



Corporate culture and board gender diversity: Evidence from textual analysis

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ABSTRACT

Exploiting a distinctive measure of corporate culture based on advanced machine learning, we investigate the effect of board gender diversity on corporate culture. Our results demonstrate that greater board gender diversity considerably strengthens positive corporate culture. The findings support the notion that board gender diversity enhances board oversight and helps solve agency problems, resulting in managers being compelled to take measures that benefit shareholders and consequently, building a strong company culture. Further analysis validates the results, including propensity score matching (PSM), entropy balancing, an instrumental-variable analysis, Lewbel's (2012) heteroscedastic identification, and Oster's (2019) testing for coefficient stability. Our study is the first to link board gender diversity to corporate culture, using cutting-edge information obtained from sophisticated machine learning.

1. Introduction

The issue of gender diversity on corporate boards of directors has gained prominence in recent decades (Adams & Ferreira, 2009; Arun, Almahrog, & Ali Aribi, 2015; Campbell & Mínguez-Vera, 2007; Carter, Simkins, & Simpson, 2003; Erhardt, Werbel, & Shrader, 2003; Kim & Starks, 2016; Lücknerath-Rovers, 2011; Reguera-Alvarado, de Fuentes, & Laffarga, 2015; Sabatier, 2015). For example, several countries, such as Australia, Belgium, France, Germany, Iceland, Italy, Norway, and Spain, have enacted legislation requiring female presence on corporate boards (Chapple & Humphrey, 2013; Li & Chen, 2018). Therefore, the issue of board gender diversity is of interest not only to academics, but also to investors, shareholders, regulators, policymakers, as well as legislators. The importance of female directors on the board cannot be over-emphasized. While previous research has concentrated on the influence of board gender diversity on financial performance, there has been much less emphasis on the effects of board gender diversity on other aspects of firm performance. We address this gap in the literature by investigating the influence of board gender diversity on company culture.

Corporate culture may be described as the shared beliefs or

preferences of employees inside a business (Crémer, 1993; Li, Liu, Mai, & Zhang, 2021; Likitapiwat, Treepongkaruna, Jiraporn, & Uyar, 2022; Van den Steen, 2010). Corporate culture matters because employees will ultimately face tough choices that cannot be effectively regulated ex ante (Griffin, Li, & Xu, 2020; O'Reilly, 1989). In contrast to formal control systems such as rules and procedures, company culture is influenced by peer pressure and social construction of reality (Griffin et al., 2020).

One problem that has made studying corporate culture particularly challenging is the difficulty in defining or quantifying corporate culture. However, through advanced machine learning, a new measure of company culture has just been developed. Using this innovative measure recently devised by Li et al. (2021), we investigate how board gender diversity influences company culture. Li et al. (2021) use cutting-edge machine learning algorithms and earnings call transcripts to assess business cultural values. Earnings conference calls, as an external corporate communication channel that consists mostly of CEOs (and occasionally CFOs) speaking to financial analysts, typically expose a company's set of values (Graham, Harvey, & Rajgopal, 2016). Following Li et al. (2021), we focus on the top five corporate culture qualities identified by Guiso, Sapienza, and Zingales (2015): innovation,

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integrity, quality, respect, and teamwork.

Using the resource dependency theory and agency theory, we advance two competing hypotheses about the implications of board gender diversity on corporate culture. First, to the extent that board gender diversity improves board monitoring, it should mitigate agency problems and thus induce managers to adopt corporate policies and strategies that are advantageous to shareholders in the long run, such as promoting strong positive corporate culture. This view suggests that higher board gender diversity produces stronger corporate culture. In contrast, it might be argued that board gender diversity enhances the board of directors, which is a formal monitoring instrument, to the point where informal mechanisms such as corporate culture have only a limited role to play. In other words, powerful boards might serve as a substitute for a strong corporate culture. This argument suggests that higher board gender diversity weakens corporate culture.

Based on a large sample spanning almost 20 years (2001–2018), our results demonstrate that companies exhibit significantly stronger corporate culture when a larger proportion of board members are female. Board gender diversity strengthens corporate culture considerably. To circumvent endogeneity, we execute a variety of robustness checks, including propensity score matching, entropy balancing, an instrumental-variable analysis, Lewbel (2012) heteroscedastic identification, and Oster (2017) testing for coefficient stability. Our results survive all the robustness checks and thus appear to be strongly robust. Therefore, our results likely reflect a causal effect, rather than a mere association. Finally, we also investigate the prediction of the critical mass theory, which posits that female directors matter if there are enough of them on the board. Prior research suggests that three female directors constitute a critical threshold (Brahma, Nwafor, & Boateng, 2020; Joecks, Pull, & Vetter, 2012; Kanter, 1977; Liu, Wei, & Xie, 2014). Corroborating this argument, our results reveal that the effect of board gender diversity is significantly more pronounced when there are at least three female board members. Finally, we show that board gender diversity helps cushion the adverse impact of the takeover market on corporate culture.

