**	-0.058***	0.011
	(0.148)	(0.014)	(0.000)	(0.339)
Log(1+Delta-top 5)	0.024	0.003	0.037*	0.006
	(0.156)	(0.797)	(0.052)	(0.547)
Log(1+Vega-top 5)	0.004	0.004	-0.010	-0.001
	(0.732)	(0.706)	(0.518)	(0.903)
Institutional Ownership	-0.044	-0.012	-0.051	0.010
	(0.352)	(0.754)	(0.372)	(0.806)
P(Female)-Board	0.477***	0.078	0.402**	0.162
	(0.002)	(0.475)	(0.025)	(0.187)
P(Independent)-Board	-0.123	-0.011	-0.116	0.128*
	(0.114)	(0.863)	(0.274)	(0.058)
Log(Board Size)	-0.031	0.064	-0.074	0.065
	(0.663)	(0.194)	(0.387)	(0.216)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	8,216	3,031	8,216	3,031
Adjusted R^2	0.899	0.842	0.868	0.813

Table 4B: Executive Overconfidence, Gender, and Firm Innovation – Innovative Industries

This table provides summary statistics for variables used to predict the firm innovation. P(Overconfident-Male)-top 5 is the proportion of the top 5 executives who are overconfident males. P(Overconfident-Female)-top 5 is the proportion of the top 5 executives who are overconfident females. P(Non-Overconfident-Female)-top 5 is the proportion of the top 5 executives who are female and not overconfident. Patent Count is the total number of patents applied for during the year. Citation Count is the total number of citations summed across all patents applied for during the year. TTcitation is the total number of citations divided by the average citation count of all patents in the same technology class and applied in the same year. Qcitation is the total number of citations multiplied by the weighting index from Hall, Jaffe, and Trajtenberg (2001, 2005). Patent Quality is the number of patents applied for during the year. Patent Value-Nominal is the value of innovation in millions of nominal dollars. Patent Value-Real is the value of innovation in millions of real dollars deflated using CPI. Sales is firm sales (in millions). PPE/EMP is net property, plant, and equipment (in thousands) per employee. Stock Return is buy-and-hold return over the fiscal year. Tenure-CEO is the tenure (in years) of the CEO. Delta-top 5 is the dollar change (in thousands) in executive's stock and option portfolio for 1% change in stock price averaged across the top 5 executives. Vega-top 5 is the dollar change (in thousands) in executive's options holdings for 1% change in stock price averaged across the top 5 executives. Institutional Ownership is the percentage of shares held by financial institutions, averaged over the fiscal year. P-values are calculated using robust standard errors and are shown in parenthesis.

	Log(1+Qcitation)		Log(1+Patent Value - Real)	
	Innovative Industries	Non-Innovative Industries	Innovative Industries	Non-Innovative Industries
P(Overconfident-Male)-top 5	0.108**	-0.062	0.246***	-0.048
	(0.011)	(0.132)	(0.000)	(0.546)
P(Overconfident-Female)-top 5	0.442***	-0.004	0.701***	0.036
	(0.001)	(0.958)	(0.000)	(0.771)
P(Non-Overconfident-Female)-top 5	-0.062	0.043	-0.100	0.102
	(0.607)	(0.585)	(0.545)	(0.535)
Log(Sales)	0.367***	0.079***	0.617***	0.228***
	(0.000)	(0.003)	(0.000)	(0.000)
Log(PPE/EMP)	0.066*	-0.030	0.068*	-0.074**
	(0.053)	(0.122)	(0.093)	(0.047)
Stock Return	-0.003	-0.009	0.029	-0.008
	(0.883)	(0.662)	(0.227)	(0.773)
Log(1+Tenure-CEO)	-0.042***	0.024**	-0.049**	0.053**
	(0.009)	(0.048)	(0.023)	(0.036)
Log(1+Delta-top 5)	0.044**	0.004	0.158***	-0.001
	(0.023)	(0.723)	(0.000)	(0.974)
Log(1+Vega-top 5)	-0.007	0.002	-0.033*	0.006
	(0.646)	(0.861)	(0.075)	(0.749)
Institutional Ownership	-0.065	-0.004	-0.161**	-0.015
	(0.261)	(0.940)	(0.030)	(0.866)
P(Female)-Board	0.614***	0.102	0.891***	0.149
	(0.001)	(0.441)	(0.000)	(0.553)
P(Independent)-Board	-0.128	0.048	-0.207*	-0.050
	(0.183)	(0.534)	(0.092)	(0.746)
Log(Board Size)	-0.093	0.087	-0.223**	0.156
	(0.275)	(0.141)	(0.039)	(0.178)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	8,216	3,031	8,216	3,031
Adjusted R^2	0.892	0.827	0.898	0.794

