Why female board representation matters: The role of female directors in reducing male CEO overconfidence in corporate decisions

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ABSTRACT

We provide novel manifestations why female board representation matters. We find that male CEOs at firms with female directors are less likely to be overconfident as they hold fewer deep-in-the-money options. Female directors are associated with less aggressive investment policies, better acquisition decisions, and improved firm performance. This is the case for industries with high overconfidence prevalence, but not for those with low overconfidence prevalence. Finally, firms with female directors experience less of a drop in performance during the 2007-2009 financial crisis. These results are consistent with the view that female directors improve firm outcomes through reducing male CEO overconfidence in corporate decisions.

JEL classification: G30, G32, G34

Keywords: Female board representation; CEO overconfidence; Investment; Firm performance

1. Introduction

There has been increased attention afforded to gender composition of corporate boards amidst the current corporate governance reforms across the world. A rapidly growing literature suggests that female directors, who behave differently from male directors, have a significant impact as a greater representation of women on the board is associated with fewer employee layoffs (Matsa and Miller, 2013), lower propensity to initiate acquisition bids as well as lower bid premiums (Levi et al., 2014), higher research and development (R&D) expenditures (Miller and Triana, 2009), improved stock price informativeness (Gul et al., 2011), more equity-based pay for directors and higher CEO turnover-performance sensitivity (Adams and Ferreira, 2009). Still, gender differences in behavior (see Croson and Gneezy, 2009, for a review) alone may not necessarily lead to female directors having an impact because they are by and large minorities in the boardroom (Adams and Ferreira, 2009).[1] This begs the question as to why female directors are so influential. We attempt to answer this question by studying whether female board representation affects the beliefs and behavior of the CEO, who typically has the greatest influence on corporate decisions. Specifically, we examine whether the option exercise behavior of the CEO, an indicator of the CEO's degree of overconfidence, is affected by female board representation.

The CEO's option exercise behavior provides an ideal setting to answer our main research question. First, stock options have become an important component of executive compensation (Hall and Liebman, 1998; Murphy, 1999; Hall and Murphy, 2002). Therefore, the timing of option exercise is a primary concern relating to the CEO's management of their individual wealth. Second, CEOs' personal portfolio decisions are indicative of their beliefs about future firm performance. Previous literature suggests that CEOs who voluntarily hold

[1] The representation of female directors on boards continues to be relatively small, despite the increase over time. The fraction of female directors in Australia, the United States, Canada, New Zealand, and Europe is 9.2%, 16.1%, 10.3%, 9.3%, and 12%, respectively (Equal Opportunity for Women in the Workplace Agency-EOWA, 2012; European Professional Women's Network-EPWN, 2010). Moreover, the majority of firms with female directors have only one female director. For example, 61.5% of Australia's top 200 companies have at least one female director in 2012, but only 23% have more than one. In our sample of US firms, 74% of firms have at least one female director in 2012, but only 37.2% have more than one. Kanter (1977) argues that minorities may sometimes be seen as tokens, whose opinions are less likely to be noticed and accepted. Further, the contrast between minorities and majorities could lead to the social and professional isolation of the former. It is therefore possible that minorities that fear isolation remain silent or conform to the opinions of the majority (Asch, 1951). All these arguments suggest that, as a minority, female directors may not have an impact.

deep-in-the-money options are likely to be overconfident of their ability to keep their company's stock price rising, which induces them to postpone option exercise in order to gain from the expected price increases (Malmendier and Tate, 2005; Malmendier and Tate, 2008; Malmendier et al., 2011). Third, unlike corporate decisions made by the top management team that likely reflect the team's collective beliefs, option holding and exercise decisions made by CEOs themselves are more likely to reveal their individual beliefs. Hence, CEOs' option exercise behavior is an excellent laboratory to investigate the following question: Does female board representation help reduce managerial overconfidence?

We focus on CEOs because overconfidence is likely to be more prevalent among CEOs (Goel and Thakor, 2008; Graham et al., 2013). They are also the principal decision-maker within the firm and their biased beliefs due to overconfidence are therefore likely to have a notable influence on firm decisions and performance.[2] In turn, female directors may affect corporate outcomes through moderating the CEO's biased beliefs. We investigate this possibility.

The extant literature suggests that women tend to be less overconfident in their investment decisions than men (Huang and Kisgen, 2013; Levi et al., 2014; Barber and Odean, 2001). Further, female directors tend to be less conformist and are more likely to exhibit activism and express their independent views relative to male directors because they do not belong to 'old-boy' networks (Adams and Ferreira, 2009; Adams et al., 2010; Carter et al., 2003). A primary benefit of having female directors on the board, given the above gender differences, is that they likely improve the quality of board deliberations on complex issues by bringing in different and sometimes conflicting perspectives and enriching the information set available to the board (Miller and Triana, 2009; Gul et al., 2011). The presence of female directors on boards tends to lead to more competitive interactions so that decision-making processes are less likely to be characterized by acquiescence or rapid consensus (Chen et al., 2016). Therefore, a gender-diverse board more likely than an all-male board pushes the CEO to consider a wider range of alternatives as well as the full set of arguments in favor and

[2] See Ho et al. (2016), Humphery-Jenner et al. (2016), Ahmed and Duellman (2013), Kim et al. (2015), Otto (2014), Deshmukh et al. (2013), Campbell et al. (2011), Ben-David et al. (2013), Hirshleifer et al. (2012), Malmendier and Tate (2005), Malmendier and Tate (2008), and Malmendier et al. (2011).

against any given alternative. This will likely result in a more thorough and realistic assessment of the decision problem and attenuate the CEO's potentially biased beliefs (Sniezek, 1992; Dallas, 2001; Paredes, 2005). Hence, we expect that male CEOs at firms with female directors are more likely to engage in divergent thinking, and less likely to focus selectively on information confirming their individual judgment, to overestimate the firm's prospects, and to hold options that are deep in the money.

To test the validity of our hypothesis, we follow Campbell et al. (2011) and Hirshleifer et al. (2012) in calculating the moneyness of CEOs' option portfolios (i.e., the extent to which the stock price exceeds the exercise price) for each year and use it to capture their levels of (over)confidence. Holding onto options that are already deep in the money is considered evidence of overconfidence about the company's prospects, drawing upon the rationale proposed by Malmendier and Tate (2005), Malmendier and Tate (2008) and Malmendier et al. (2011).

We find a negative and significant effect of the representation of women on boards, as measured by the fraction of female directors, on the level of option moneyness for male CEOs. For instance, the baseline specification indicates that an increase of 10 percentage points in the fraction of female directors is associated with a 6.24 percentage-point decrease in the male CEO's option moneyness, or a 9.1% reduction relative to its mean level. Interpreting option moneyness as a proxy for overconfidence suggests that CEOs at firms with female directors are less likely to exhibit overconfidence. This finding is robust to alternative econometric specifications. Further, the effect of female representation is statistically insignificant for female CEOs, suggesting that the observed negative effect on male CEO option moneyness likely reflects differences in gender.

While consistent with our hypothesis, the observed relation could nevertheless be spurious due to the endogeneity of board gender composition. First, some unobservable factors may influence both board gender composition and the CEO's option exercise decisions, causing our estimates to be biased. For instance, a major shift in the firm's strategy or business environment may call for the appointment of more or fewer female directors. Second, firms led by more rational CEOs, and therefore less likely to pursue aggressive

strategies, might be more attractive to female directors (Farrell and Hersch, 2005). To address these endogeneity concerns and help establish causality, we employ several alternative approaches, including propensity score matching, the instrumental variable approach and a difference-in-differences analysis. We find that our results are robust to these alternative approaches.

We conduct several additional tests to increase our confidence that the above findings reflect the effect of female directors in moderating the CEO's biased beliefs. In the first set of tests, we isolate the sample of options exercised and examine the relation between female board representation and characteristics of exercised options. Sen and Tumarkin (2015) show that optimistic CEOs exercise options closer to expiration and at higher stock prices than non-optimistic CEOs. Our results show that the representation of women on boards is associated with less optimistic option exercise choices as evidenced by lower stock prices at exercise and more time remaining until expiration. In addition, using alternative measures of overconfidence based on the CEO's stock-related portfolio decisions, we find that CEOs at firms with female directors are less likely to be net buyers of company stock and to retain shares received from option exercise. Together, these results provide further evidence that female board representation attenuates the CEO's optimistic beliefs about the firm's growth prospects.

Having established a negative effect of female board representation on the extent of the CEO's overconfidence, we next explore whether this effect matters sufficiently to affect corporate investment decisions, and ultimately performance. It is evident from the literature that too much overconfidence is detrimental to the firm because it leads to overly optimistic views about investment opportunities, resulting in overinvestment, a heightened sensitivity of corporate investment to cash flows, and suboptimal acquisition decisions (Malmendier and Tate, 2005; Malmendier and Tate, 2008; Malmendier et al., 2011; Banerjee et al., 2015). Therefore, by reducing the CEO's overconfidence, female board representation may result in less aggressive investment policies and better acquisition decisions. If this were to be the case, then a natural implication would be for board gender composition to be particularly important in industries in which CEOs are more likely to develop overconfidence. The effects of female

board representation on corporate investment decisions should then be stronger in these industries. We find evidence in support of this argument as female board representation is associated with less aggressive investment policies, better acquisition decisions, and ultimately improved firm performance in industries with high overconfidence prevalence. There is no such effect in industries with low overconfidence prevalence.

In the final set of tests, we examine whether female board representation can explain the cross-sectional heterogeneity in firm performance during the financial crisis of 2007-2009. Managerial overconfidence is likely associated with poor performance during the crisis because it may lead CEOs to pursue aggressive strategies that ex post make their firms more vulnerable to the crisis (Ho et al., 2016). If female directors are more likely to caution against an overly optimistic assessment of investment prospects in noncrisis years, then the subsequent financial crisis should represent less of a shock to CEOs with female directors on their boards than to those without. A further prediction along this line of reasoning is that firms with female directors should experience less severe worsening of operating and stock performance compared to those without. The results are consistent with these predictions. We find that greater female board representation is associated with a smaller reduction in the CEO's option moneyness during the crisis. This finding suggests that, being cautioned against overconfident views about the firm's future prospects, CEOs of firms with more gender-diverse boards appear to be less affected by and adjust their personal portfolios less substantially in response to the crisis. We also find that female board representation attenuates the negative impact of the crisis on firm performance, consistent with CEOs with gender-diverse boards adopting less aggressive strategies that make their firms less vulnerable to the crisis.

Our paper makes three major contributions to the extant literature. First, it contributes to the literature on board gender composition (see e.g. Adams and Ferreira, 2009; Gul et al., 2011; and Levi et al., 2014) by providing novel manifestations why female board representation matters and how women on boards affect firm decision making. We also add to the debate over whether board gender diversity enhances or undermines firm performance. The literature is as yet divided with Campbell and Minguez-Vera (2008) and Liu et al. (2014)

documenting a positive effect, Ahern and Dittmar (2012) documenting a negative effect, and Farrell and Hersch (2005) finding insignificant abnormal returns on the announcement of a female appointment to the board. Finally, Adams and Ferreira (2009) find that gender diversity has beneficial effects in firms with weak governance, but detrimental effects in firms with strong governance. Our results suggest that female board representation is particularly valuable in industries with high CEO overconfidence prevalence.

Second, it adds to research on the types of firms that perform better during a financial crisis. Lins et al. (2017) find that firms with more socially responsible investments did better in crisis years. Adams and Ragunathan (2015) show that banks with female directors performed better during the crisis. We also find that firms with female directors experience less of a drop in performance during the crisis. Further, our paper complements prior studies by showing that the role of female directors in moderating male CEO overconfidence in corporate decisions can help explain this cross-sectional heterogeneity in firm performance.

Third, our paper also contributes to the literature on whether overconfidence is more likely in certain types of decision-making environment. For instance, field research suggests that individuals are more prone to overestimate outcomes to which they are highly committed (Weinstein, 1980) and when the feedback they receive is delayed or ambiguous (Nisbett and Ross, 1980; Simon and Houghton, 2003). Gervais and Odean (2001) develop a theoretical model that describes how self-attribution bias develops overconfident traders and how traders' levels of overconfidence change dynamically with their successes and failures. More recently, Kolasinski and Li (2013), and Banerjee et al. (2015) find that board monitoring improves decision making by overconfident CEOs. Billett and Qian (2008) provide empirical evidence that overconfidence in acquisitions is developed from past acquisition experience. Similarly, Hilary and Menzly (2015) find that analysts are more likely to display overconfidence after experiencing a short series of successful predictions. Our findings extend this line of inquiry by showing that male CEOs are less likely to exhibit overconfidence when there is a greater representation of women on their boards.

The rest of the paper is organized as follows. Section 2 describes the sample, model specification, and measurement of variables. Section 3 discusses the main results and

addresses identification issues. Section 4 examines the relations between female board representation, overconfidence and various corporate decisions and the impact of these relations on firm performance. Section 5 examines whether firms with female directors perform better during the 2007-2009 financial crisis. Section 6 tests the robustness of our results. Section 7 concludes.

2. Data, methodology and descriptive statistics

2.1. Data

We utilize several databases to construct our sample. The data on CEO characteristics (e.g., age, tenure, and gender) and their option compensation are from Execucomp. We obtain additional data on CEO careers and education from BoardEx. The data on director characteristics is from IRRC/Riskmetrics. Further, accounting data is from Compustat and stock returns are from CRSP. Financial firms are excluded. The final sample consists of 1,629 firms with 11,435 firm-year observations between 1998 and 2013. There are 11,113 firm-years with male CEOs and 322 firm-years with female CEOs.

2.2. Methodology

To explore whether female board participation influences the CEO's option holding and exercise behavior, we estimate the following baseline empirical model:

$$\begin{aligned} \textit{CEO option moneyness}_{i,t+1} = {} & \alpha + \beta\, \textit{Fraction of female directors}_{i,t} \\ & + \gamma Z_{i,t} + \textit{Industry}_i + \textit{Year}_t + \varepsilon_{i,t}, \end{aligned} \tag{1}$$

where *CEO option moneyness* is the estimated moneyness of the CEO's stock options, which is discussed in detail in the following subsection. The key independent variable of interest, *Fraction of female directors*, is the number of female directors divided by the total number of directors on the board. *Z* is a vector of firm, CEO and governance characteristics that potentially affect the CEO's option holding and exercise decisions or level of confidence. $Industry_i$ represents industry fixed effects constructed using the Fama and French 49-industry specifications and $Year_t$ captures the year fixed effects.

2.2.1. Defining the dependent variable

The use of the option-based CEO confidence measure is motivated by extant literature that links CEO levels of confidence with their stock option holding and exercise decisions. The rationale is that CEOs are highly exposed to the idiosyncratic risk of their companies given that their human capital is undiversified and that they typically have a large part of their wealth tied to their firms. Therefore, risk averse, rational CEOs would exercise their stock options early to divest themselves of idiosyncratic risk (Lambert et al., 1991; Hall and Murphy, 2002). Holding exercisable deep-in-the-money options suggests that CEOs may overestimate the returns on their investment projects and postpone option exercise to tap into the expected future gains, reflecting some degree of overconfidence (Malmendier and Tate, 2005). Moreover, Malmendier and Tate (2005) and Malmendier and Tate (2008) rule out taxes, corporate governance, board pressure, signaling, inside information, and inertia as alternative explanations for delaying option exercise, thereby strengthening the interpretation of the option-based measure as a proxy for the CEO's level of confidence.[3]

The Execucomp data that we use to construct the option-based measure is not as detailed as the proprietary stock option holding and exercise data that Hall and Murphy (2002) and Malmendier and Tate (2005) uses.[4] Thus, we use a modified version of the Malmendier and Tate (2005) overconfidence measure, following the methodology of Campbell et al. (2011) and Hirshleifer et al. (2012). Specifically, we estimate the average CEO stock option moneyness for each year as follows. We first calculate the average realizable value per option by dividing the total realizable value of the exercisable options by the number of exercisable options. Next, we subtract the average realizable value from the fiscal year-end stock price to

[3] Malmendier and Tate (2005, 2008) find no evidence that option non-exercise has signaling value. Moreover, although it is arguable that less risk-averse CEOs would also be more likely to hold deep-in-the-money options, such an interpretation predicts a negative relation between the option-based measure of overconfidence and investment-cash flow sensitivity. Higher risk tolerance should be associated with lower investment-cash flow sensitivity since, *ceteris paribus*, less risk-averse CEOs would be more willing to leverage up the firm if necessary to finance investment projects (Malmendier and Tate, 2008; Campbell et al., 2011; Hirshleifer et al., 2012). This prediction is inconsistent with the finding both in this paper and in a prior study (Malmendier and Tate, 2005) that the relation between the option-based measure and investment-cash flow sensitivity is positive.