Table 4C: Executive Overconfidence, Gender, and Firm Innovation – Innovative Industries

This table provides summary statistics for variables used to predict the firm innovation. P(Overconfident-Male)-top 5 is the proportion of the top 5 executives who are overconfident males. P(Overconfident-Female)-top 5 is the proportion of the top 5 executives who are overconfident females. P(Non-Overconfident-Female)-top 5 is the proportion of the top 5 executives who are female and not overconfident. Patent Count is the total number of patents applied for during the year. Citation Count is the total number of citations summed across all patents applied for during the year. TTcitation is the total number of citations divided by the average citation count of all patents in the same technology class and applied in the same year. Qcitation is the total number of citations multiplied by the weighting index from Hall, Jaffe, and Trajtenberg (2001, 2005). Patent Quality is the number of patents applied for during the year. Patent Value-Nominal is the value of innovation in millions of nominal dollars. Patent Value-Real is the value of innovation in millions of real dollars deflated using CPI. Sales is firm sales (in millions). PPE/EMP is net property, plant, and equipment (in thousands) per employee. Stock Return is buy-and-hold return over the fiscal year. Tenure-CEO is the tenure (in years) of the CEO. Delta-top 5 is the dollar change (in thousands) in executive's stock and option portfolio for 1% change in stock price averaged across the top 5 executives. Vega-top 5 is the dollar change (in thousands) in executive's options holdings for 1% change in stock price averaged across the top 5 executives. Institutional Ownership is the percentage of shares held by financial institutions, averaged over the fiscal year. P-values are calculated using robust standard errors and are shown in parenthesis.

	Log(1+Patents)	Log(1+ TTcitation)	Log(1+ Qcitation)	Log(1+Patent Value - Nominal)
P(Overconfident-Male)-top 5	-0.060*	-0.054	-0.060	-0.113
	(0.066)	(0.135)	(0.123)	(0.116)
P(Overconfident-Female)-top 5	0.005	0.080	0.052	-0.025
	(0.947)	(0.339)	(0.555)	(0.874)
P(Non-Overconfident-Female)-top 5	0.114*	0.071	0.142*	0.180
	(0.087)	(0.363)	(0.088)	(0.279)
P(Overconfident-Male)-top 5 *	0.143***	0.117***	0.161***	0.384***
I(Innovative Industry)	(0.000)	(0.008)	(0.001)	(0.000)
P(Overconfident-Female)-top 5 *	0.406***	0.360***	0.403***	0.890***
I(Innovative Industry)	(0.000)	(0.007)	(0.004)	(0.000)
P(Non-Overconfident-Female)-top 5 *	-0.117	-0.235*	-0.210	-0.225
I(Innovative Industry)	(0.289)	(0.061)	(0.111)	(0.303)
I(Innovative Industry)	0.084***	0.145***	0.155***	0.192***
	(0.007)	(0.000)	(0.000)	(0.004)
Log(Sales)	0.303***	0.269***	0.305***	0.558***
	(0.000)	(0.000)	(0.000)	(0.000)
Log(PPE/EMP)	0.048**	0.078***	0.057**	0.040
	(0.015)	(0.001)	(0.017)	(0.190)
Stock Return	-0.001	0.010	0.002	0.034*
	(0.962)	(0.533)	(0.886)	(0.086)
Log(1+Tenure-CEO)	-0.006	-0.038***	-0.021*	-0.013
	(0.543)	(0.001)	(0.074)	(0.459)
Log(1+Delta-top 5)	0.012	0.023*	0.024*	0.093***
	(0.323)	(0.090)	(0.077)	(0.000)
Log(1+Vega-top 5)	0.006	-0.003	0.000	-0.015
	(0.520)	(0.780)	(0.981)	(0.315)
Institutional Ownership	-0.041	-0.042	-0.055	-0.125**
	(0.256)	(0.328)	(0.203)	(0.034)
P(Female)-Board	0.383***	0.357***	0.479***	0.678***
	(0.001)	(0.006)	(0.000)	(0.000)
P(Independent)-Board	-0.087	-0.042	-0.073	-0.147
	(0.127)	(0.580)	(0.303)	(0.144)
Log(Board Size)	-0.029	-0.052	-0.069	-0.177**
	(0.587)	(0.412)	(0.276)	(0.040)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	11,379	11,379	11,379	11,379
Adjusted R^2	0.913	0.884	0.906	0.903

Table 5A: Executive Overconfidence, Gender, and Firm Innovation – Innovative Firms

This table provides summary statistics for variables used to predict the firm innovation. P(Overconfident-Male)-top 5 is the proportion of the top 5 executives who are overconfident males. P(Overconfident-Female)-top 5 is the proportion of the top 5 executives who are overconfident females. P(Non-Overconfident-Female)-top 5 is the proportion of the top 5 executives who are female and not overconfident. Patent Count is the total number of patents applied for during the year. Citation Count is the total number of citations summed across all patents applied for during the year. TTcitation is the total number of citations divided by the average citation count of all patents in the same technology class and applied in the same year. Qcitation is the total number of citations multiplied by the weighting index from Hall, Jaffe, and Trajtenberg (2001, 2005). Patent Quality is the number of patents applied for during the year. Patent Value-Nominal is the value of innovation in millions of nominal dollars. Patent Value-Real is the value of innovation in millions of real dollars deflated using CPI. Sales is firm sales (in millions). PPE/EMP is net property, plant, and equipment (in thousands) per employee. Stock Return is buy-and-hold return over the fiscal year. Tenure-CEO is the tenure (in years) of the CEO. Delta-top 5 is the dollar change (in thousands) in executive's stock and option portfolio for 1% change in stock price averaged across the top 5 executives. Vega-top 5 is the dollar change (in thousands) in executive's options holdings for 1% change in stock price averaged across the top 5 executives. Institutional Ownership is the percentage of shares held by financial institutions, averaged over the fiscal year. P-values are calculated using robust standard errors and are shown in parenthesis.

	Log(1+Patents)		Log(1+ TTcitation)	
	Innovative Firms	Non-Innovative Firms	Innovative Firms	Non-Innovative Firms
P(Overconfident-Male)-top 5	-0.040	0.062**	-0.067	0.009
	(0.461)	(0.024)	(0.348)	(0.738)
P(Overconfident-Female)-top 5	0.383**	0.054	0.338	0.102
	(0.018)	(0.491)	(0.125)	(0.162)
P(Non-Overconfident-Female)-top 5	-0.157	0.045	-0.410**	-0.023
	(0.265)	(0.549)	(0.032)	(0.738)
Log(Sales)	0.330***	0.186***	0.305***	0.171***
	(0.000)	(0.000)	(0.000)	(0.000)
Log(PPE/EMP)	0.034	0.068***	0.063	0.082***
	(0.353)	(0.002)	(0.225)	(0.000)
Stock Return	-0.003	-0.002	0.024	-0.012
	(0.883)	(0.851)	(0.417)	(0.317)
Log(1+Tenure-CEO)	-0.014	0.002	-0.081***	-0.003
	(0.426)	(0.827)	(0.001)	(0.792)
Log(1+Delta-top 5)	-0.010	0.018*	0.038	0.010
	(0.694)	(0.078)	(0.217)	(0.290)
Log(1+Vega-top 5)	0.031	-0.002	0.004	0.004
	(0.110)	(0.850)	(0.872)	(0.679)
Institutional Ownership	-0.008	-0.015	0.002	-0.006
	(0.913)	(0.664)	(0.978)	(0.847)
P(Female)-Board	0.330*	0.139	0.348	0.044
	(0.097)	(0.181)	(0.214)	(0.647)
P(Independent)-Board	-0.115	0.075	0.105	0.040
	(0.288)	(0.157)	(0.551)	(0.492)
Log(Board Size)	0.125	-0.025	0.078	0.019
	(0.202)	(0.631)	(0.549)	(0.713)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	3,587	7,547	3,587	7,547
Adjusted R^2	0.897	0.900	0.846	0.875