[4] The Execucomp database does not contain details about individual option packages such as grant dates, expiration dates, and strike prices. We therefore are limited in our ability to assess the timing of exercise relative to either grant dates or expiration dates.

obtain the average exercise price of the options. The estimated moneyness of the options is then calculated as the stock price divided by the estimated average exercise price minus one.[5] As we are interested in the CEO's decisions to hold options that could have been exercised, we include only exercisable options held by the CEO. Further, we allow the continuous "CEO confidence" measure[6] to vary over time because prior literature posits that overconfidence may vary with past experience and performance (Hilary and Menzly, 2006; Billett and Qian, 2008) and, more importantly, because our paper attempts to examine, among others, whether male CEO overconfidence varies with female board representation.

An alternative measure of CEO beliefs in the future, proposed by Malmendier and Tate (2008), builds on the perception of outsiders. A common approach to infer market perception of CEO confidence is to count articles in the financial press, such as the *Wall Street Journal*, and the *Financial Times*, that refer to the CEO as "Confident" ("confident" or "confidence", "optimistic" or "optimism") relative to the number of articles that characterize the CEO as "Cautious" ("cautious", "conservative", "reliable", "steady", "frugal" and "practical"). However, we do not use this measure in our study, because it is an indicator variable based on the CEO's press portrayal, rather than the latter's actions, and hence is noisier (Malmendier and Tate, 2008), and fails to capture changes in the CEO's behavior due to the influence of female directors.

2.2.2. Control variables

We include a number of firm, governance, and CEO characteristics that potentially affect CEO overconfidence as measured by their option holding and exercise behavior. Firm size can be linked to the presence of talented CEOs, because talented CEOs tend to work at larger

[5] Note that the option moneyness variable is winsorized at the 1st and 99th percentiles to reduce the potential impact of outliers.

[6] Our continuous "CEO confidence" variable is to the basis for the indicator variable used in Malmendier and Tate (2005), Malmendier and Tate (2008), and Malmendier et al. (2010), according to which CEOs are overconfident if they hold exercisable stock options that are at least 67% in the money. The choice of the 67% moneyness cutoff comes from calibrating Hall and Murphy's (2002) model using a detailed dataset on CEOs' stock option holding and exercise decisions. If a CEO is identified as overconfident, he or she remains so for the rest of the sample period. In our main tests, however, we use a *continuous* CEO confidence measure (as in Banerjee et al., 2015), because Ben-David et al. (2013) provide evidence that executives miscalibrate the risk and return distributions, which implies that managerial miscalibration and overconfidence are likely to be continuous. In additional tests, we apply indicator variables based on alternative cutoffs, i.e., 100% and top quartile, and obtain similar results.

firms to allow their talent to have greater impact (Edmans and Gabaix, 2011), and because managing large, complex firms requires more managerial skills and expertise. Similarly, firms with more growth opportunities have greater scope for talented CEOs to add value and hence are more likely to appoint them (Edmans and Gabaix, 2011; Graham et al., 2013). We measure firm size as the logarithm of sales[7] and measure growth opportunities as *Tobin's q*. In turn, talented CEOs are more likely to exhibit overconfidence (Goel and Thakor, 2008). In addition, leverage increases the riskiness of equity-based compensation and thereby may affect the CEO's decisions to hold options. Hilary and Menzly (2006) provide evidence that individuals who have experienced past successes are more likely to display overconfidence. Thus, we use both market (*Stock return*) and operating (*Return on assets*) measures to proxy for the CEO's prior performance. Controlling for stock returns also helps mitigate the concern that our option moneyness variable may simply be a manifestation of stock performance. To reduce the potential impact of outliers, all of the above accounting variables are winsorized at the 1st and 99th percentiles.

Banerjee et al. (2015) show that increased board monitoring after the Sarbanes-Oxley Act (SOX) serves to restrain the excesses of overconfident CEOs and improve their decision making. We include three governance indicators suggested in prior studies to account for the restraining effect of governance on CEO overconfidence: the Bebchuk et al. (2009) *E index*; *Board size*, which is the number of directors on the board; and *Board independence*, which is the ratio of the number of independent directors to board size. All firm, governance and board characteristics are lagged one year relative to the dependent variable to mitigate endogeneity concerns.

We incorporate several controls for the personal characteristics of CEOs and related demographics because of prior evidence that they are important in determining individual behavior and decision making (Goergen et al., 2015; Bertrand and Schoar, 2003; Pfeffer, 1983). First, we include *CEO age* as age consists of a variety of factors that progressively shape an individual's behavioral characteristics (Medawar, 1952). Age encompasses the

[7] Our results are robust to the use of the logarithm of total assets and the logarithm of market capitalization as alternative measures of firm size.

diversity of experiences that one has made. Relatedly, Agarwal et al. (2009) indicate that the sophistication of financial decisions varies with age. There is also some evidence that CEOs from older generations appear to be less aggressive compared to their younger counterparts (Bertrand and Schoar, 2003; Ferris et al., 2013). Second, *CEO tenure* is the number of years the CEO has been in office, and *CEO Chairman* is an indicator variable that equals one if the CEO also chairs the board, and zero otherwise. We use these two controls to account for possible entrenchment, which may exacerbate managerial moral hazard and biased beliefs (Banerjee et al., 2015). Moreover, we include *CEO ownership* to avoid entangling the measurement of overconfidence with the potential ownership and incentive implications of stock option exercise (Yermack, 1995; Ofek and Yermack, 2000).

The final set of controls captures the CEO's professional background, past experience, and education. Graduating from a prestigious college and obtaining an MBA degree may reflect innate intelligence and the accumulation of human and social capital (Graham et al., 2013), which could affect CEO behavior and beliefs. Bertrand and Schoar (2003) provide some evidence that CEOs with MBAs behave more aggressively. We define *MBA* as an indicator variable that equals one if the CEO has a Master of Business Administration (MBA) degree, and zero otherwise, and define *Ivy League* as an indicator variable that equals one if the CEO attended an Ivy League university, and zero otherwise. Similarly, *Age first CEO role*, defined as the age at which the CEO became CEO for the first time, is likely a relevant managerial characteristic as it indicates innate talent. In addition, *Qualification* is an indicator variable that equals one if the CEO has professional qualifications (e.g., Chartered Financial Analyst, Certified Public Accountant), and zero otherwise. Further, the psychology literature suggests that military service during early adulthood has a lasting effect on veterans' life-choices and decision making (Elder, 1986; Elder and Clipp, 1989). Malmendier et al. (2011) examine the effects of military experience in the corporate context and find that CEOs with military experience pursue more aggressive financial policies. Therefore, we include an indicator variable, *Military experience*, set to one for CEOs with prior military service, and zero otherwise.

2.3. Descriptive statistics

Table 1 reports the distribution of female board presence and the average option-based overconfidence measure across years and industries. Panel A shows the number and percentage of firm-years with female directors as well as the number and percentage of firm-years with more than one female director, in addition to the average CEO option moneyness across years. Panel B shows the equivalent numbers across industries.

Panel A suggests that, over the period of study, a majority of firms have female directors. While the number of firms with female directors increases during the first part of the period of study, it is relatively stable at about 75% during 2006-2013. The percentage of firms with more than one female director increases steadily, from 23.8% in 1998 to 43.6% in 2013. Not surprisingly, the average CEO option moneyness plummets around the 2001-2002 dotcom bubble burst, and the 2007-2009 financial crisis given that CEOs are less likely to be overly optimistic during recessions than during economically prosperous periods. To ensure that our findings are not simply a manifestation of the recession effect, we conduct additional analysis in Section 6 showing that the results are robust to excluding the two recession periods. In addition, the recent financial crisis provides an interesting setting to examine how firms with female directors perform during a crisis to shed further light on the importance of female board representation. This analysis is elaborated in Section 5.

Insert Table 1 about here

Panel B presents the statistics across the 11 Fama-French industries (financial firms, forming the twelfth industry, are excluded).[8] There are notable differences across industries in terms of female board presence. Specifically, the percentage of firm-years with female directors ranges from a low of 56.2% in Business Equipment to a high of 92.4% in Utilities. There is also variation across industries in the percentage of firm-years with more than one female director, ranging from 20.2% for Energy to 57.4% for Non-Durables. Moreover, the industry with the lowest average CEO option moneyness is Utilities (0.401).

[8] In the regression analysis, we use the Fama-French 49-industry classification.

Table 2 provides descriptive statistics for our sample. Panel A presents the gender difference in the propensity to hold deep-in-the-money options. Specifically, the average male CEO holds options that are 68.6% in the money, which is significantly (52.4%) higher than the average moneyness of 45% for female CEOs. This pattern is consistent with Huang and Kisgen (2013), who report that male executives exhibit relative overconfidence in their option holding and exercise decisions compared to female executives. The difference in medians confirms the pattern. Panel B contains summary statistics for the sample of firm-years with male CEOs upon which most of our empirical analysis is based. The average fraction of female directors in firms with a male CEO is 10.4%. In terms of the firm characteristics, the average firm has annual sales of 5619.7 million US dollars, leverage of 22.5%, a stock return of 13.0%, a return on assets of 14.3%, and a Tobin's q of 1.9. As to the governance and board characteristics, the fraction of independent directors is 72.6%, board size is approximately 9, and the E index has an average value of 2.6. These descriptive statistics are similar to those reported by previous studies on gender and corporate behavior (e.g. Adams and Ferreira, 2009; Gul et al., 2011; Huang and Kisgen, 2013; and Levi et al., 2014).

Insert Table 2 about here

Moving onto the CEO characteristics, average CEO age and tenure are 56 years and 8 years, respectively. In addition, the average age at which a CEO becomes CEO for the first time is about 46 years. The mean and median of CEO ownership are 1.5% and 0.3%. This variable is skewed, consistent with previous studies (Himmelberg et al., 1999; Kim and Lu, 2011). Further, the chair is the firm's CEO for 61.3% of all firm-year observations. The CEO holds professional qualifications for 8.4% and an MBA degree for 37.9% of all observations, respectively. Finally, the CEO has military experience for 6.6% of the firm-years and has attended an Ivy League university for 19.3% of the firm-years. These CEO characteristics have values in line with those reported by Custodio et al. (2013).

Table 3 focuses on the subsample with male CEOs. It compares the means as well as medians of various firm, governance, and CEO characteristics across firm-years with at least

one female director to those without. On average, male CEOs at firms without female directors hold options that are 82.8% in the money, which is significantly (33.5%) higher than the average moneyness of 62% for those at firms with female directors. This finding supports the hypothesis that male CEOs at firms with female directors are less overconfident about their firm's prospects and thus are more likely to exercise deep-in-the-money options early compared to those at firms with all-male boards.

Insert Table 3 about here

With respect to the firm and governance characteristics, firms with female directors are larger, have higher leverage, a lower Tobin's q, have better performance in terms of ROA, a larger board, a higher fraction of independent directors, and a higher E index value than firms without female directors. These patterns are consistent with those reported by Adams and Ferreira (2009).

In terms of the CEO characteristics, male CEOs at firms with female directors are older but less experienced as reflected by shorter tenure, became CEO for the first time at a later age, and have lower stock ownership. They are more likely to assume the position of chairman, to have military experience, to hold an MBA degree, and to have attended an Ivy League university than those at firms without female directors. These patterns suggest that the presence of female directors could well be related to firm, governance, and/or CEO characteristics, highlighting the importance of controlling for these characteristics in our analysis, as we do.

3. Empirical results

3.1. Baseline regressions

Table 4 contains the regressions testing whether CEOs exhibit less overconfidence in their option holding and exercise behavior when there are women on the board. The base specifications in Panel A are ordinary least squares (OLS) panel regressions where the dependent variable is the CEO's option moneyness. Regressions (1) to (3) are based on the firm-years with male CEOs, varying in terms of the control variables included. We start the

analysis by regressing *CEO option moneyness* on the fraction of female directors as well as industry and year effects in regression (1). Regression (2) augments the model by including the firm characteristics as control variables. In addition to these, regression (3) also controls for the governance and CEO characteristics. In all of the above specifications, the coefficient on *Fraction of female directors* is negative and statistically significant at the 1% level. In terms of economic significance, the coefficient in regression (3) indicates that an increase of 10 percentage points in the fraction of female directors is associated with a 6.24 percentage-point decrease in the male CEO's option moneyness. Given that the average male CEO option moneyness in our sample is 68.6%, this represents a 9.1% reduction relative to the mean level. We also reran the regressions in Table 4 by including an additional variable, the square of *Fraction of female directors*, allowing for a non-linear relation between the fraction of female directors and the dependent variable. We did not find any evidence of such a non-linear relation.

Insert Table 4 about here

Turning to the control variables, we find that CEOs at firms with better performance and more growth opportunities are more likely to delay option exercise, in line with our predictions. There is also evidence that male CEOs with MBAs tend to hold options deeper in the money, consistent with such CEOs exhibiting more aggressiveness in their financial decisions (Bertrand and Schoar, 2003).

In a similar vein, we also examine whether women on boards have any effect on the female CEO's option moneyness using the sample of firm-years with female CEOs in regression (4). Interestingly, we find no such evidence. Comparing the coefficient on *Fraction of female directors* across regressions (3) and (4), the finding that the negative effect observed for male CEOs is not observed for female CEOs suggests that the relation between female representation on the board and the male CEO's option moneyness likely reflects differences in gender. This is an interesting result as it confirms our hypothesis that female directors influence the behavior of male CEOs by making the latter less overconfident about his firm's prospects. For the rest of our empirical analysis, we focus on the male CEO sample.

In Panel B, we estimate several other specifications for robustness. We first estimate a firm fixed effects regression (regression (1)) to address the potential joint determination problem whereby an unobserved time-invariant firm characteristic simultaneously determines *CEO option moneyness* and *Fraction of female directors*. In firm fixed effects regressions, only the effects of within-firm changes on *CEO option moneyness* are taken into account. This suggests that firm-specific unobservables cannot explain the relation between *CEO option moneyness* and *Fraction of female directors*. We also verify the robustness of our results using a Fama and MacBeth regression (regression (2)) with Newey-West standard errors. Regressions (3) and (4) consist of two different logit models whose dependent variable is an indicator variable set to one if the CEO has estimated option moneyness greater than 100% and 67%, respectively, and zero otherwise.[9] These binary measures identify CEOs with relatively high optimism. The two cutoffs of 100% and 67% are suggested by previous studies, such as Campbell et al. (2011), Malmendier and Tate (2005), and Malmendier and Tate (2008). In all of the above specifications, we include the same firm, governance and CEO controls as in regression (3) of Panel A. For brevity, we only report the regression coefficient on the main variable of interest. The coefficient on *Fraction of female directors* is negative and statistically significant at the 1% level in all four regressions, confirming the negative effect of female board representation on the male CEO's option moneyness.

3.2. Identification

While the results so far are robust and consistent with the hypothesis, the observed relation between *Fraction of female directors* and *CEO option moneyness* could be spurious due to the endogenous nature of board composition (Wintoki et al., 2012). To obtain a meaningful causal interpretation of our results, at least two types of endogeneity concerns must be taken into account. The first is unobserved heterogeneity, which arises when some unobserved firm and CEO characteristics affect both the selection of female directors and the CEO's option exercise decisions. Although panel data allows us to control for firm and year fixed effects

[9] Alternatively, we define overconfident CEOs as those with option moneyness that is in the top quartile of our sample and find that the results are qualitatively similar.

(see also regression (1) of Panel B of Table 4, which controls for firm fixed effects), and we further control for a broad set of firm, governance, and CEO characteristics, the observed relation could still be driven by unobserved time-varying factors such as changes in the information set available to the firm and the CEO. For example, a major shift in the firm's strategy or business environment that affects its prospects could make it a better or worse time to appoint female directors, leading to spurious regression results.

The second endogeneity concern is reverse causality, which would occur if overconfident and powerful CEOs who have influence over the board selection process (Hermalin and Weisbach, 1988) dislike the greater monitoring provided by female directors (Adams and Ferreira, 2009) and therefore prefer an all-male board. Alternatively, firms led by non-overconfident CEOs, and therefore less likely to pursue aggressive strategies, might be more attractive to risk-averse female directors (Farrell and Hersch, 2005).

To address these two endogeneity concerns, we employ three approaches. We first conduct propensity score matching whereby firm-years with female directors are matched with those without, based on observable characteristics. We also employ an instrumental variable approach to adjust for the potential endogeneity of board composition. Finally, we employ a difference-in-differences (DID) matching estimator that exploits changes in female board representation resulting from female director appointments to identify whether women on the board affect the male CEO's behavior.

3.2.1. Propensity score matching estimates

To identify a control sample of firm-year observations without female directors that exhibit no significant differences in observable characteristics compared to those with female directors, we first estimate the probability that a firm hires female directors using a logit model, i.e., regression (1) of Panel A in Table 5,[10] which includes the same controls as regression (3) of Panel A in Table 4. This specification captures a significant amount of variation in the presence of female directors, as indicated by a pseudo R^2 of 29.4% and a *p*-value from the χ^2 test (not tabulated) of the overall fit of the model well below 0.001. The

[10] The results are qualitatively similar when we use a probit model in the first step.

results suggest that firms with female directors are larger and have larger and more independent boards, consistent with Adams and Ferreira (2009).

We then construct a treatment group and a control group of observations using the nearest-neighbor method based on the predicted probabilities, or propensity scores, from regression (1) of Panel A. Specifically, each firm-year with female directors (the treatment group) is matched with the firm-year without female directors (the control group) with the closest propensity score. If a firm-year in the control group is matched with more than one firm-year in the treatment group, we retain only the pair for which the difference in propensity scores is the smallest.[11] To ensure that observations in the treatment and control groups are sufficiently indistinguishable, we further require that the maximum difference (i.e., the caliper) between the propensity score of each firm-year with female directors and that of its matched peer does not exceed 0.01 in absolute value. We obtain 2,250 unique pairs of matched observations.

We conduct two diagnostic tests to verify that observations in the treatment and control groups are truly indistinguishable in terms of observable characteristics. First, we re-estimate the logit model (not tabulated) using the matched sample in regression (2) of Panel A. All of the coefficient estimates are statistically insignificant, indicating that there are no distinguishable trends between the two groups. Further, the pseudo R^2 drops substantially from 29.4% in the pre-match model to only 0.3% in the post-match model. The χ^2 test also fails to reject the null hypothesis that all coefficient estimates equal zero.

Insert Table 5 about here

The second test consists of examining the difference in means for each observable characteristic between the treatment and matched control groups. The results, reported in Panel B of Table 5, show that none of the differences is statistically significant. Overall, the diagnostic test results suggest that the propensity score matching removes observable differences other than the difference in board gender composition. Thus, it increases the

[11] Alternatively, we allow control firm-years to be matched with multiple treatment firm-years and find that the results are qualitatively similar.

likelihood that any difference in *CEO option moneyness* between the two groups is due to the presence of female directors on the board. Finally, Panel C of Table 5 reports the propensity score matching estimates.[12] The results suggest that, if a director is female, the male CEO's option moneyness decreases by 8.1 percentage points on average, which amounts to a 11.8% reduction relative to the mean level. This effect is significant at the 1% level. Thus, we conclude that potential matching between female directors and firms/CEOs—at least based on observable characteristics—does not drive our findings.

3.2.2. Instrumental variable estimates

To jointly address our concerns of potential unobserved heterogeneity and reverse causality, we use the instrumental variables approach to extract the exogenous component of female board representation. The latter is then used to explain the male CEO's option moneyness. As sources of exogenous variation, we use two instrumental variables that capture a firm's likelihood of appointing female directors, one at the firm level and the other at the state level. Both are uncorrelated with *CEO option moneyness*, except through variables we control for.

The first instrument is the fraction of a firm's male directors who sit on other boards with at least one female director, which has also been used by Adams and Ferreira (2009) and Levi et al. (2014). The rationale behind this instrument is that the more connected a firm's male directors are to women, the more female directors should be observed and appointed (Adams and Ferreira, 2009). Therefore, we expect this instrumental variable to be positively correlated with the fraction of female directors. The second instrument is the female-to-male population ratio calculated as the female population divided by the male population in the state where the firm is headquartered. Firms in states where the female-to-male population ratio is higher are more likely to find qualified female candidates for their board of directors, *ceteris paribus*, given the potentially broader talent pools. Therefore, we expect that, the greater the female-to-male population ratio, the greater the representation of women on

[12] The propensity score matching estimate of the average treatment effect on the treated (ATT) is the difference in means between the treatment and matched control groups.

boards will be. Meanwhile, it is reasonable to argue that a state's female-to-male population ratio is not directly correlated with *CEO option moneyness*.

The first column of Table 6 (regression (1)) contains the results of the first-stage regression where the dependent variable is the fraction of female directors. Consistent with our prediction, the coefficient estimates for the two instruments are positive and significant at the 1% level. We conduct three additional tests to verify that our instruments are not weak. First, we test the joint significance of the two instruments and find that the value of the *F-test* is relatively large (9.120) and highly significant (*p-value*=0.000). Second, the *p-value* of the Cragg-Donald's Wald *F* weak-instrument test statistic is close to zero, rejecting the null hypothesis that the instruments are weak (Cragg and Donald, 1993; Stock and Yogo, 2005).[13] Third, the *p-value* for Hansen's *J* over-identification test is large (0.170), suggesting that the two instruments are valid, i.e., uncorrelated with the error term (Hansen, 1982).

Insert Table 6 about here

The second column (regression (2)) contains the second-stage regression results where the dependent variable is the male CEO's option moneyness. The main variable of interest is the predicted value of the fraction of female directors. The coefficient on *Fraction of female directors* is negative and significant at the 1% level. Male CEOs at firms with lower fractions of female directors tend to hold options that are deeper in the money, after endogeneity is taken care of, confirming the causal relationship between female board representation and less overconfidence in the male CEO's option exercise decisions.

A potential concern is that the *Fraction male linked to female* instrument might capture the connectedness of the board and bias the results. To address this concern, we follow Adams and Ferreira (2009) in controlling for more direct measures of board connectedness (regressions (3) to (6)): the total number of external board seats held by directors and male directors, respectively. Our results are robust to the inclusion of these additional controls.

[13] The Stock and Yogo (2005) critical value with one endogenous regressor and two instrumental variables based on 2SLS size is 19.93. For all the regressions, the Cragg Donald Wald F-statistic is much larger than 19.93. Therefore, we reject the null hypothesis that the instruments are weak.

3.2.3. Changes in CEO option moneyness around director appointments

An alternative explanation for the negative impact of female board representation on the male CEO's optimistic bias is that firms with women on the board are more likely to fire overconfident CEOs or hire CEOs less likely to exhibit overconfidence. To rule out this alternative explanation, we employ an identification strategy of difference-in-differences around female director appointments, which do *not* coincide with a CEO change, to identify the effect of women on boards. The DID analysis compares the outcomes for two similar groups with and without the treatment but that would otherwise be subject to similar influence from the trending variables. Therefore, if any trends in outcomes for the two groups prior to treatment are the same (i.e., the parallel trends assumption), then the impact of the treatment should be reflected in the difference between the changes for the two groups (Roberts and Whited, 2013).

This analysis is based on the firm-years one year before and one year after a director appointment, excluding the year of the appointment. We carefully construct the treatment group to mitigate the likelihood that any director appointment is driven by unobserved factors, such as changes in corporate strategy, which may affect the CEO's option exercise decisions. To be included in the treatment group, the firm must appoint only one female director to replace a departing male director in the year of the appointment and the departing male director must be older than 60.[14] As stated above, to eliminate the possible confounding effects of CEO changes we exclude firms that experience CEO turnover during the period. The application of these criteria results in a total of 60 female director appointments for our treatment group. For the control group, we identify 174 observations where a departing male director aged above 60 is replaced with one newly appointed *male* director.

We then match treatment and control observations using propensity score matching to help satisfy the parallel trends assumption and ensure that the results are not driven by differences in CEO, firm and/or industry characteristics.[15] The matching procedure is

[14] This restriction ensures that director turnover is more likely due to retirement than to corporate strategic changes or bad director performance. As a robustness test, we require that the departing director must be older than 61, 63, and 65, respectively. The results continue to hold.

[15] The results are robust to using the unmatched sample.

analogous to that described in section 3.2.1.[16] We end up with 56 unique pairs of matched firms. Based on this matched sample, we estimate the following regression.

$$\textit{CEO option moneyness}_{i,t+1} = \alpha + \beta_1 \textit{Female appointment}_{i,t+1} + \beta_2 \textit{Post}_{i,t+1} + \beta_3 \textit{Female appointment}_{i,t+1} \times \textit{Post}_{i,t+1} + \gamma Z_{i,t} + \textit{Industry}_i + \textit{Year}_t + \varepsilon_{i,t} \quad (2)$$

where *Post* is an indicator variable stating whether the year is after the director appointment. *Female appointment* is an indicator variable stating whether the firm is in the treatment group.

The results are reported in the first column (regression (1)) of Table 7 where we include the same firm, governance and CEO controls as in regression (3) of Panel A in Table 4. The coefficient on *Female appointment* × *Post* is negative and significant at the 5% level, indicating that, after female director appointments, male CEOs are less likely to exhibit overconfidence in their personal portfolio decisions than after male director appointments. The estimated effect is also economically meaningful. On average, male CEOs tend to hold options that are 28.2 percentage points lower in the money (or 41.1% lower relative to the mean level) for the year after the female director appointment than they do after the male director appointment.

Insert Table 7 about here

If it is harder for women to get on the board than it is for men, then the potential selection and resulting quality differences between female and male directors could alter the interpretation of the results. For example, it could be the case that those females that break through the glass ceiling are much better than their male counterparts. We take two steps to

[16] We start the matching by estimating the probability, or propensity score, of a firm replacing a departing male director with a female director rather than a male director using the same variables as in Panel A of Table 4. We then match each observation in the treatment group with the observation in the control group with the closest propensity score. If an observation in the control group is matched with more than one observation in the treatment group, we retain only the pair with the smallest difference in propensity scores. We also require that the maximum difference in propensity scores does not exceed 0.01 in absolute value. An alternative matching procedure (with replacement) consists of allowing control firms already matched with a treatment firm to remain in the sample and to be reused. The resulting DID estimators become even more statistically significant than those reported. However, there are differences in firm characteristics in the pretreatment period across the treatment and control groups, making it less likely that a comparison of treatment and control groups provides an accurate estimate of the effect of female director appointments. Our choice of matching procedure (without replacement) improves matching precision at the expense of a loss of sample observations.

mitigate the concern that our findings are driven by differences in director quality and not gender. First, in regression (2) we include additional controls to capture several observable dimensions of director quality: [17] *Dummy_MBA replaces non-MBA* (*Dummy_Non-MBA replaces MBA*) is an indicator variable stating whether a departing director without (with) an MBA degree is replaced with a new director with (without) an MBA degree; *Dummy_Non-Ivy replaces Ivy* (*Dummy_Ivy replaces non-Ivy*) is an indicator variable stating whether a departing director who attended (did not attend) an Ivy-League university is replaced with a new director who did not (did); *Dummy_Qualif. replaces non-Qualif.* (*Dummy_Non-Qualif. replaces Qualif.*) is an indicator variable stating whether a departing director without (with) professional qualification is replaced with a new director with (without) professional qualification. The results show that controlling for the education and qualification variables does not have a large impact on the magnitude of the coefficient on the interaction term. Second, in regression (3) we use director-pair fixed effects (i.e. fixed effects for each pair of departing male director and his replacement new director) to eliminate the impact of any unobserved time-invariant director characteristics on *CEO option moneyness*. The coefficient on the interaction term remains negative and significant at the 5% level. Thus, we view this evidence as suggesting that the effect of female board representation on CEO overconfidence is not due to selection.

To rule out alternative explanations pertaining to reverse causality, we examine the dynamics of the female board representation effect in regressions (4) and (5). The sample for this additional analysis includes the firm-years up to two years before and up to two years after a director appointment. Specifically, we create a set of dummy variables indicating the first year and second year before the appointment ($Post^{-1}$ and $Post^{-2}$), the first year after the appointment ($Post^{+1}$), and two years after the appointment ($Post^{+2}$), and replace *Female appointment* × *Post* with the four interaction terms between *Female appointment* and these timing dummies. [18] If our results are affected by reverse causation, the likelihood of

[17] In this analysis, we also account for the quality of the departing male director by incorporating their MBA, Ivy-League, and professional qualification dummies in the propensity score matching procedure described in footnote 16.

[18] Note that one of the interaction terms is omitted from regression (5) to avoid perfect collinearity.

appointing a female director might already be correlated with *CEO option moneyness* before the appointment, and thus we should observe a negative and significant coefficient for *Female appointment* × $Post^{-2}$ or *Female appointment* × $Post^{-1}$. However, the results indicate that, in both the OLS and director-pair fixed effects specifications, it is only after the appointment that the negative effect on *CEO option moneyness* becomes large and significant. These findings suggest that the estimated female board representation effect does not reflect reverse causation or pre-existing trends.

A potential caveat is that director appointments that involve changes in director type (i.e., replacing an executive director with an independent director, or vice versa) might be indicative of a firm's strategic changes that would affect its prospects. To tackle this issue, we first exclude those appointments with director type changes and then match each treatment female director appointment with the male director appointment with the same director type and closest propensity score. These further restrictions reduce the number of matched pairs to 36, and our results still hold. Another robustness check (effectively a placebo test) consists of falsely assuming that director appointments occur one and two years before they actually do, respectively. The resulting insignificant estimates of the treatment effect suggest that the observed change is more likely due to actual director appointments, as opposed to some alternative forces (Roberts and Whited, 2013).

3.3. Female board representation and CEO option exercise behavior

The *CEO option moneyness* variable used in the above analyses measures the average moneyness of all exercisable options held by the CEO, which could vary (i) when the CEO exercises some existing options, and (ii) when new packages of options become vested and exercisable. The former source of variation captures differences in the CEO's exercise behavior. The latter, however, is less likely to reflect CEO behavior and beliefs since the CEO has little control over it. As an alternative, we isolate the sample of options exercised and examine the relation between the characteristics of exercised options and female board representation. Investigating the characteristics of exercised options should provide insights into the CEO's timing of option exercise and improve the robustness of our findings.

For each option exercise in the sample, we study the following two characteristics: *Value ratio* is defined as the ratio of the intrinsic value to the strike price of the option, where the intrinsic value is calculated as the stock price at exercise minus the strike price; and *Time to expiration* is defined as the remaining number of years until the option expiration at exercise. These data are then aggregated for each CEO on an annual basis, using a simple average over the number of options exercised. The option exercise data is from the Thomson Reuters Insider Filings database.[19] Sen and Tumarkin (2015) show that optimistic CEOs exercise options closer to expiration and at higher stock prices than non-optimistic CEOs. Thus, we expect female board representation to be associated with less optimistic option exercise choices characterized by more time remaining until expiration and lower value ratios at exercise.

Table 8 provides support for our predictions. Regressions (1) and (2) show a negative relation between *Fraction of female directors* and the value ratio, and regressions (3) and (4) demonstrate a positive relation between *Fraction of female directors* and the remaining time to expiration. The coefficient on *Fraction of female directors* is statistically significant at the 10% level or better in all four regressions. Moreover, the results indicate that an increase of 10 percentage points in the fraction of female directors is associated with a 17.53 percentage-point decrease in the value ratio and 0.045 more years until option maturity, based on the firm fixed effects specifications (regressions (2) and (4)).

Insert Table 8 about here

The approach that we have adopted thus far captures the impact of female board representation on the CEO's option exercise behavior. It is then useful to ask whether female board representation also influences the CEO's stock-related portfolio decisions, as would be expected if the CEO's biased beliefs are attenuated. To shed light on this question, we

[19] In the Thomson Reuters database, an option is identified by a derivative indicator equal to one for the following: options (OPTNS), employee stock option (EMPO), non-qualified stock options (NONQ), incentive stock options (ISO), call options (CALL), directors' stock options (DIRO), warrants (WT) or non-employee director stock option (DIREO). To ensure the accuracy of the data, we follow Sen and Tumarkin (2015) and keep only those option records with the following 'cleanse indicators': indicators R, H, and C, meaning a high degree of confidence in the reported data's accuracy; and indicators L and I, meaning the data is cleaned or improved. We drop all records that are an amendment to a previous report.

construct two alternative measures of overconfidence based on the CEO's stock transactions: (i) *Net buyer*[20] is an indicator variable that equals one if the CEO is a net buyer of company stock in that year, and zero otherwise; and (ii) *Share retainer*[21] is an indicator variable that equals one if the fraction of shares retained from option exercise during a year exceeds 1%, and zero otherwise.[22] The former indicator variable exploits the CEO's tendency to purchase additional company stock despite his already high exposure to company risk, following the rationale proposed by Malmendier and Tate (2005). The latter is based on the theoretical analysis of Sen and Tumarkin (2015) that shows that an executive will retain shares received from exercising company stock options if and only if he is optimistic. Untabulated results suggest that male CEOs at firms with women on the board are less likely to be net buyers of company stock and to retain shares received from option exercise, consistent with the hypothesis that female board representation helps attenuate inflated beliefs about growth prospects.