Table 5B: Executive Overconfidence, Gender, and Firm Innovation – Innovative Firms

This table provides summary statistics for variables used to predict the firm innovation. P(Overconfident-Male)-top 5 is the proportion of the top 5 executives who are overconfident males. P(Overconfident-Female)-top 5 is the proportion of the top 5 executives who are overconfident females. P(Non-Overconfident-Female)-top 5 is the proportion of the top 5 executives who are female and not overconfident. Patent Count is the total number of patents applied for during the year. Citation Count is the total number of citations summed across all patents applied for during the year. TTcitation is the total number of citations divided by the average citation count of all patents in the same technology class and applied in the same year. Qcitation is the total number of citations multiplied by the weighting index from Hall, Jaffe, and Trajtenberg (2001, 2005). Patent Quality is the number of patents applied for during the year. Patent Value-Nominal is the value of innovation in millions of nominal dollars. Patent Value-Real is the value of innovation in millions of real dollars deflated using CPI. Sales is firm sales (in millions). PPE/EMP is net property, plant, and equipment (in thousands) per employee. Stock Return is buy-and-hold return over the fiscal year. Tenure-CEO is the tenure (in years) of the CEO. Delta-top 5 is the dollar change (in thousands) in executive's stock and option portfolio for 1% change in stock price averaged across the top 5 executives. Vega-top 5 is the dollar change (in thousands) in executive's options holdings for 1% change in stock price averaged across the top 5 executives. Institutional Ownership is the percentage of shares held by financial institutions, averaged over the fiscal year. P-values are calculated using robust standard errors and are shown in parenthesis.

	Log(1+Qcitation)		Log(1+Patent Value - Real)	
	Innovative Firms	Non-Innovative Firms	Innovative Firms	Non-Innovative Firms
P(Overconfident-Male)-top 5	-0.063	0.058*	0.054	0.153***
	(0.303)	(0.057)	(0.412)	(0.000)
P(Overconfident-Female)-top 5	0.347*	0.070	0.187	0.310**
	(0.052)	(0.425)	(0.342)	(0.023)
P(Non-Overconfident-Female)-top 5	-0.294*	0.029	-0.180	0.036
	(0.081)	(0.724)	(0.300)	(0.752)
Log(Sales)	0.289***	0.203***	0.511***	0.322***
	(0.000)	(0.000)	(0.000)	(0.000)
Log(PPE/EMP)	0.031	0.085***	0.047	0.068**
	(0.482)	(0.000)	(0.324)	(0.027)
Stock Return	0.002	-0.007	0.036	0.017
	(0.949)	(0.645)	(0.162)	(0.425)
Log(1+Tenure-CEO)	-0.050**	0.002	-0.042**	-0.006
	(0.013)	(0.874)	(0.043)	(0.720)
Log(1+Delta-top 5)	0.023	0.020*	0.189***	0.048***
	(0.394)	(0.081)	(0.000)	(0.004)
Log(1+Vega-top 5)	0.024	-0.002	-0.029	0.003
	(0.242)	(0.797)	(0.165)	(0.807)
Institutional Ownership	0.004	-0.015	-0.033	-0.078
	(0.959)	(0.695)	(0.687)	(0.159)
P(Female)-Board	0.465**	0.148	0.666***	0.182
	(0.042)	(0.195)	(0.005)	(0.274)
P(Independent)-Board	-0.052	0.083	-0.103	0.128
	(0.700)	(0.158)	(0.426)	(0.117)
Log(Board Size)	0.077	-0.018	-0.016	-0.233**
	(0.491)	(0.761)	(0.886)	(0.014)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	3,587	7,547	3,587	7,547
Adjusted R^2	0.883	0.898	0.922	0.902