4. Female board representation, overconfidence, investment policy and corporate performance

Our results so far are consistent with female board representation moderating the CEO's overconfidence about the firm's prospects. The question that naturally arises is whether this moderating effect is sufficiently strong to affect corporate investment decisions and performance. This is not a trivial question as the discussion in the introduction suggests that female directors may not have an impact because they are by and large minorities in the boardroom (Adams and Ferreira, 2009).

In response to the above question, a strand of research shows that too much managerial overconfidence may be detrimental to the firm because it leads CEOs to form overly optimistic views about investment opportunities, resulting in overinvestment, a heightened

[20] Data on the CEO's purchases and sales of company stock is from the Thomson Reuters Insider Filings database.
[21] *Share retainer* data is obtained from Sen and Tumarkin (2015).
[22] The 1% threshold ensures that the indicator variable captures only those cases where a CEO holds a non-trivial proportion of shares received from option exercise (Sen and Tumarkin, 2015). *Share retainer* is based on the CEO's stock transactions that coincide with option exercise. It is set to its most recent computed value for years in which a CEO did not exercise an option, following Sen and Tumarkin (2015).

sensitivity of investment to cash flows, and suboptimal acquisition decisions (Malmendier and Tate, 2005; Malmendier and Tate, 2008; Malmendier et al., 2011; Banerjee et al., 2015). Hence, it is possible that a board with female representation, by mitigating the CEO's optimistic bias, reduces overinvestment and the sensitivity of investment to cash flows, as well as improving acquisition decisions, and ultimately firm performance. If this is the case, then board gender composition should be particularly important in industries in which CEOs are more likely to develop overconfidence and the moderating effects of female board representation on corporate investment decisions should be more prominent in these industries.

The propensity of CEOs to hold biased beliefs may vary across industries, given that differences in industry-wide practices (e.g., work attitudes, motivation techniques, and managerial practices) and growth prospects can significantly influence individual behavior (Form, 1979; Rasmussen and Rauner, 1996; Ferris et al., 2013). There is also evidence from field studies implying that overconfidence is more likely to occur in industries in which the decision-making environment is non-repetitive and ambiguous, resulting in lack of prior similar actions to help calibrate judgment (Simon and Houghton, 2003). Consistent with these conjectures, we find that the dispersion of overconfidence among CEOs varies considerably across industries during the sample period and that the industries with the highest average CEO option moneyness are pharmaceuticals, computer software and fabricated products. To capture the cross-industry differences in the prevalence of overconfidence, we construct two variables: *High industry OC (overconfidence) representation* is an indicator variable that equals one if the fraction of overconfident CEOs for an industry in that year is greater than the sample median across all industries, and zero otherwise, with overconfident CEOs being those who hold stock options that are more than 67% in the money.[23] *High industry OC (overconfidence) intensity* is an indicator variable that equals one if the average *CEO option moneyness* for an industry in that year is greater than the median average *CEO option moneyness* across all industries, and zero otherwise. We hypothesize that the effects of female board representation on corporate investment decisions are more prominent in

[23] The results are qualitatively similar when we use the 100% or top quartile cutoff.

industries with a high prevalence of overconfident beliefs. We find evidence in support of this hypothesis.

An alternative approach to testing whether female directors affect corporate decisions by moderating the CEO's biased beliefs is to directly control for *CEO option moneyness* when examining the effect of *Fraction of female directors* on firm outcomes. If this effect occurs because of the change in the CEO's degree of overconfidence, then controlling for *CEO option moneyness* should lessen the estimated effect of *Fraction of female directors*. In other words, part of the effect should be explained by *CEO option moneyness*. However, a potential issue with this approach is that the CEO/firm level overconfidence measure is likely to be influenced by the CEO's career trajectory that is important in shaping his management style, and in turn biases the results. In contrast, industry-level measures are arguably unrelated to the characteristics of the individual CEO/firm. Thus, we use the aforementioned industry-level versions of the overconfidence measure for our main analysis in Sections 4.1-4.3. Nevertheless, in untabulated tests we find that, after controlling for individual *CEO option moneyness*, the estimated coefficient on *Fraction of female directors* has a much smaller effect on the various types of firm's decisions, consistent with the view that female board representation affects firm outcomes through reducing the CEO's optimistic bias.

4.1. Corporate investment

Table 9 presents the regression results where the dependent variable is capital expenditures defined as the firm's capital expenditures scaled by beginning of year net property, plant and equipment (Kaplan and Zingales, 1997).[24] The first specification uses *High industry OC (overconfidence) representation* whereas the second one uses *High industry OC (overconfidence) intensity*. For each specification, we estimate the regression using three alternative econometric techniques: OLS, firm fixed effects, and a dynamic panel system

[24] The results continue to hold when we define the dependent variable as industry-adjusted capital expenditures, i.e., a firm's capital expenditures minus the median capital expenditures in the firm's industry for the year in question. Again, we scale capital expenditures by beginning of year net property, plant and equipment.

GMM regression.[25] The coefficients on both of the above industry overconfidence prevalence variables are positive and statistically significant at the 1% level, consistent with overconfident beliefs leading CEOs to invest more heavily. Focusing on the main variable of interest, the coefficient on *Fraction of female directors* is typically insignificant, but the coefficients on the interactions of the former with each of the two industry overconfidence prevalence variables are negative and significant at the 10% level or better. This suggests that female board representation reduces investment in industries with high overconfidence prevalence. However, there is no such effect in industries with low overconfidence prevalence.

Insert Table 9 about here

Table 10 examines how female board representation affects a firm's investment sensitivity to cash flows. Malmendier and Tate (2005) find that managerial overconfidence is associated with a heightened sensitivity of corporate investment to cash flows, i.e., overconfident CEOs overinvest when the firm has abundant internal funds, but investment is curtailed when the firm requires external financing. By moderating managerial overconfidence, female board representation is likely to reduce the investment sensitivity to cash flows. To test this conjecture, we augment the regressions in Table 9 by including *Cash flow* and its interaction with *Fraction of female directors*. We then estimate regressions separately for the subsamples with above and below median *industry OC representation* in Panel A and above and below median *industry OC intensity* in Panel B. As per our expectations, we find that the coefficients on the interactions are negative and statistically significant only in the high industry overconfidence prevalence subsample. This is the case for both *industry OC representation* and *industry OC intensity*.

[25] To address the dynamic endogeneity concern in the investment regressions (i.e., past realizations of the dependent variable affecting current levels of some or all of the independent variables), we use the dynamic panel system GMM method developed by Arellano and Bover (1995) and Blundell and Bond (1998). The system GMM estimator improves the first differences GMM estimator by including the equations in levels to form a system of equations that includes the equations in both levels and differences. We then use lagged levels as instruments for the equations in first differences and lagged differences as instruments for the levels equations, respectively (Wintoki et al. 2012). Two lags are used as the instrument set.

Insert Table 10 about here

Table 11 presents the regression results where the dependent variable is the growth in total assets and growth in property, plant and equipment (PPE), respectively. Consistent with the argument that overly optimistic views on firm prospects lead CEOs to pursue greater assets growth, we find positive and statistically significant coefficients on our two industry overconfidence prevalence variables. Further, the coefficient on *Fraction of female directors* is insignificant, but the coefficients on the interactions are again negative and significant at the 10% level or better, suggesting that female board representation helps moderate assets growth in industries with high overconfidence prevalence, but not in those with low overconfidence prevalence.

Insert Table 11 about here

Overall, we find that female board representation is associated with less investment, less aggressive assets growth, and a reduced sensitivity of investment to cash flows, and that these effects are concentrated in industries with a high prevalence of overconfidence. This is consistent with our hypothesis.

4.2. Mergers and acquisitions

Malmendier and Tate (2008) argue that CEOs with overly optimistic beliefs tend to overestimate their ability to generate returns, overpay for target firms, and make value-destroying acquisitions, resulting in lower quality acquisition deals and negative market reaction. We expect female board representation to have a positive effect on shareholder gains from acquisitions by attenuating managerial overconfidence about acquisition activities, especially in industries with high overconfidence prevalence. This is tested in Table 12.[26] We

[26] The acquisition dataset starts with all acquisition announcements listed in the Securities Data Company (SDC) database, which we then merge with accounting data, stock return and CEO characteristics data. To construct this dataset, we identify the acquirer in an acquisition and include several controls that are standard in the acquisition literature. Following previous studies (e.g., Malmendier and Tate, 2008; Netter et al., 2011), we impose the following restrictions on our sample: (i) the deal status is "completed"; (ii) the acquirer is a US publicly listed firm, and the target is a US public or private firm, and neither is in the financial services industries; (iii) the acquiring firm obtains at least 50% of the target shares; (iv) the percentage of stocks held by the acquiring firm six months prior to the announcement must be below 50%; (v) deal value is greater than 5%

start by estimating OLS models (regressions (1) and (2)) where the dependent variable is the acquirer's cumulative abnormal returns (CAR)[27] from five days before the acquisition announcement to five days after.[28] The coefficient on *Fraction of female directors* is insignificant, whereas the coefficients on the interactions are positive and significant at the 10% level or better, suggesting that female board representation makes a positive contribution to cumulative abnormal returns in industries with high overconfidence prevalence, but not in those with low overconfidence prevalence. In regressions (3) and (4), we use the Heckman two-step method to address the potential self-selection bias in deal-initiation decisions. The first step involves estimating a selection equation for the deal-initiation decision. Following Masulis and Simsir (2015), we use *Prior industry merger intensity* as the identifying instrument in the first step equation. It is calculated as the total number of merger deals in the industry (based on the Fama-French 49-industry classification) within the past two years divided by the total number of mergers across all industries over the same period. On the one hand, CEO deal initiation decisions are likely to be positively related to the frequency of prior deals in their industries. On the other hand, there is no clear economic rationale for *Prior industry merger intensity* to affect the outcome variable directly. The controls are the same as in regression (3) of Panel A in Table 4. In the second step, we estimate the same model as regressions (1) and (2) of Table 12, augmented by the estimated inverse Mills ratio from the first step. We find that our results are robust to this alternative approach.

Insert Table 12 about here

In terms of deal characteristics, we find that deal size is negatively associated with the cumulative abnormal returns, consistent with Banerjee et al. (2015). Additionally, the coefficient on *All equity* is negative and significant at the 5% level, in line with the findings

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of the acquirer value; (vi) the deal type is "disclosed and undisclosed (deal value) deals"; (vii) the deal announcement occurs between 1998 and 2013.

[27] Abnormal returns are calculated as the market model residuals, with the parameters estimated over the [-205, -6] window relative to the announcement day, day 0, following Moeller et al. (2004).

[28] The results are qualitatively similar when we use the three-day [-1, +1] and five-day [-2, +2] event window for computing the CAR.

of previous literature that equity deals are on average viewed less favorably by the market (Malmendier and Tate, 2008).

4.3. Corporate performance and value

Our analysis has so far focused on the role of female board representation in mitigating overinvestment and reducing the investment sensitivity to cash flows, as well as improving acquisition decisions. Next, we examine whether these effects contribute to firm performance and value. We conjecture that female board representation is particularly important in industries with high overconfidence prevalence, where they might add value by mitigating investment distortions associated with overconfidence. We use both market and accounting based measures of performance in what follows.

Insert Table 13 about here

The results in Table 13 are consistent with our hypothesis. Female board representation significantly influences neither firm value, measured by *Tobin's q* (Panel A), nor firm performance, measured by the return on equity (*ROE*) (Panel B) and return on assets (*ROA*) (Panel C), in low overconfidence-prevalence industries, as indicated by the insignificant coefficient on *Fraction of female directors*. However, the coefficients associated with the interaction terms are positive and significant (with two exceptions), suggesting that female board representation helps alleviate investment distortions associated with managerial overconfidence and improve firm performance and value, especially in industries with high overconfidence prevalence.

5. Female board representation and corporate performance during the 2007-2009 crisis

The recent financial crisis, which started in 2007 after a period of credit expansion, has been described as the worst financial crisis in the last 50 years (Fahlenbrach et al., 2012). Ho et al. (2016) show evidence of a link between managerial overconfidence and poor performance during the crisis. They indicate that overconfident CEOs tend to overestimate the probability of a positive state, underestimate the downside risk of a project, and pursue aggressive

strategies that ex post make their firms more vulnerable when a credit boom is followed by a crisis. Thus, if female directors are more likely to caution against an overly optimistic assessment of investment prospects during an economic upswing, then (i) the subsequent financial crisis should represent less of a shock to CEOs with female directors on their boards; and (ii) firms with female directors should experience less of a drop in operating and stock performance.

Recent studies show that regions that suffered larger drops in house prices were more severely affected by the crisis, resulting in a larger reduction in consumption and employment (Mian and Sufi, 2011; Mian et al., 2013; Mian and Sufi, 2014). Accordingly, we exploit state differences in the house price collapse to capture the cross-sectional variation in the severity of the crisis.[29] We then investigate the interactive effect of whether female board representation attenuates the effect of the crisis on the change in the variable of interest. Specifically, we estimate the following regression:

$$\begin{aligned}\Delta y_{i,s} = {} & \alpha + \beta_1 \textit{ Fraction of female directors}_{i,s} + \beta_2 \textit{ 1st Qtile House price shock}_{s} \\ & + \beta_3 \textit{ 1st Qtile House price shock}_{s} \times \textit{Fraction of female directors}_{i,s} \\ & + \beta_4 \textit{ 4th Qtile House price shock}_{s} + \beta_5 \textit{ 4th Qtile House price shock}_{s} \\ & \times \textit{Fraction of female directors}_{i,s} + \gamma Z_{i,s} + \textit{Industry}_{i,s} + \varepsilon_{i,s} \qquad (3)\end{aligned}$$

where index *i* refers to the firm and index *s* refers to the state. Δy is the change in the variable of interest, including *CEO option moneyness*, *Tobin's q*, *ROA*, and *ROE*, from 2007 to 2009. *1st Qtile House price shock* and *4th Qtile House price shock* are indicator variables for the first (least severe) quartile and the fourth (most severe) quartile of *House price shock*, where *House price shock* is the percentage drop in the Zillow Home Value Index (ZHVI)[30] from December 2006 until December 2009 in the state of the company's headquarters. We classify

[29] This approach is analogous to a difference-in-differences analysis which compares the change in the variable of interest for firms in more affected regions ('treatment group') with those for firms in less affected regions ('control group').

[30] The house value index data is obtained from Zillow (http://www.zillow.com/research/data/). Zillow provides estimates of the price of more than 110 million individual houses in the US, based on information from several sources, including prior sales, county records, tax assessments, real estate listings, and mortgage information. These house-level valuations are then aggregated into the Zillow Home Value Index (ZHVI). We find that, on average, the ZHVI dropped by 10.5% from December 2006 to December 2009.

House price shock into quartiles to reflect the nonlinear type of relation between the severity of the house price collapse and the variables of interest. *Fraction of female directors* is the number of female directors divided by board size. As in previous regressions, we control for the same set of firm, governance, and CEO characteristics, all measured in 2006. Our timings are consistent with recent studies of the recession (Mian and Sufi, 2014; Flammer and Ioannou, 2015).

Insert Table 14 about here

Several important observations can be made from Table 14. First, for the house price shock quartiles, we find in general that only the coefficient representing the 4th quartile is significant, suggesting that the true relation is asymmetric. Second, in regression (1) where the dependent variable is the change in CEO option moneyness, we find that the coefficient on the interaction term *4th Qtile House price shock* × *Fraction of female directors* is positive and significant at the 5% level, weakening the negative impact of *4th Qtile House price shock* on the CEO's option moneyness. Being cautioned against overconfident views about the firm's future prospects in the noncrisis years, CEOs of firms with more gender-diverse boards appear to be less shocked by and adjust their personal portfolios less substantially in response to the subsequent crisis. Third, in regressions (2) to (4) where the dependent variable is the change in measures of firm performance/valuation, we find again that the coefficient on the interaction term *4th Qtile House price shock* × *Fraction of female directors* is generally positive and significant, offsetting the negative baseline effect of *4th Qtile House price shock*. This finding, along with the findings from previous sections, implies that CEOs with gender-diverse boards adopt less aggressive strategies that make their firms less vulnerable to the crisis.

6. Robustness tests

We take the following seven steps to ensure the robustness of our main findings.[31] First, a potential concern with using the option-based measure as a proxy for overconfidence is that it may be correlated with the CEO's private information about future stock prices. A CEO with favorable insider information may choose to delay the exercise of in-the-money options to gain from the expected price increases. To address this possibility, we construct a 'residual' confidence measure, which is the residual from the regression of *CEO option moneyness* on future stock returns, i.e., stock returns from year *t+1*. This alternative measure, *CEO option moneyness residual FR*, represents the proportion that is less likely to reflect future performance. The results are robust to using this alternative measure, suggesting that private information about future stock prices does not drive our main finding. Similarly, the results are robust to using *CEO option moneyness residual LR*, which is the residual of a regression of *CEO option moneyness* on the firm's lagged stock returns (or stock market returns).[32] This ensures that our confidence measure is not merely an artifact of prior performance.

Second, to address the concern that our option-based measure does not capture whether the vested options are economically important to the CEO, we construct an alternative option-based measure, i.e. the natural logarithm of one plus the ratio of the total value of vested but unexercised options to the CEO's total compensation, following Banerjee et al. (2015). The results are robust when using this measure.

Third, to make sure that our results do not merely reflect mechanistic changes in overconfidence due to CEO changes, we exclude firm-years with CEO turnover and find that the results remain qualitatively the same.

Fourth, the statistics shown in Table 1 suggest that the average CEO option moneyness plummets during crises. Meanwhile, the percentage of firms with more than one female director increased steadily over the period of study. Hence, it is possible that our findings are simply a manifestation of the crisis effect. To rule out this concern, we exclude the two crisis periods, the 2001-2002 dotcom bubble burst and 2007-2009 financial crisis, from our sample

[31] These robustness test results are not tabulated, but are available from the authors on request.
[32] Market return is based on the CRSP value-weighted market index.

and find that the results are not materially affected. This evidence suggests that our findings are not driven by crises.

Fifth, the previous regressions include controls for various CEO and firm-level governance characteristics to address the concern that the observed effects of female board representation may simply reflect corporate governance factors. The results suggest that governance characteristics do not explain our findings. To further address this concern, we confirm that the results are also robust to splitting the sample into subsamples based on the sample median of our governance indicators, including *E index*, *CEO tenure*, and *Board independence*, and whether the CEO is also the Chairman, confirming that governance factors on their own do not drive the results. Relatedly, Adams and Ferreira (2009) show that female directors are more likely to be assigned to monitoring-related committees (including audit, nominating, and corporate governance committees), but less likely to sit on compensation committees than male directors. We therefore examine whether our findings can be related to differences in committee functions and find that female directors are equally significant in mitigating male CEO overconfidence regardless of their committee assignments.

Sixth, we test whether the results are robust to the inclusion of additional director/board characteristics as controls by including *Average director age*, which is the average of directors' age; *Age dispersion*, the standard deviation of director age divided by the average age of directors on the board; *Average director tenure*, the average of directors' board tenure; *Tenure dispersion*, the standard deviation of director tenure divided by the average tenure of directors on the board; and *Fraction of (female) busy directors*, the number of (female) directors with three or more directorships divided by board size. The results continue to hold.

Finally, we also test whether the results are robust to the use of alternative clustering and alternative definitions of industry dummies. The above reported regressions include either Fama-French 49 industry dummies and year dummies, or firm and year dummies. For all regressions, standard errors are clustered by firm. We confirm that our findings are robust to using *industry-year* dummies based on the Fama-French 49 industries, to using two-digit SIC industry dummies, to using three-digit NAICS industry dummies, to the exclusion of year dummies, and to clustering by year, industry, or double clustering by firm and year.

7. Conclusion

We find that male CEOs at firms with female directors are less likely to hold options deep in the money and retain shares received from exercising stock options, and less likely to be net purchasers of company stock. We also find that female board representation is associated with less optimistic option exercise behavior as evidenced by more time remaining until expiration and lower value ratios at exercise. These findings suggest that female board representation moderates the CEO's overly optimistic beliefs about the firm's growth prospects.

Further, we find that female board representation is associated with lower investment, reduced investment sensitivity to cash flows, less aggressive assets growth, better acquisition decisions, and ultimately improved firm performance in industries with high overconfidence prevalence, but not in those with low overconfidence prevalence, consistent with the view that female board representation affects firm outcomes through reducing the optimistic bias of male CEOs.

Our study suggests that board gender composition is paramount in industries where male CEOs are likely to suffer from overconfidence about their firm's prospects. In such firms, female representation on the board leads to better corporate decisions, including investment and acquisition decisions, and ultimately better performance and firm value. In contrast, female board representation does not have a significant effect on CEO behavior in industries where male CEOs are less likely to be overconfident. Our study is an important contribution to the ongoing debate about board gender quotas.

Finally, we show that female board representation can help explain the cross-sectional heterogeneity in firm performance during the financial crisis of 2007-2009. Overall, the results suggest that firms with female directors experience a less severe drop in operating and stock performance during the crisis. This finding highlights the importance of female board representation and provides further evidence for the role of female directors in mitigating the CEO's optimistic bias.

A meaningful extension to the paper involves identifying the channel(s) whereby female directors manage to reduce male CEO overconfidence in corporate decisions. One possibility is that when female directors are on the board additional meetings are held to reach consensus because of more competitive interactions, and this change results in a more thorough assessment of the firm's prospects. We investigate whether the number of board meetings increases after the appointment of a female director replacing a male director. We find no evidence of such an increase. Still, it could be the case that female directors change boardroom dynamics, e.g. via improving the quality of and/or intensity of discussions around complex decision problems. However, to test the validity of this argument one would require access to board meetings, or to the very least access to detailed minutes of board meetings,[33] which are not accessible to us. Future research that specifies the working of boardroom dynamics would shed important light on both the role of women in the boardroom, and corporate policy implications of mitigating managerial overconfidence.

[33] Schwartz-Ziv and Weisbach (2013) is the first systematic study of the minutes of board meetings. However, their sample is small and covers only 11 Israeli firms for which the Israeli government has a substantial equity stake.

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Table 1
Sample details by year and industry

Our final sample consists of 1,629 firms with 11,435 firm-year observations between 1998 and 2013. This table reports the distribution of female directors and the average option-based overconfidence measure, *CEO option moneyness*, across years (Panel A) and industries (Panel B). Panel A shows the number and proportion of firms with at least one female director, and those with more than one female director, in addition to the average CEO option moneyness in each year. Panel B reports the same information as Panel A, but across the Fama-French 12 industries (financial firms are excluded).

Panel A. By year

Year	No. of obs.	No. of firm-year obs. with female directors	%	No. of firm-year obs. with more than one female directors	%	Average CEO option moneyness
1998	453	314	69.3%	108	23.8%	0.947
1999	620	412	66.5%	157	25.3%	1.035
2000	624	415	66.5%	160	25.6%	0.941
2001	673	444	66.0%	163	24.2%	0.647
2002	678	482	71.1%	217	32.0%	0.431
2003	756	514	68.0%	208	27.5%	0.662
2004	712	506	71.1%	219	30.8%	0.721
2005	734	532	72.5%	221	30.1%	0.801
2006	691	508	73.5%	227	32.9%	0.770
2007	742	568	76.5%	318	42.9%	0.744
2008	703	517	73.5%	257	36.6%	0.332
2009	840	614	73.1%	302	36.0%	0.392
2010	832	620	74.5%	299	35.9%	0.543
2011	810	605	74.7%	319	39.4%	0.564
2012	808	608	75.2%	318	39.4%	0.653
2013	759	591	77.9%	330	43.5%	0.822
Total	11,435	8252	72.2%	3824	33.4%	0.688

Panel B. By Fama-French 12 industry

Industry	No. of obs.	No. of firm-year obs. with female directors	%	No. of firm-year obs. with more than one female directors	%	Average CEO option moneyness
Non-Durables	802	670	83.5%	460	57.4%	0.593
Durables	340	241	70.9%	82	24.1%	0.633
Manufacturing	1855	1289	69.5%	462	24.9%	0.593
Energy	628	380	60.5%	126	20.1%	0.743
Chemicals	511	426	83.4%	239	46.8%	0.594
Business Eq.	2323	1306	56.2%	477	20.5%	0.741
Telecom	183	141	77.0%	84	45.9%	0.536
Utilities	748	691	92.4%	424	56.7%	0.401
Shops	1536	1271	82.7%	689	44.9%	0.759
Healthcare	1092	808	74.0%	350	32.1%	0.824
Other	1417	1027	72.5%	430	30.3%	0.724
Total	11,435	8252	72.2%	3824	33.4%	0.649

Table 2
Descriptive statistics

Panel A reports the percent option moneyness for male and female CEOs. Panel B presents the summary statistics for the sample of firm-years with male CEOs. *CEO option moneyness* is the estimated moneyness of the CEO's stock options. *Fraction of female directors* is the number of female directors divided by board size. *Sales* is the firm's sales in 2000 dollars. *Leverage* is the sum of short-term and long-term debts divided by total assets. *Stock return* is the firm's stock return over the past year. *ROA* is earnings before interest, taxes, depreciation, and amortization divided by total assets. *Tobin's q* is the market value of equity plus total assets minus book value of equity, all divided by total assets. *Board independence* is the fraction of independent directors on the board. *Board size* is the number of directors on the board. *E index* is the Bebchuk et al. (2009) entrenchment index. *CEO age* is the age of the CEO. *CEO Chairman* is an indicator variable that equals one if the CEO also chairs the board, and zero otherwise. *CEO tenure* is the number of years the CEO has been in office. *CEO ownership* is the fraction of the firm's stocks owned by the CEO. *MBA* is an indicator variable that equals one if the CEO has an MBA degree, and zero otherwise. *Age first CEO role* is the age at which CEO became CEO for the first time. *Qualification* is an indicator variable that equals one if the CEO holds professional qualifications, and zero otherwise. *Military experience* is an indicator variable that equals one if the CEO has prior military service, and zero otherwise. *Ivy League* is an indicator variable that equals one if the CEO attended an Ivy League university, and zero otherwise. t-tests (Wilcoxon-Mann-Whitney tests) are conducted to test for differences in the means (medians) between male and female CEOs. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Panel A. Difference in option moneyness between male and female CEOs

	N	Mean	Median
Full sample	11,435	0.680	0.333
Male	11,113	0.686	0.337
Female	332	0.450	0.211
Difference	–	0.236***	0.126***

Panel B. Descriptive statistics for the male CEO sample

Variables	N	Mean	Median	Stdev	Min	Max
Main variables						
CEO option moneyness	11,113	0.686	0.337	1.014	0.000	6.201
Fraction of female directors	11,113	0.104	0.100	0.090	0.000	0.625
Firm characteristics						
Sales (million $)	11,113	5619.7	1623.8	11658.6	56.8	78667.6
Leverage	11,113	0.225	0.223	0.165	0.000	0.675
Stock return	11,113	0.130	0.089	0.436	-0.730	1.851
ROA	11,113	0.143	0.136	0.083	-0.133	0.402
Tobin's q	11,113	1.930	1.542	1.191	0.752	7.424
Governance and board characteristics						
Board independence	11,113	0.726	0.750	0.154	0.000	1.000
Board size	11,113	9.368	9.000	2.333	4.000	26.000
E index	11,113	2.571	3.000	1.272	0.000	6.000
CEO characteristics						
CEO age	11,113	55.612	56.000	6.738	33.000	90.000
CEO Chairman	11,113	0.613	1.000	0.487	0.000	1.000
CEO tenure	11,113	8.213	6.000	6.945	1.000	51.000
CEO ownership	11,113	0.015	0.003	0.043	0.000	0.761
MBA	11,113	0.379	0.000	0.485	0.000	1.000
Age first CEO role	11,113	46.486	47.000	7.493	19.000	72.000
Qualification	11,113	0.084	0.000	0.277	0.000	1.000
Military experience	11,113	0.066	0.000	0.249	0.000	1.000
Ivy League	11,113	0.193	0.000	0.395	0.000	1.000

Table 3
Univariate analysis

This table compares the means and medians of firm, governance and CEO characteristics for firm-years with female directors to those without, using the male CEO sample. The total number of observations is 11,113. All variables are defined in the appendix. t-tests (Wilcoxon-Mann-Whitney tests) are conducted to test for differences in the means (medians). ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Firm-years with female directors (N=7,571)		Firm-years without female directors (N=3,542)		Difference			
Variables	Mean	Median	Mean	Median	Mean		Median	
Main variables								
CEO option moneyness	0.620	0.314	0.828	0.392	-0.208	***	-0.078	***
Fraction of female directors	0.153	0.125	0.000	0.000	0.153	***	0.125	***
Firm characteristics								
Sales (million $)	7524.890	2500	1548.822	699	5976.068	***	1800.285	***
Leverage	0.242	0.241	0.189	0.172	0.053	***	0.069	***
Stock return	0.123	0.093	0.145	0.080	-0.021	**	0.012	
ROA	0.147	0.139	0.132	0.131	0.015	***	0.008	***
Tobin's q	1.896	1.518	2.004	1.597	-0.108	***	-0.079	***
Governance and board characteristics								
Board independence	0.749	0.778	0.675	0.714	0.075	***	0.063	***
Board size	10.122	10.000	7.757	8.000	2.365	***	2.000	***
E index	2.674	3.000	2.350	2.000	0.324	***	1.000	***
CEO characteristics								
CEO age	55.806	56.000	55.197	55.000	0.609	***	1.000	***
CEO Chairman	0.655	1.000	0.524	1.000	0.131	***	0.000	***
CEO tenure	7.443	6.000	9.857	7.000	-2.414	***	-1.000	***
CEO ownership	0.011	0.002	0.023	0.004	-0.013	***	-0.002	***
MBA	0.401	0	0.333	0	0.068	***	0.000	***
Age first CEO role	47.309	48	44.725	45	2.585	***	3.000	***
Qualification	0.085	0	0.082	0	0.003		0.000	
Military experience	0.073	0	0.051	0	0.023	***	0.000	***
Ivy League	0.202	0	0.174	0	0.028	***	0.000	***

Table 4
Female board representation and CEO option moneyness

This table examines how female board representation affects the CEO's option holding and exercise behavior. Panel A presents OLS regression results for the male and female CEO samples. The dependent variable is the CEO's stock option moneyness (*CEO option moneyness*). Independent variables include the following. *Fraction of female directors* is the number of female directors divided by board size. *Sales* is the firm's sales in 2000 dollars. *Leverage* is the sum of short-term and long-term debt divided by total assets. *Stock return* is the firm's stock return over the past year. *ROA* is earnings before interest, taxes, depreciation, and amortization divided by total assets. *Tobin's q* is the market value of equity plus total assets minus book value of equity, all divided by total assets. *Board independence* is the fraction of independent directors on the board. *Board size* is the number of directors on the board. *E index* is the Bebchuk et al. (2009) entrenchment index. *CEO age* is the age of the CEO. *CEO Chairman* is an indicator variable that equals one if the CEO also chairs the board, and zero otherwise. *CEO tenure* is the number of years the CEO has been in office. *CEO ownership* is the fraction of the firm's stocks owned by the CEO. *MBA* is an indicator variable that equals one if the CEO has an MBA degree, and zero otherwise. *Age first CEO role* is the age at which CEO became CEO for the first time. *Qualification* is an indicator variable that equals one if the CEO holds professional qualifications, and zero otherwise. *Military experience* is an indicator variable that equals one if the CEO has prior military service, and zero otherwise. *Ivy League* is an indicator variable that equals one if the CEO attended an Ivy League university, and zero otherwise. Panel B presents regression results based on alternative modelling techniques for the male CEO sample. Regressions (1) to (3) use *CEO option moneyness* as the dependent variable, while regressions (4) and (5) use *Confident CEO* as the dependent variable, where *Confident CEO* is an indicator variable that equals one if the CEO's option moneyness is greater than 100% (or 67%), and zero otherwise. The regressions in Panel B include the same firm, governance, and CEO characteristics as regression (3) of Panel A. However, only the regression coefficient on the main variable of interest, *Fraction of female directors*, is reported for brevity. Industry effects are constructed based on the Fama-French 49-industry classification. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in parentheses. The t-statistics for the Fama-MacBeth regressions are computed using the Newey-West standard errors. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Panel A. OLS regression results for the male and female CEO samples