Table 5C: Executive Overconfidence, Gender, and Firm Innovation – Innovative Firms

This table provides summary statistics for variables used to predict the firm innovation. P(Overconfident-Male)-top 5 is the proportion of the top 5 executives who are overconfident males. P(Overconfident-Female)-top 5 is the proportion of the top 5 executives who are overconfident females. P(Non-Overconfident-Female)-top 5 is the proportion of the top 5 executives who are female and not overconfident. Patent Count is the total number of patents applied for during the year. Citation Count is the total number of citations summed across all patents applied for during the year. TTcitation is the total number of citations divided by the average citation count of all patents in the same technology class and applied in the same year. Qcitation is the total number of citations multiplied by the weighting index from Hall, Jaffe, and Trajtenberg (2001, 2005). Patent Quality is the number of patents applied for during the year. Patent Value-Nominal is the value of innovation in millions of nominal dollars. Patent Value-Real is the value of innovation in millions of real dollars deflated using CPI. Sales is firm sales (in millions). PPE/EMP is net property, plant, and equipment (in thousands) per employee. Stock Return is buy-and-hold return over the fiscal year. Tenure-CEO is the tenure (in years) of the CEO. Delta-top 5 is the dollar change (in thousands) in executive's stock and option portfolio for 1% change in stock price averaged across the top 5 executives. Vega-top 5 is the dollar change (in thousands) in executive's options holdings for 1% change in stock price averaged across the top 5 executives. Institutional Ownership is the percentage of shares held by financial institutions, averaged over the fiscal year. P-values are calculated using robust standard errors and are shown in parenthesis.

	Log(1+Patents)	Log(1+ TTcitation)	Log(1+ Qcitation)	Log(1+Patent Value - Real)
P(Overconfident-Male)-top 5	0.055*	0.016	0.043	0.063
	(0.059)	(0.604)	(0.192)	(0.195)
P(Overconfident-Female)-top 5	0.048	0.178**	0.081	0.155
	(0.542)	(0.026)	(0.355)	(0.271)
P(Non-Overconfident-Female)-top 5	-0.019	-0.044	-0.040	-0.195
	(0.805)	(0.563)	(0.636)	(0.128)
P(Overconfident-Male)-top 5 *	-0.068	-0.025	-0.027	0.210***
I(Innovative Firm)	(0.148)	(0.649)	(0.612)	(0.006)
P(Overconfident-Female)-top 5 *	0.519***	0.117	0.411**	0.853***
I(Innovative Firm)	(0.001)	(0.518)	(0.018)	(0.002)
P(Non-Overconfident-Female)-top 5 *	0.105	-0.269	0.003	0.550
I(Innovative Firm)	(0.494)	(0.131)	(0.988)	(0.125)
I(Innovative Firm)	0.542***	0.872***	0.875***	1.021***
	(0.000)	(0.000)	(0.000)	(0.000)
Log(Sales)	0.281***	0.239***	0.272***	0.516***
	(0.000)	(0.000)	(0.000)	(0.000)
Log(PPE/EMP)	0.061***	0.098***	0.078***	0.067**
	(0.001)	(0.000)	(0.000)	(0.015)
Stock Return	-0.009	-0.001	-0.010	0.017
	(0.507)	(0.925)	(0.478)	(0.390)
Log(1+Tenure-CEO)	-0.002	-0.032***	-0.016	-0.004
	(0.794)	(0.002)	(0.149)	(0.784)
Log(1+Delta-top 5)	0.013	0.023*	0.025**	0.091***
	(0.260)	(0.057)	(0.046)	(0.000)
Log(1+Vega-top 5)	0.006	-0.002	0.001	-0.014
	(0.537)	(0.826)	(0.949)	(0.321)
Institutional Ownership	-0.026	-0.017	-0.029	-0.086
	(0.452)	(0.659)	(0.453)	(0.116)
P(Female)-Board	0.345***	0.309***	0.428***	0.601***
	(0.001)	(0.008)	(0.000)	(0.000)
P(Independent)-Board	-0.050	0.014	-0.013	-0.061
	(0.343)	(0.842)	(0.836)	(0.492)
Log(Board Size)	-0.016	-0.037	-0.052	-0.159**
	(0.744)	(0.524)	(0.361)	(0.048)
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	11,379	11,379	11,379	11,379
Adjusted R^2	0.921	0.903	0.922	0.918