	Dependent variable: CEO option moneyness			
	Male CEO sample			Female CEO sample
	(1)	(2)	(3)	(4)
Fraction of female directors	-0.943***	-0.836***	-0.624***	0.229
	(0.174)	(0.170)	(0.167)	(0.377)
Ln(Sales)	–	-0.013	0.020	-0.065
		(0.011)	(0.014)	(0.042)
Leverage	–	-0.006	0.026	0.333
		(0.097)	(0.097)	(0.283)
Stock return	–	0.526***	0.525***	0.234*
		(0.032)	(0.032)	(0.122)
ROA	–	0.878***	0.860***	0.509
		(0.244)	(0.245)	(0.785)
Tobin's q	–	0.214***	0.210***	0.209**
		(0.023)	(0.023)	(0.095)
Board independence	–	–	-0.126	0.701
			(0.117)	(0.591)
Board size	–	–	-0.030***	-0.066*
			(0.007)	(0.035)
E index	–	–	-0.008	-0.039
			(0.013)	(0.032)
CEO age	–	–	0.002	0.013
			(0.003)	(0.011)
CEO Chairman	–	–	-0.017	-0.297**
			(0.030)	(0.123)
CEO tenure	–	–	0.005*	-0.002
			(0.003)	(0.008)
CEO ownership	–	–	0.534	1.165
			(0.397)	(1.156)
MBA	–	–	0.058*	-0.280**
			(0.030)	(0.128)
Age first CEO role	–	–	-0.004	0.002
			(0.003)	(0.010)
Qualification	–	–	0.009	0.438**
			(0.057)	(0.175)
Military experience	–	–	0.022	0.078
			(0.057)	(0.204)
Ivy League	–	–	0.030	0.018
			(0.038)	(0.150)
Industry effects	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
Number of observations	11,113	11,113	11,113	322
Adjusted R^2	0.070	0.216	0.224	0.433

Panel B. Alternative modelling techniques using the male CEO sample

	Dependent variables			
	CEO option moneyness		Overconfident CEO (moneyness>100%)	Overconfident CEO (moneyness>67%)
	Firm fixed effects (1)	Fama and MacBeth (2)	Logit (3)	Logit (4)
Fraction of female directors	-0.615***	-0.566***	-1.854***	-1.691***
	(0.235)	(0.102)	(0.544)	(0.460)
All controls	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	No	No	No
Industry effects	No	Yes	Yes	Yes
Year effects	Yes	No	Yes	Yes
Number of observations	11,113	11,113	11,113	11,113
Adjusted R^2/Average R^2	0.197	0.315	–	–
Pseudo R^2	–	–	0.174	0.154

Table 5
Propensity score matching estimates

Table 4 reports the propensity score matching estimation results for the male CEO sample. Panel A reports parameter estimates from the logit model used to estimate propensity scores. The dependent variable is an indicator variable for the presence of female directors in a firm for a given year. All independent variables are defined in the appendix. Industry effects are constructed based on the Fama-French 49-industry classification. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in parentheses. Panel B reports the univariate comparisons of firm characteristics between firms with and without female directors and the corresponding t-statistics. Panel C reports the average treatment effect estimates. *CEO option moneyness* is the CEO's estimated stock option moneyness. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Panel A. Prematch propensity score regression and postmatch diagnostic regression

	Dependent variable: *Dummy equals 1 if female directors are on the board and 0 otherwise*	
	Prematch (1)	Postmatch (2)
Ln(Sales)	0.408***	-0.028
	(0.049)	(0.052)
Leverage	0.243	0.172
	(0.315)	(0.332)
Stock return	-0.115*	0.055
	(0.062)	(0.073)
ROA	0.528	0.120
	(0.591)	(0.641)
Tobin's q	0.073	-0.001
	(0.048)	(0.056)
Board independence	2.209***	-0.216
	(0.332)	(0.360)
Board size	0.404***	-0.004
	(0.032)	(0.032)
E index	0.100**	-0.005
	(0.044)	(0.047)
CEO age	0.003	-0.003
	(0.011)	(0.011)
CEO Chairman	0.399***	-0.016
	(0.102)	(0.110)
CEO tenure	-0.037***	0.005
	(0.011)	(0.011)
CEO ownership	-1.511	-0.326
	(1.136)	(1.224)
MBA	0.166	-0.001
	(0.107)	(0.118)
Age first CEO role	-0.007	-0.002
	(0.011)	(0.011)
Qualification	-0.218	-0.023
	(0.186)	(0.196)
Military experience	0.130	0.003
	(0.214)	(0.255)
Ivy League	0.048	-0.023
	(0.136)	(0.150)
Industry effects	Yes	Yes
Year effects	Yes	Yes
Number of observations	11,091	4,500
Pseudo R^2	0.294	0.003

Panel B. Differences in firm characteristics

Variables	Firm-year obs. with female dirs. (N=2,250)	Firm-year obs. without female dirs. (N=2,250)	Difference	t-statistics
Ln(Sales)	6.928	6.970	-0.042	-1.153
Leverage	0.211	0.210	0.001	0.168
Stock return	0.141	0.130	0.011	0.772
ROA	0.135	0.136	-0.001	-0.140
Tobin's q	1.927	1.909	0.018	0.514
Board independence	0.705	0.707	-0.002	-0.298
Board size	8.480	8.508	-0.028	-0.535
E index	2.527	2.543	-0.016	-0.429
CEO age	55.028	55.138	-0.110	-0.524
CEO Chairman	0.543	0.547	-0.004	-0.269
CEO tenure	8.750	8.553	0.197	0.933
CEO ownership	0.015	0.016	-0.001	-0.055
MBA	0.352	0.352	0.000	0.031
Age first CEO role	45.442	45.707	-0.265	-1.171
Qualification	0.088	0.090	-0.001	-0.157
Military experience	0.055	0.056	-0.001	-0.131
Ivy League	0.181	0.182	-0.001	-0.077

Panel C. Propensity Score Matching Estimator

Variables	Firm-year obs. with female dirs. (N=2,250)	Firm-year obs. without female dirs. (N=2,250)	Difference	t-statistics
CEO option moneyness	0.696	0.776	-0.081***	-2.510

Table 6
Instrumental variables estimates

Table 5 presents estimates of the instrumental variables method using two-stage least square (2SLS) panel regressions. The dependent variable is the fraction of female directors and *CEO option moneyness* for the first and second stage regressions, respectively. The instrumental variables are as follows. *Fraction of male directors linked to female directors* is the fraction of male directors on the board who sit on other boards with at least one female director. *Female-to-male population ratio* is calculated as the female population divided by the male population in the state where the firm has its headquarters. All other variables are defined in the appendix. Industry and year effects are included. Industry effects are constructed based on the Fama-French 49-industry classification. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in brackets. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Dependent variables					
	Fraction female directors	CEO option moneyness	Fraction female directors	CEO option moneyness	Fraction female directors	CEO option moneyness
	First stage (1)	Second stage (2)	First stage (3)	Second stage (4)	First stage (5)	Second stage (6)
Fraction male linked to female, z_1	0.029***	–	0.038***	–	0.084***	–
	(0.009)		(0.010)		(0.009)	
Female-to-male population ratio, z_2	0.211***	–	0.212***	–	0.203***	–
	(0.074)		(0.074)		(0.072)	
Fraction of female directors	–	-6.672***	–	-4.991***	–	-3.814***
		(2.365)		(1.931)		(1.003)
Ln(Sales)	0.012***	0.106***	0.012***	0.095***	0.014***	0.085***
	(0.002)	(0.037)	(0.002)	(0.031)	(0.002)	(0.023)
Leverage	0.014	0.112	0.014	0.100	0.018*	0.094
	(0.011)	(0.114)	(0.011)	(0.105)	(0.010)	(0.100)
Stock return	-0.004**	0.502***	-0.004**	0.505***	-0.005***	0.508***
	(0.002)	(0.036)	(0.002)	(0.035)	(0.002)	(0.033)
ROA	-0.015	0.712***	-0.017	0.697***	-0.030	0.684***
	(0.020)	(0.269)	(0.020)	(0.257)	(0.019)	(0.251)
Tobin's q	0.002	0.221***	0.002	0.221***	0.003**	0.220***
	(0.002)	(0.024)	(0.002)	(0.023)	(0.001)	(0.023)
Board independence	0.077***	0.393	0.079***	0.311	0.089***	0.249
	(0.011)	(0.245)	(0.011)	(0.209)	(0.011)	(0.155)

Board size	0.004***	-0.002	0.005***	-0.003	0.007***	-0.004
	(0.001)	(0.014)	(0.001)	(0.013)	(0.001)	(0.010)
E index	0.002*	0.008	0.002*	0.004	0.002*	0.002
	(0.001)	(0.015)	(0.001)	(0.014)	(0.001)	(0.013)
CEO age	0.000	0.004	0.000	0.004	0.000	0.004
	(0.000)	(0.004)	(0.000)	(0.004)	(0.000)	(0.004)
CEO Chairman	0.013***	0.068	0.013***	0.049	0.013***	0.034
	(0.003)	(0.048)	(0.003)	(0.043)	(0.003)	(0.035)
CEO tenure	-0.001***	-0.004	-0.002***	-0.002	-0.002***	-0.000
	(0.000)	(0.005)	(0.000)	(0.004)	(0.000)	(0.004)
CEO ownership	-0.015	0.231	-0.014	0.254	-0.013	0.264
	(0.038)	(0.410)	(0.038)	(0.382)	(0.037)	(0.370)
MBA	0.006*	0.091**	0.006*	0.083**	0.006*	0.076**
	(0.003)	(0.038)	(0.003)	(0.035)	(0.003)	(0.033)
Age first CEO role	-0.000	-0.006	-0.000	-0.005	-0.000	-0.005
	(0.000)	(0.004)	(0.000)	(0.003)	(0.000)	(0.003)
Qualification	-0.005	-0.013	-0.005	-0.007	-0.006	0.001
	(0.006)	(0.070)	(0.006)	(0.065)	(0.006)	(0.061)
Military experience	0.017**	0.131	0.017**	0.101	0.016**	0.078
	(0.007)	(0.085)	(0.007)	(0.076)	(0.007)	(0.065)
Ivy League	0.001	0.053	0.001	0.051	0.001	0.049
	(0.004)	(0.045)	(0.004)	(0.041)	(0.004)	(0.040)
No. external board seats	–	–	-0.001**	-0.008***	–	–
			(0.000)	(0.003)		
No. male external board seats	–	–	–	–	-0.004***	-0.015***
					(0.000)	(0.004)
Industry effects	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	10,844	10,844	10,844	10,844	10,844	10,844
F-statistics (z_1=z_2=0)	9.120***	–	11.380***	–	45.010***	–
CD Wald F-statistics	45.610	–	51.630	–	165.740	–
Hansen's *J* test *p-value*	–	0.170	–	0.260	–	0.647

Table 7

Changes in CEO option moneyness around director appointments

This table reports the results of the difference-in-differences analysis for the male CEO sample. The dependent variable is the CEO's stock option moneyness. The treatment group consists of firms that replace a departing male director with a female director and the control group consists of firms that replace a departing male director with another male director. We match treatment and control observations using propensity score matching. *Female appointment* is an indicator variable that equals one if the firm appoint a female director, and zero otherwise. *Post* is a dummy variable that equals one in the period after the appointment, and zero otherwise. *Post* $^{-2}$, *Post* $^{-1}$, *Post* $^{+1}$, and *Post* $^{+2}$ are indicator variables for the second year prior to, the first year pripr to, the first year after, and the second year after the appointment, respectively. *Dummy_MBA replaces non-MBA* (*Dummy_Non-MBA replaces MBA*) is an indicator variable equal to one if the departing director without (with) an MBA degree is replaced by a new director with (without) an MBA degree, and zero otherwise. *Dummy_Ivy replaces non-Ivy* (*Dummy_Non-Ivy replaces Ivy*) is an indicator variable equal to one if the departing director who did not attend (attended) an Ivy-League university is replaced by a new director who did (did not), and zero otherwise. *Dummy_Qualif. replaces non-Qualif.* (*Dummy_Non-Qualif. replaces Qualif.*) is an indicator variable equal to one if the departing director without (with) professional qualifications is replaced by a new director with (without) professional qualifications, and zero otherwise. The other control variables are the same as for regression (3) of Panel A in Table 4. For the sake of brevity, we report only the coefficients on the main variables of interest. Industry effects are constructed based on the Fama-French 49-industry classification. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in brackets. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Dependent variable: CEO option moneyness				
	OLS [-1, +1] (1)	OLS [-1, +1] (2)	Pair FE [-1, +1] (3)	OLS [-2, +2] (4)	Pair FE [-2, +2] (5)
Female appointment	-0.074	-0.049	–	–	–
	(0.158)	(0.195)			
Post	0.207*	0.219*	0.029	0.273**	0.387**
	(0.121)	(0.120)	(0.458)	(0.114)	(0.170)
Female appointment × Post	-0.282**	-0.301**	-0.251**	–	–
	(0.135)	(0.136)	(0.097)		
Female appointment × Post $^{-2}$	–	–	–	0.162	–
				(0.152)	
Female appointment × Post $^{-1}$	–	–	–	0.031	-0.047
				(0.128)	(0.101)
Female appointment × Post $^{+1}$	–	–	–	-0.265**	-0.331**
				(0.119)	(0.137)
Female appointment × Post $^{+2}$	–	–	–	-0.308**	-0.343*
				(0.150)	(0.174)
Dummy_MBA replaces non-MBA	–	-0.044	–	–	–
		(0.177)			
Dummy_Non-MBA replaces MBA	–	0.205	–	–	–
		(0.283)			
Dummy_Ivy replaces non-Ivy	–	0.282	–	–	–
		(0.282)			
Dummy_Non-Ivy replaces Ivy	–	-0.049	–	–	–
		(0.227)			
Dummy_Qualif. replaces non-Qualif.	–	-0.008	–	–	–
		(0.167)			
Dummy_Non-Qualif. replaces Qualif.	–	-0.114	–	–	–
		(0.311)			
All controls	Yes	Yes	Yes	Yes	Yes
Director-pair effects	No	No	Yes	No	Yes
Industry effects	Yes	Yes	No	Yes	No
Year effects	Yes	Yes	Yes	Yes	Yes
Number of observations	224	224	224	360	360
Adjusted R^2	0.391	0.381	0.518	0.360	0.368

Table 8

Female board representation and CEO option exercise behavior

This table contains the regressions that examine the relation between female board representation and the characteristics of the exercised options. The dependent variable in regressions (1) and (2) is *Value ratio*, which is defined as the ratio of the intrinsic value to the strike price of the option, where the intrinsic value is calculated as the stock price at exercise minus the strike price. The dependent variable in regressions (3) and (4) is *Time to expiration*, which is defined as the remaining number of years until option expiration at exercise. Both *Value ratio* and *Time to expiration* are aggregated for each CEO on an annual basis, using a simple average over the number of options exercised. CEO-years without option exercises are omitted from the analysis. *Fraction of female directors* is the number of female directors divided by board size. The control variables are the same as for regression (3) of Panel A in Table 3. For the sake of brevity, we report only the coefficients on the main variable of interest. Industry effects are constructed based on the Fama-French 49-industry classification. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Value ratio		Time to expiration	
	OLS	Firm fixed effects	OLS	Firm fixed effects
	(1)	(2)	(3)	(4)
Fraction of female directors	-1.584**	-1.753**	0.560*	0.445*
	(0.783)	(0.868)	(0.306)	(0.258)
All controls	Yes	Yes	Yes	Yes
Industry effects	Yes	No	Yes	No
Year effects	Yes	Yes	Yes	Yes
Number of observations	8380	8380	8427	8427
Adjusted R^2	0.138	0.148	0.087	0.067