Table 6A: Patent Quality

This table provides summary statistics for variables used to predict the firm innovation. P(Overconfident-Male)-top 5 is the proportion of the top 5 executives who are overconfident males. P(Overconfident-Female)-top 5 is the proportion of the top 5 executives who are overconfident females. P(Non-Overconfident-Female)-top 5 is the proportion of the top 5 executives who are female and not overconfident. Patent Count is the total number of patents applied for during the year. Citation Count is the total number of citations summed across all patents applied for during the year. TTcitation is the total number of citations divided by the average citation count of all patents in the same technology class and applied in the same year. Qcitation is the total number of citations multiplied by the weighting index from Hall, Jaffe, and Trajtenberg (2001, 2005). Patent Quality is the number of patents applied for during the year. Patent Value-Nominal is the value of innovation in millions of nominal dollars. Patent Value-Real is the value of innovation in millions of real dollars deflated using CPI. Sales is firm sales (in millions). PPE/EMP is net property, plant, and equipment (in thousands) per employee. Stock Return is buy-and-hold return over the fiscal year. Tenure-CEO is the tenure (in years) of the CEO. Delta-top 5 is the dollar change (in thousands) in executive's stock and option portfolio for 1% change in stock price averaged across the top 5 executives. Vega-top 5 is the dollar change (in thousands) in executive's options holdings for 1% change in stock price averaged across the top 5 executives. Institutional Ownership is the percentage of shares held by financial institutions, averaged over the fiscal year. P-values are calculated using robust standard errors and are shown in parenthesis.

	Log(1+TTcitation per Patent)	Log(1+Qcitation per Patent)	Log(1+ Patent Value – Real per Patent)
P(Overconfident-Male)-top 5	0.019	0.028**	0.131***
	(0.164)	(0.047)	(0.000)
P(Overconfident-Female)-top 5	0.048	0.064	0.294***
	(0.209)	(0.109)	(0.003)
P(Non-Overconfident-Female)-top 5	-0.058*	-0.010	0.036
	(0.079)	(0.778)	(0.651)
Log(Sales)	0.019*	0.033***	0.250***
	(0.069)	(0.001)	(0.000)
Log(PPE/EMP)	0.004	-0.002	-0.017
	(0.698)	(0.826)	(0.379)
Stock Return	0.007	0.003	0.029**
	(0.376)	(0.642)	(0.019)
Log(1+Tenure-CEO)	-0.017***	-0.010*	-0.001
	(0.000)	(0.063)	(0.944)
Log(1+Delta-top 5)	0.007	0.009	0.072***
	(0.232)	(0.144)	(0.000)
Log(1+Vega-top 5)	-0.011**	-0.010**	-0.024**
	(0.013)	(0.020)	(0.024)
Institutional Ownership	-0.021	-0.033	-0.092**
	(0.287)	(0.112)	(0.021)
P(Female)-Board	0.091*	0.117**	0.231*
	(0.069)	(0.028)	(0.065)
P(Independent)-Board	0.024	0.012	-0.055
	(0.453)	(0.699)	(0.429)
Log(Board Size)	-0.026	-0.044	-0.127**
	(0.306)	(0.109)	(0.031)
Year Fixed Effects	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes
Observations	11,379	11,379	11,379
Adjusted R^2	0.644	0.757	0.796

Table 6B: Patent Quality – Innovative Industries

This table provides summary statistics for variables used to predict the firm innovation. P(Overconfident-Male)-top 5 is the proportion of the top 5 executives who are overconfident males. P(Overconfident-Female)-top 5 is the proportion of the top 5 executives who are overconfident females. P(Non-Overconfident-Female)-top 5 is the proportion of the top 5 executives who are female and not overconfident. Patent Count is the total number of patents applied for during the year. Citation Count is the total number of citations summed across all patents applied for during the year. TTcitation is the total number of citations divided by the average citation count of all patents in the same technology class and applied in the same year. Qcitation is the total number of citations multiplied by the weighting index from Hall, Jaffe, and Trajtenberg (2001, 2005). Patent Quality is the number of patents applied for during the year. Patent Value-Nominal is the value of innovation in millions of nominal dollars. Patent Value-Real is the value of innovation in millions of real dollars deflated using CPI. Sales is firm sales (in millions). PPE/EMP is net property, plant, and equipment (in thousands) per employee. Stock Return is buy-and-hold return over the fiscal year. Tenure-CEO is the tenure (in years) of the CEO. Delta-top 5 is the dollar change (in thousands) in executive's stock and option portfolio for 1% change in stock price averaged across the top 5 executives. Vega-top 5 is the dollar change (in thousands) in executive's options holdings for 1% change in stock price averaged across the top 5 executives. Institutional Ownership is the percentage of shares held by financial institutions, averaged over the fiscal year. P-values are calculated using robust standard errors and are shown in parenthesis.

	Log(1+TTcitation per Patent)	Log(1+Qcitation per Patent)	Log(1+ Patent Value – Real per Patent)
P(Overconfident-Male)-top 5	-0.000	-0.006	-0.049
	(0.988)	(0.755)	(0.377)
P(Overconfident-Female)-top 5	0.036	0.036	-0.021
	(0.350)	(0.418)	(0.859)
P(Non-Overconfident-Female)-top 5	0.008	0.045	0.072
	(0.825)	(0.305)	(0.586)
P(Overconfident-Male)-top 5 *	0.027	0.046**	0.242***
I(Innovative Industry)	(0.165)	(0.036)	(0.000)
P(Overconfident-Female)-top 5 *	0.026	0.051	0.477***
I(Innovative Industry)	(0.658)	(0.432)	(0.004)
P(Non-Overconfident-Female)-top 5 *	-0.105**	-0.092	-0.089
I(Innovative Industry)	(0.048)	(0.119)	(0.578)
I(Innovative Firm)	0.096***	0.117***	0.158***
	(0.000)	(0.000)	(0.002)
Log(Sales)	0.020**	0.036***	0.257***
	(0.048)	(0.001)	(0.000)
Log(PPE/EMP)	0.006	0.000	-0.012
	(0.553)	(0.967)	(0.526)
Stock Return	0.008	0.005	0.032***
	(0.284)	(0.468)	(0.008)
Log(1+Tenure-CEO)	-0.017***	-0.010**	-0.002
	(0.000)	(0.048)	(0.895)
Log(1+Delta-top 5)	0.007	0.009	0.072***
	(0.206)	(0.124)	(0.000)
Log(1+Vega-top 5)	-0.011**	-0.009**	-0.023**
	(0.017)	(0.028)	(0.031)
Institutional Ownership	-0.024	-0.036*	-0.099**
	(0.231)	(0.078)	(0.013)
P(Female)-Board	0.097*	0.125**	0.266**
	(0.053)	(0.018)	(0.032)
P(Independent)-Board	0.022	0.010	-0.058
	(0.490)	(0.757)	(0.397)
Log(Board Size)	-0.029	-0.047*	-0.131**
	(0.259)	(0.086)	(0.024)
Year Fixed Effects	0.155	0.280***	-0.846***
Firm Fixed Effects	(0.115)	(0.005)	(0.000)
Observations	11,379	11,379	11,379
Adjusted R^2	0.647	0.760	0.799