Table 9

Female board representation, overconfidence and capital expenditures

This table contains regression models that examine the relation between female board representation, overconfidence and capital expenditures. The dependent variable, *Capital expenditures*, is defined as the firm's capital expenditures in year t+1 scaled by net property, plant and equipment in year t. *High industry OC representation* is an indicator variable that equals one if the fraction of overconfident CEOs for an industry in that year is greater than the sample median across all industries, and zero otherwise, where overconfident CEOs are those who hold stock options that are more than 67% in the money. *High industry OC intensity* is an indicator variable that equals one if the average *CEO option moneyness* for an industry in that year is greater than the median average *CEO option moneyness* across all industries, and zero otherwise. For both variables, industries are classified using the Fama-French 49-industry classification. The control variables are the same as regression (3) of Panel A in Table 3. For the sake of brevity, we report only the coefficients on the main variables of interest. Industry effects are constructed based on the Fama-French 49-industry classification. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Dependent Variable: Capital expenditures ($CAPEX_{t+1}/PPE_t$)					
	OLS (1)	Firm FE (2)	GMM (3)	OLS (4)	Firm FE (5)	GMM (6)
Lagged capital expenditures	0.239***	0.003	0.137*	0.536***	0.243***	0.393***
	(0.058)	(0.072)	(0.078)	(0.018)	(0.022)	(0.027)
Fraction of female directors	0.044	0.039	-0.027	0.047**	0.052	0.029
	(0.035)	(0.047)	(0.109)	(0.022)	(0.034)	(0.053)
High industry OC representation	0.046***	0.039***	0.060***	–	–	–
	(0.012)	(0.013)	(0.016)			
Fraction of female directors × High industry OC representation	-0.131**	-0.114*	-0.165*	–	–	–
	(0.065)	(0.068)	(0.093)			
High industry OC intensity	–	–	–	0.031***	0.036***	0.064***
				(0.005)	(0.006)	(0.010)
Fraction of female directors × High industry OC intensity	–	–	–	-0.074**	-0.097***	-0.142**
				(0.032)	(0.037)	(0.057)
All controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	No	No	Yes	No	No
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	8,802	8,802	8,802	8,802	8,802	8,802
Adjusted R^2	0.195	0.033	–	0.475	0.142	–
AR(1) *p-value*	–	–	0.090	–	–	0.000
AR(2) *p-value*	–	–	0.636	–	–	0.812
Hansen's *J* test *p-value*	–	–	0.699	–	–	0.898

Table 10

Female board representation, overconfidence and the sensitivity of investment to cash flows

This table contains regression models that examine the relation between female board representation, overconfidence and the sensitivity of investment to cash flows. The dependent variable, *Capital expenditures*, is defined as the firm's capital expenditures in year t+1 scaled by net property, plant and equipment in year t. *Cash flow* is calculated as the sum of income before extraordinary items and depreciation, scaled by net plant, property and equipment. Panel A presents regression results for the subsamples based on median industry OC representation, where industry OC representation is the fraction of CEOs who hold stock options that are more than 67% in the money for the industry in a year. Panel B presents regression results for subsamples based on median industry OC intensity, where industry OC intensity is defined as the average *CEO option moneyness* for the industry in a year. The control variables are the same as in regression (3) of Panel A in Table 3. For the sake of brevity, we report only the coefficients on the main variables of interest. Industry effects are constructed based on the Fama-French 49-industry classification. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Dependent variable: Capital expenditures ($CAPEX_{t+1}/PPE_t$)					
Panel A. Subsamples by industry OC representation						
	High industry OC representation			Low industry OC representation		
	OLS (1)	Firm FE (2)	GMM (3)	OLS (4)	Firm FE (5)	GMM (6)
Lagged capital expenditures	0.164***	-0.252*	0.355***	0.385***	0.063	0.314***
	(0.055)	(0.135)	(0.079)	(0.057)	(0.064)	(0.056)
Cash flow	0.376**	0.916**	0.553***	0.076	0.307***	0.234**
	(0.172)	(0.385)	(0.152)	(0.053)	(0.090)	(0.102)
Fraction of female directors	0.191	0.440*	0.335	0.055	0.080	0.033
	(0.123)	(0.241)	(0.251)	(0.048)	(0.069)	(0.100)
Fraction of female directors × Cash flow	-1.989*	-2.936*	-3.191**	-0.382	-0.874	-1.127
	(1.144)	(1.778)	(1.541)	(0.362)	(0.552)	(0.718)
All controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	No	No	Yes	No	No
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	4,133	4,133	4,133	4,669	4,669	4,669
Adjusted R^2	0.167	0.142	–	0.354	0.086	–
AR(1) *p-value*	–	–	0.000	–	–	0.000
AR(2) *p-value*	–	–	0.200	–	–	0.400
Hansen's *J* test *p-value*	–	–	0.582	–	–	0.327

Panel B. Subsamples by industry OC intensity

	High industry OC intensity			Low industry OC intensity		
	OLS (1)	Firm FE (2)	GMM (3)	OLS (4)	Firm FE (5)	GMM (6)
Lagged capital expenditures	0.174**	0.156***	0.384***	0.272***	0.180***	0.260***
	(0.070)	(0.032)	(0.071)	(0.074)	(0.035)	(0.047)
Cash flow	0.326*	0.354***	0.590***	0.132**	0.175***	0.109
	(0.169)	(0.081)	(0.187)	(0.055)	(0.065)	(0.098)
Fraction of female directors	0.179	0.123	0.424**	0.041	0.011	0.001
	(0.117)	(0.091)	(0.205)	(0.047)	(0.053)	(0.101)
Fraction of female directors × Cash flow	-2.036*	-0.807	-2.401*	-0.204	-0.140	-0.660
	(1.123)	(0.549)	(1.296)	(0.348)	(0.404)	(0.658)
All controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	No	No	Yes	No	No
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	4,178	4,178	4,178	4,624	4,624	4,624
Adjusted R^2	0.160	0.175	–	0.340	0.140	–
AR(1) *p-value*	–	–	0.000	–	–	0.000
AR(2) *p-value*	–	–	0.947	–	–	0.171
Hansen's *J* test *p-value*	–	–	0.408	–	–	0.356

Table 11

Female board representation, overconfidence and asset growth

This table contains regression models that examine the relation between female board representation, overconfidence and asset growth. The dependent variable is *Asset growth* and *PPE growth*, respectively. *High industry OC representation* is an indicator variable that equals one if the fraction of overconfident CEOs for an industry in that year is greater than the sample median across all industries, and zero otherwise, where overconfident CEOs are those who hold stock options that are more than 67% in the money. *High industry OC intensity* is an indicator variable that equals one if the average *CEO option moneyness* for an industry in that year is greater than the median average *CEO option moneyness* across all industries, and zero otherwise. For both variables, industries are classified using the Fama-French 49-industry classification. The control variables are the same as in regression (3) of Panel A in Table 3. For the sake of brevity, we report only the coefficients on the main variables of interest. Industry effects are constructed based on the Fama-French 49-industry classification. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Dependent variables							
	Asset growth (Assets $_{t+1}$/Assets $_{t}$ - 1)				PPE growth (PPE $_{t+1}$/PPE $_{t}$ - 1)			
	OLS (1)	Firm FE (2)	OLS (3)	Firm FE (4)	OLS (5)	Firm FE (6)	OLS (7)	Firm FE (8)
Fraction of female directors	-0.045	-0.081	-0.031	-0.035	-0.094	-0.012	-0.049	0.023
	(0.039)	(0.050)	(0.033)	(0.050)	(0.065)	(0.053)	(0.038)	(0.051)
High industry OC representation	0.029***	0.007	–	–	0.056**	0.018**	–	–
	(0.009)	(0.008)			(0.027)	(0.008)		
Fraction of female directors × High industry OC representation	-0.097*	-0.016	–	–	-0.239	-0.017	–	–
	(0.058)	(0.051)			(0.219)	(0.054)		
High industry OC intensity	–	–	0.033***	0.023***	–	–	0.034***	0.036***
			(0.007)	(0.008)			(0.008)	(0.008)
Fraction of female directors × High industry OC intensity	–	–	-0.103**	-0.108**	–	–	-0.093*	-0.088*
			(0.045)	(0.049)			(0.050)	(0.053)
All controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	No	Yes	No	Yes	No	Yes	No
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	10,973	10,973	10,973	10,973	10,961	10,961	10,961	10,961
Adjusted R^2	0.045	0.107	0.064	0.108	0.030	0.060	0.049	0.062

Table 12

Female board representation, overconfidence and merger activities

This table contains regression models that examine the relation between female board representation, overconfidence and merger activities. The dependent variable is the acquirer's cumulative abnormal returns from five days before the acquisition announcement to five days after. *High industry OC representation* is an indicator variable that equals one if the fraction of overconfident CEOs for the industry in that year is greater than the sample median across all industries, and zero otherwise, where overconfident CEOs are those who hold stock options that are more than 67% in the money. *High industry OC intensity* is an indicator variable that equals one if the average *CEO option moneyness* for the industry in that year is greater than the median average *CEO option moneyness* across all industries, and zero otherwise. *Diversifying deal is* a dummy variable that equals one if the bidder and target are in different two-digit SIC industries, and zero otherwise. *All equity* is an indicator variable that equals one if the method of payment was 100% equity, and zero otherwise. *Deal size* the natural logarithm of one plus the reported deal value. The other control variables are the same as in regression (3) of Panel A in Table 3. Industry effects are constructed based on the Fama-French 49-industry classification. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Dependent variable: CAR [-5,+5]			
	OLS		Heckman 2nd stage	
	(1)	(2)	(3)	(4)
Fraction of female directors	-0.010	-0.013	-0.015	-0.015
	(0.055)	(0.056)	(0.055)	(0.057)
High industry OC representation	-0.017	–	-0.017	–
	(0.012)		(0.012)	
Fraction of female directors	0.155**	–	0.153**	–
× High industry OC representation	(0.075)		(0.076)	
High industry OC intensity	–	-0.015	–	-0.015
		(0.011)		(0.011)
Fraction of female directors	–	0.130*	–	0.132*
× High industry OC intensity		(0.071)		(0.071)
Diversifying deal	-0.008	-0.008	-0.008	-0.008
	(0.007)	(0.007)	(0.007)	(0.007)
All equity	-0.024**	-0.024**	-0.024**	-0.024**
	(0.010)	(0.010)	(0.010)	(0.010)
Deal size	-0.010***	-0.010***	-0.010***	-0.010***
	(0.003)	(0.003)	(0.003)	(0.003)
Inverse Mills ratio	–	–	0.034	0.012
			(0.050)	(0.034)
All controls	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
Number of observations	742	742	742	742
Adjusted R^2	0.082	0.077	0.081	0.076

Table 13

Female board representation, overconfidence and corporate performance

This table contains regression models that examine the relation between female board representation, overconfidence and corporate performance/value. The dependent variable is *Tobin's q* for Panel A, the return on equity (*ROE*) for Panel B, and the return on assets (*ROA*) for Panel C. *High industry OC representation* is an indicator variable that equals one if the fraction of overconfident CEOs for the industry in that year is greater than the sample median across all industries, and zero otherwise, where overconfident CEOs are those who hold stock options that are more than 67% in the money. *High industry OC intensity* is an indicator variable that equals one if the average *CEO option moneyness* for an industry in that year is greater than the median average *CEO option moneyness* across all industries, and zero otherwise. For both variables, industries are classified using the Fama-French 49-industry classification. The control variables are the same as in regression (3) of Panel A in Table 3. Industry effects are constructed based on the Fama-French 49-industry classification. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Panel A. Tobin's q

	Dependent variable: Tobin's q					
	OLS (1)	Firm FE (2)	GMM (3)	OLS (4)	Firm FE (5)	GMM (6)
Lagged Tobin's q	0.795***	0.504***	0.704***	0.795***	0.506***	0.690***
	(0.011)	(0.023)	(0.030)	(0.011)	(0.023)	(0.031)
Fraction of female directors	-0.068	-0.171	-0.262	-0.070	-0.182	-0.110
	(0.083)	(0.139)	(0.270)	(0.087)	(0.137)	(0.268)
High industry OC representation	-0.062***	0.005	-0.191***	–	–	–
	(0.020)	(0.022)	(0.064)			
Fraction of female directors × High industry OC representation	0.412***	0.424***	1.623***	–	–	–
	(0.128)	(0.144)	(0.346)			
High industry OC intensity	–	–	–	-0.052**	-0.008	-0.083
				(0.021)	(0.023)	(0.061)
Fraction of female directors × High industry OC intensity	–	–	–	0.418***	0.440***	1.487***
				(0.135)	(0.151)	(0.357)
All controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	No	No	Yes	No	No
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	8,851	8,851	8,851	8,851	8,851	8,851
Adjusted R^2	0.760	0.415	–	0.760	0.415	–
AR(1) *p-value*	–	–	0.000	–	–	0.000
AR(2) *p-value*	–	–	0.585	–	–	0.424
Hansen's *J* test *p-value*	–	–	0.231	–	–	0.242

Panel B. ROE

	Dependent variable: ROE					
	OLS (1)	Firm FE (2)	GMM (3)	OLS (4)	Firm FE (5)	GMM (6)
Lagged ROE	0.561***	0.292***	0.305***	0.560***	0.292***	0.299***
	(0.040)	(0.054)	(0.076)	(0.041)	(0.054)	(0.076)
Fraction of female directors	-0.021	0.104	0.012	0.019	0.132	0.074
	(0.047)	(0.086)	(0.147)	(0.054)	(0.094)	(0.162)
High industry OC representation	0.002	0.005	0.026	–	–	–
	(0.008)	(0.010)	(0.024)			
Fraction of female directors × High industry OC representation	0.189***	0.177**	0.412***	–	–	–
	(0.062)	(0.075)	(0.151)			
High industry OC intensity	–	–	–	-0.000	0.007	0.040
				(0.009)	(0.010)	(0.029)
Fraction of female directors × High industry OC intensity	–	–	–	0.146**	0.117**	0.258*
				(0.060)	(0.059)	(0.150)
All controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	No	No	Yes	No	No
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	8,851	8,851	8,851	8,851	8,851	8,851
Adjusted R^2	0.410	0.100	–	0.413	0.099	–
AR(1) *p-value*	–	–	0.000	–	–	0.000
AR(2) *p-value*	–	–	0.259	–	–	0.259
Hansen's *J* test *p-value*	–	–	0.385	–	–	0.522

Panel C. ROA

	Dependent variable: ROA					
	OLS (1)	Firm FE (2)	GMM (3)	OLS (4)	Firm FE (5)	GMM (6)
Lagged ROA	0.800***	0.486***	0.719***	0.805***	0.487***	0.621***
	(0.011)	(0.024)	(0.032)	(0.011)	(0.023)	(0.030)
Fraction of female directors	0.001	0.024**	-0.001	-0.001	0.021*	0.001
	(0.008)	(0.012)	(0.023)	(0.007)	(0.012)	(0.021)
High industry OC representation	0.000	0.006***	0.003	–	–	–
	(0.002)	(0.002)	(0.005)			
Fraction of female directors × High industry OC representation	0.017*	0.002	0.047*	–	–	–
	(0.010)	(0.012)	(0.026)			
High industry OC intensity	–	–	–	0.001	0.006***	0.002
				(0.002)	(0.002)	(0.004)
Fraction of female directors × High industry OC intensity	–	–	–	0.026***	0.007	0.050**
				(0.010)	(0.012)	(0.024)
All controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	No	No	Yes	No	No
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	8,851	8,851	8,851	8,851	8,851	8,851
Adjusted R^2	0.681	0.272	–	0.695	0.272	–
AR(1) *p-value*	–	–	0.000	–	–	0.000
AR(2) *p-value*	–	–	0.272	–	–	0.147
Hansen's *J* test *p-value*	–	–	0.272	–	–	0.982

Table 14

Female board representation and corporate performance during the recent financial crisis

This table presents the OLS regressions results of the change in firm performance (denoted as *ΔTobin's q*, *ΔROA*, and *ΔROE*) and CEO option moneyness (denoted as *ΔCEO option moneyness*) from 2007 to 2009 on the severity of the house price collapse across firms with varying degrees of female board representation. The independent variables include the following. *Fraction of female directors* is the number of female directors divided by board size. *1st Qtile House price shock* and *4th Qtile House price shock* are indicator variables for the first (least severe) and fourth quartiles (most severe) of *House price shock*, where *House price shock* is the percentage drop in the Zillow Home Value Index (ZHVI) from December 2006 until December 2009 in the company's state of headquarters. The control variables are the same as in regression (3) of Panel A in Table 4. All independent variables are measured in 2006. Industry effects are constructed based on the Fama-French 49-industry classification. Statistical significance is based on the heteroskedasticity robust firm-clustered standard errors reported in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