Table 7: Instrumental Variables Analysis

This table provides summary statistics for variables used to predict the firm innovation using instrumental variables analysis. P(Non-Overconfident-Female-Connection)-Board is the proportion of the board that has had a bad experience with an overconfident female executive. N(Female)-Higher Education is the total number of females (in millions) that have at least a masters degree in the state in which the firm is incorporated. P(Overconfident-Male)-top 5 is the proportion of the top 5 executives who are overconfident males. P(Overconfident-Female)-top 5 is the proportion of the top 5 executives who are overconfident females. P(Non-Overconfident-Female)-top 5 is the proportion of the top 5 executives who are female and not overconfident. Patent Count is the total number of patents applied for during the year. Citation Count is the total number of citations summed across all patents applied for during the year. TTcitation is the total number of citations divided by the average citation count of all patents in the same technology class and applied in the same year. Qcitation is the total number of citations multiplied by the weighting index from Hall, Jaffe, and Trajtenberg (2001, 2005). Patent Quality is the number of patents applied for during the year. Patent Value-Nominal is the value of innovation in millions of nominal dollars. Patent Value-Real is the value of innovation in millions of real dollars deflated using CPI. Sales is firm sales (in millions). PPE/EMP is net property, plant, and equipment (in thousands) per employee. Stock Return is buy-and-hold return over the fiscal year. Tenure-CEO is the tenure (in years) of the CEO. Delta-top 5 is the dollar change (in thousands) in executive's stock and option portfolio for 1% change in stock price averaged across the top 5 executives. Vega-top 5 is the dollar change (in thousands) in executive's options holdings for 1% change in stock price averaged across the top 5 executives. Institutional Ownership is the percentage of shares held by financial institutions, averaged over the fiscal year. P-values are calculated using robust standard errors and are shown in parenthesis.

	First Stage	Second Stage			
	P(Overconfident-Female)-top 5	Log(1+Patents)	Log(1+ TTcitation)	Log(1+ Qcitation)	Log(1+Patent Value - Real)
Instrumented P(Non-Overconfident-Female)-top 5		29.599***	29.855***	33.306***	41.135***
		(0.000)	(0.000)	(0.000)	(0.000)
P(Non-Overconfident-Female-Connection)-Board	-0.161**				
	(0.050)				
N(Female)-Higher Education	0.082***				
	(0.000)				
Log(Sales)	-0.027***	0.485***	0.485***	0.504***	0.789***
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)
Log(PPE/EMP)	0.003	0.041***	0.035**	0.036**	0.114***
	(0.699)	(0.006)	(0.025)	(0.035)	(0.000)
Stock Return	0.006	0.070*	0.100**	0.089*	0.150**
	(0.793)	(0.078)	(0.017)	(0.053)	(0.012)
Log(1+Tenure-CEO)	-0.001	-0.008***	-0.008***	-0.009***	-0.017***
	(0.645)	(0.002)	(0.001)	(0.002)	(0.000)
Log(1+Delta-top 5)	0.067***	-0.196***	-0.175***	-0.196***	-0.101**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.049)
Log(1+Vega-top 5)	-0.045***	0.428***	0.415***	0.500***	0.621***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Institutional Ownership	0.241***	-1.730***	-1.750***	-1.912***	-2.399***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
P(Female)-Board	1.157***	-6.372***	-6.713***	-7.271***	-8.556***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
P(Independent)-Board	-0.128*	1.689***	1.545***	1.916***	2.777***
	(0.056)	(0.000)	(0.000)	(0.000)	(0.000)
Log(Board Size)	-0.055	0.251***	0.274***	0.270**	0.453***
	(0.268)	(0.010)	(0.008)	(0.017)	(0.002)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	8,510	8,510	8,510	8,510	8,510
Adjusted R^2	NA	0.368	0.321	0.356	0.414