	Dependent variables			
	ΔCEO option moneyness (1)	ΔTobin's q (2)	ΔROA (3)	ΔROE (4)
Fraction of female directors	0.400	-0.259	-0.043	-0.125
	(0.282)	(0.320)	(0.040)	(0.104)
4th Qtile House price shock	-0.096*	-0.084*	-0.016**	-0.050***
	(0.055)	(0.047)	(0.007)	(0.018)
Fraction of female directors × 4th Qtile House price shock	0.667**	-0.188	0.142***	0.329**
	(0.323)	(0.328)	(0.045)	(0.127)
1st Qtile House price shock	-0.138	0.025	-0.008	-0.035*
	(0.089)	(0.050)	(0.008)	(0.020)
Fraction of female directors × 1st Qtile House price shock	0.320	-0.653	0.036	0.098
	(0.651)	(0.432)	(0.059)	(0.148)
All controls	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes
Number of observations	516	516	516	516
Adjusted R^2	0.220	0.099	0.153	0.078

Appendix

Variable definition

Variables	Description	Source
Main variables		
CEO option moneyness	We estimate the average CEO stock option moneyness for each year following Campbell et al. (2011) and Hirshleifer et al. (2012). Specifically, we first calculate the average realizable value per option by dividing the total realizable value of the exercisable options by the number of exercisable options. Next, we subtract the average realizable value from the fiscal year-end stock price to obtain the average exercise price of the options. The estimated moneyness of the options is then calculated as the stock price divided by the estimated average exercise price minus one.	Execucomp
Fraction of female directors	The ratio of the number of female directors on the board to board size.	IRRC/RiskMetrics
Fraction of male directors linked to female directors	The fraction of male directors on the board who sit on other boards with at least one female director.	IRRC/RiskMetrics
Female-to-male population ratio	The ratio of the female population to the male population in the state where the firm is headquartered for a given year.	US Economic Census
Female appointment	An indicator variable that equals one if the firm appoint a female director, and zero otherwise.	IRRC/RiskMetrics
Firm characteristics		
Ln(Sales)	The natural logarithm of the firm's sales.	Compustat
Leverage	The sum of short-term and long-term debt divided by total assets.	Compustat
Stock return	The firm’s stock return over the past year	CSRP
ROA	Earnings before interest, taxes, depreciation, and amortization divided by total assets.	Compustat

ROE	Earnings before interest, taxes, depreciation, and amortization divided by common equity.	Compustat
Tobin's q	The market value of equity plus book value of total assets minus book value of equity, all divided by total assets, where the market value of equity is the year-end closing price times the number of stocks outstanding.	Compustat
Board variables and other controls		
Board independence	The fraction of independent directors on the board.	IRRC/RiskMetrics
Board size	The number of directors on the board.	IRRC/RiskMetrics
E index	The Bebchuk et al. (2009) entrenchment index based on six antitakeover provisions: staggered boards, limits to shareholder bylaw amendments, poison pills, golden parachutes, supermajority requirements for mergers, and charter amendments. The index measures the number of antitakeover provisions in place.	RiskMetrics,
No. external board seats	The total number of external board seats by directors.	IRRC/RiskMetrics
No. male external board seats	The total number of external board seats by male directors.	IRRC/RiskMetrics
CEO characteristics		
CEO age	The age of the CEO in years.	Execucomp
CEO Chairman	An indicator variable that equals one if the CEO also chairs the board, and zero otherwise.	Execucomp
CEO tenure	The number of years the CEO has been in office.	Execucomp
CEO ownership	The fraction of the firm’s stocks owned by the CEO.	Execucomp
MBA	An indicator variable that equals one if the CEO has an MBA degree, and zero otherwise.	BoardEx

Age first CEO role	The age at which the CEO became CEO for the first time.	BoardEx
Qualification	An indicator variable that equals one if the CEO holds professional qualifications, and zero otherwise.	BoardEx
Military experience	An indicator variable that equals one if the CEO has prior military service, and zero otherwise.	BoardEx
Ivy League	An indicator variable that equals one if the CEO attended an Ivy League university (i.e., Brown University, Columbia University, Cornell University, Dartmouth College, Harvard University, Princeton University, University of Pennsylvania, and Yale University) at any academic level, and zero otherwise.	BoardEx
Other variables		
Dummy_MBA replaces non-MBA	An indicator variable that equals one if an incumbent director without an MBA degree is replaced by a new director with an MBA degree, and zero otherwise.	BoardEx
Dummy_Non-MBA replaces MBA	An indicator variable that equals one if an incumbent director with an MBA degree is replaced by a new director without an MBA degree, and zero otherwise.	BoardEx
Dummy_Ivy replaces non-Ivy	An indicator variable that equals one if an incumbent director who did not attend an Ivy League university is replaced by a new director who did, and zero otherwise.	BoardEx
Dummy_Non-Ivy replaces Ivy	An indicator variable that equals one if an incumbent director who attended an Ivy League university is replaced by a new director who did not, and zero otherwise.	BoardEx
Dummy_Qualif. replaces non-Qualif.	An indicator variable that equals one if an incumbent director without professional qualification is replaced by a new director with professional qualification, and zero otherwise.	BoardEx
Dummy_Non-Qualif. replaces Qualif.	An indicator variable that equals one if an incumbent director with	BoardEx

	professional qualification is replaced by a new director without professional qualification, and zero otherwise.	
Female appointment	A dummy variable that equals one if the firm appoints a female director, and zero otherwise.	IRRC/RiskMetrics
Post	A dummy variable that equals one in the period after the appointment of a female director, and zero otherwise.	IRRC/RiskMetrics
Value ratio	The ratio of the intrinsic value to the strike price of the option, where the intrinsic value is calculated as the stock price at exercise minus the strike price.	Thomson Reuters Insider Filings database
Time to expiration	The remaining number of years until option expiration at exercise.	Thomson Reuters Insider Filings database
High industry OC representation	A dummy variable that equals one if the fraction of overconfident CEOs for an industry in that year is greater than the sample median across all industries and zero otherwise, where overconfident CEOs are those who hold stock options that are more than 67% in the money.	Execucomp
High industry OC intensity	A dummy variable that equals one if the average *CEO option moneyness* for an industry in that year is greater than the median average *CEO option moneyness* across all industries, and zero otherwise.	Execucomp
Cash flow	The sum of income before extraordinary items and depreciation, scaled by net plant, property and equipment.	Compustat
Capital expenditures	The firm's capital expenditures in year t+1 scaled by net property, plant and equipment in year t.	Compustat
Prior industry merger intensity	The total number of merger deals in the industry within the past two years divided by the total number of mergers across all industries over the same period. Industries are defined based on the Fama-French 49-industry classification.	SDC
Diversifying deal	A dummy variable that equals one if the bidder and target are in different	SDC

	two-digit SIC industries, and zero otherwise.	
All equity	A dummy variable that equals one if the method of payment was 100% equity, and zero otherwise.	SDC
Deal size	The natural logarithm of one plus the reported deal value.	SDC
CAR [-5,+5]	The acquirer's cumulative abnormal returns from five days before the acquisition announcement to five days after, where the abnormal returns are the market model residuals, with the parameters estimated over the [-205, -6] window relative to the announcement day, following Moeller et al. (2004).	CRSP
4th Qtile House price shock	An indicator variable for the fourth quartile (most severe) of *House price shock*, where *House price shock* is the percentage drop in the Zillow Home Value Index (ZHVI) from December 2006 until December 2009 in the company's state of headquarters.	Zillow
4th Qtile House price shock	An indicator variable for the first quartile (least severe) of *House price shock*, where *House price shock* is the percentage drop in the Zillow Home Value Index (ZHVI) from December 2006 until December 2009 in the company's state of headquarters.	Zillow

Supporting Documentation for Manuscript
"Why Female Board Representation Matters: The Role of Female Directors in Reducing Male CEO Overconfidence in Corporate Decisions"

NOT FOR PUBLICATION
Results Available From the Authors on Request

Section 3.3. Alternative overconfidence measures

	Dependent variable:					
	Net buyer indicator			Share retainer indicator		
	OLS (1)	Firm FE (2)	Logit (3)	OLS (4)	Firm FE (5)	Logit (6)
Fraction of female directors	-0.052	-0.105*	-0.716**	-0.227*	-0.107	-1.022*
	(0.044)	(0.063)	(0.342)	(0.127)	(0.167)	(0.565)
All controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	No	Yes	Yes	No	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	11,113	11,113	11,113	6,755	6,755	6,755
Adjusted R^2/ Pseudo R^2	0.043	0.024	0.084	0.073	0.029	0.064

Section 6. Robustness tests

Panel A. Results with residual confidence measures

	Dependent Variables:					
	CEO option moneyness residual FR *Regressed on stock returns from year t+1*		CEO option moneyness residual LR 1 *Regressed on lagged stock return*		CEO option moneyness residual LR 2 *Regressed on lagged stock market return*	
	OLS (1)	Firm fixed effects (2)	OLS (3)	Firm fixed effects (4)	OLS (5)	Firm fixed effects (6)
Fraction of female directors	-0.709***	-0.750***	-0.626***	-0.575**	-0.626***	-0.557**
	(0.185)	(0.270)	(0.173)	(0.261)	(0.173)	(0.260)
All controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	No	Yes	No	Yes	No
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	8,869	8,869	8,852	8,852	8,852	8,852
Adjusted R^2	0.229	0.197	0.151	0.135	0.217	0.178

Panel B. Alternative option-based measure

	Dependent variable: ln(1 + Vested unexercised options/Total compensation)	
	OLS (1)	Firm fixed effects (2)
Fraction of female directors	-0.288**	-0.106
	(0.139)	(0.158)
All controls	Yes	Yes
Industry effects	Yes	No
Year effects	Yes	Yes
Number of observations	11,082	11,082
Adjusted R^2	0.246	0.169

Panel C. Excluding firm-years with CEO turnovers

	Dependent variable: CEO option moneyness	
	OLS (1)	Firm fixed effects (2)
Fraction of female directors	-0.643***	-0.676***
	(0.172)	(0.249)
All controls	Yes	Yes
Industry FE	Yes	No
Year FE	Yes	Yes
Number of observations	10,589	10,589
Adjusted R^2	0.226	0.201

Panel D. Excluding recession periods 2001-2002 and 2007-2009

	Dependent variable: CEO option moneyness	
	OLS (1)	Firm fixed effects (2)
Fraction of female directors	-0.677***	-0.569**
	(0.199)	(0.282)
All controls	Yes	Yes
Industry FE	Yes	No
Year FE	Yes	Yes
Number of observations	7578	7578
Adjusted R^2	0.233	0.201

Panel E. OLS regression results for subsamples by governance variables

	Dependent variable: CEO option moneyness							
	High E index (1)	Low E index (2)	With Chairman CEO (3)	Without Chairman CEO (4)	High tenure (5)	Low tenure (6)	High board indep. (7)	Low board indep. (8)
Fraction of female directors	-0.718**	-1.021***	-0.465**	-0.947***	-0.677***	-0.727***	-0.374*	-0.900***
	(0.210)	(0.234)	(0.218)	(0.240)	(0.236)	(0.198)	(0.196)	(0.249)
All controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	5796	5317	6813	4300	5201	5912	5299	5814
Adjusted R^2	0.195	0.240	0.223	0.242	0.218	0.223	0.229	0.221
Chow test *p-value*	0.105		0.196		0.1467		0.583	

Panel F. OLS regression results with alternative clustering

	Dependent variable: CEO option moneyness		
	By year (1)	By industry (2)	By firm and year (3)
Fraction of female directors	-0.627*** (0.116)	-0.627*** (0.161)	-0.627*** (0.172)
All controls	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes
Year effects	Yes	Yes	Yes
Number of observations	11,113	11,113	11,113
Adjusted R^2	0.224	0.224	0.229

Panel G. OLS regression results with alternative definitions of industry effects

	Dependent variable: CEO option moneyness			
	SIC2 industries (1)	NAICS3 industries (2)	FF49 industries without year effects (3)	FF49×Year effects (4)
Fraction of female directors	-0.619*** (0.165)	-0.650*** (0.164)	-0.658*** (0.168)	-0.648*** (0.165)
All controls	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	No
Year effects	Yes	Yes	No	No
Industry × Year effects	No	No	No	Yes
Number of observations	11,113	11,113	11,113	11,113
Adjusted R^2	0.228	0.228	0.198	0.269

Panel H. Regression results with additional director/board controls

	Dependent variables							
	CEO option moneyness		Overconfident CEO (moneyness>100%)	Overconfident CEO (moneyness>67%)	CEO option moneyness		Overconfident CEO (moneyness>100%)	Overconfident CEO (moneyness>67%)
	OLS (1)	Firm FE (2)	Logit (3)	Logit (4)	OLS (5)	Firm FE (6)	Logit (7)	Logit (8)
Fraction of female directors	-0.637***	-0.723***	-1.900***	-1.685***	-0.492***	-0.624***	-1.776***	-1.573***
	(0.170)	(0.233)	(0.562)	(0.475)	(0.178)	(0.236)	(0.571)	(0.492)
Average director age	-0.004	-0.026***	-0.006	-0.007	-0.004	-0.026***	-0.006	-0.008
	(0.006)	(0.010)	(0.015)	(0.013)	(0.006)	(0.010)	(0.015)	(0.013)
Age dispersion	0.191	-0.030	1.476	2.234**	0.260	0.040	1.551	2.304**
	(0.446)	(0.679)	(1.148)	(1.029)	(0.446)	(0.676)	(1.143)	(1.027)
Average director tenure	-0.008	-0.004	-0.016	-0.010	-0.007	-0.004	-0.016	-0.009
	(0.005)	(0.009)	(0.015)	(0.013)	(0.005)	(0.009)	(0.015)	(0.013)
Tenure dispersion	-0.111*	-0.048	-0.216	-0.236	-0.107*	-0.047	-0.211	-0.228
	(0.063)	(0.082)	(0.184)	(0.162)	(0.063)	(0.082)	(0.184)	(0.161)
Fraction of busy directors	-0.178**	-0.159*	-0.177	-0.218	–	–	–	–
	(0.075)	(0.088)	(0.229)	(0.207)				
Fraction of female busy directors	–	–	–	–	-0.637***	-0.412	-0.551	-0.550
					(0.234)	(0.257)	(0.858)	(0.721)
All controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	No	Yes	No	No	No	Yes	No	No
Industry effects	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	10,667	10,667	10,667	10,667	10,667	10,667	10,667	10,667
Adjusted R^2/Pseudo R^2	0.224	0.193	0.175	0.157	0.224	0.193	0.175	0.157

Section 3.2.3. Robustness of difference-in-differences matching estimates (without director type changes)

	Dependent variable: CEO option moneyness	
Independent variables	OLS (1)	Firm fixed effects (2)
Female appointment	0.176	–
	(0.136)	
Post	-0.035	0.208
	(0.102)	(0.266)
Female appointment × Post	-0.128*	-0.208**
	(0.072)	(0.092)
All controls	Yes	Yes
Industry effects	Yes	No
Year effects	Yes	Yes
Number of observations	148	148
Adjusted R^2	0.198	0.556

Section 4. OLS regression results for the relation between female board representation and the firm's decisions with and without the CEO option moneyness variable

	Dependent variables							
	Asset growth ($Assets_{t+1}/Assets_{t} - 1$)		PPE growth ($PPE_{t+1}/PPE_{t} - 1$)		Capital expenditures ($CAPEX_{t+1}/PPE_{t}$)		CAR [-5,+5]	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fraction of female directors	-0.086***	-0.054**	-0.090***	-0.054*	-0.052*	0.022	0.064	0.066
	(0.029)	(0.027)	(0.033)	(0.031)	(0.031)	(0.034)	(0.043)	(0.043)
CEO option moneyness	–	0.041***	–	0.048***	–	0.040***	–	0.003
		(0.003)		(0.003)		(0.003)		(0.003)
Diversifying deal	–	–	–	–	–	–	-0.007	-0.007
							(0.007)	(0.007)
All equity	–	–	–	–	–	–	-0.024**	-0.024**
							(0.010)	(0.010)
Deal size	–	–	–	–	–	–	-0.010***	-0.010***
							(0.003)	(0.003)
All controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	10,487	10,487	10,475	10,475	10,581	10,581	742	742
Adjusted R^2	0.062	0.101	0.051	0.098	0.236	0.284	0.077	0.076