The results of our study make key contributions to several strands of the literature. First, we contribute to a crucial area of research on the effect of board gender diversity on firm performance. The vast majority of prior studies in this area concentrate on financial performance (Adams & Ferreira, 2009; Ahern & Dittmar, 2012; Arun et al., 2015; Campbell & Mínguez-Vera, 2007; Carter et al., 2003; Carter, D'Souza, Simkins, & Simpson, 2010; Erhardt et al., 2003; Kim & Starks, 2016; Lückerath-Rovers, 2011; Reguera-Alvarado et al., 2015; Rose, 2007; Sabatier, 2015; Terjesen, Couto, & Francisco, 2015; Wang & Clift, 2009). Our study, however, investigates the effect of female directors on a crucially important, yet under-explored, aspect of firm performance, i.e., the strength of corporate culture, using a novel measure made possible by machine learning.

Second, our research expands the literature on corporate culture. Previous research has looked at corporate culture from a theoretical standpoint (Crémer, 1993; Graham et al., 2016; Li et al., 2021; Van den Steen, 2010; Weber, Shenkar, & Raveh, 1996). There has however been very little empirical research on corporate culture. We fill this void in the literature. Our research is the first to establish an empirical relationship between corporate culture and board gender diversity. Our findings show that board gender diversity is one of the key determinants of company culture.

Third, our research adds to a large body of literature that takes advantage of textual analysis and machine learning (Allee & Deangelis, 2015; Antweiler & Frank, 2004; Baker, Bloom, & Davis, 2016; Bodnaruk, Loughran, & McDonald, 2015; Chen, De, Hu, & Hwang, 2014; Davis, Ge, Matsumoto, & Zhang, 2014; Davis & Tama-Sweet, 2012; Ertugrul, Lei, Qiu, & Wan, 2017; Likitapiwat et al., 2022; Loughran & McDonald, 2020; Ongsakul, Chatjuthamard, Jiraporn, & Chaivittangkun, 2021). Loughran and McDonald (2016) provide an in-depth review of how textual analysis is applied in accounting and finance. Our

findings demonstrate that textual analysis and machine learning generate a distinct and relevant measure of corporate culture that can be used in empirical research.

Finally, our study also enriches an important area of the literature that examines the critical mass theory (Yarram & Adapa, 2021; Nuber & Velte, 2021; Wiley & Monllor-Tormos, 2018; Dobija, Hryckiewicz, Zaman, & Puławska, 2021; Torchia, Calabrò, & Huse, 2011; Redor, 2018). We show that when there are at least three female directors on the board, the effect of board gender diversity on company culture is considerably more pronounced, bolstering the prediction of the critical mass theory. Our study is the first to apply this theory to the link between female directors and corporate culture.

2. Theoretical background, prior research, and hypothesis development

2.1. Machine learning and textual analysis

Textual analysis is a young, but rapidly expanding, branch of the economics and finance literature. Because of advances in computing power and sophisticated algorithms, machine learning can extract a considerable amount of information from a huge number of documents, such as corporate annual reports, conference call transcripts, or newspapers. Baker et al. (2016), for example, develop an index for economic policy uncertainty (EPU) by analyzing uncertainty-related words in newspapers using textual techniques. Their text-based EPU index has attracted a great deal of interest. EPU has been found to influence mergers and acquisitions (Bonaime, Gulen, & Ion, 2018; Nguyen & Phan, 2017), executive risk-taking incentives (Chatjuthamard, Wongboonsin, Kongsompong, & Jiraporn, 2020), governance arrangements (Ongsakul, Treepongkaruna, Jiraporn, & Uyar, 2021), and board gender diversity (Jumreonwong, Treepongkaruna, Tong, & Jiraporn, 2021).

Likewise, Hassan, Hollander, van Lent, and Tahoun (2019) utilize computational linguistics to create a novel text-based measure of political risk faced by individual U.S. firms: the fraction of their quarterly earnings conference calls devoted to political risk. Chatjuthamard, Treepongkaruna, Jiraporn, and Jiraporn (2021) demonstrate that when political risk is higher, businesses invest significantly more in corporate social responsibility (CSR).

2.2. Corporate culture

Corporate culture is defined as “a set of shared values and conventions that establishes acceptable attitudes and actions for organizational members” (Griffin et al., 2020). Culture is significant because employees will eventually confront difficult decisions that cannot be adequately regulated ex ante (Griffin et al., 2020; Likitapiwat et al., 2022; O'Reilly, 1989). Unlike formal control mechanisms such as rules and procedures, corporate culture is governed by peer influence and social construction of reality, resulting in positive emotions of solidarity and a strong sense of autonomy among individuals inside a company (Griffin et al., 2020; Li et al., 2021; Likitapiwat et al., 2022). Corporate culture is an intangible asset that is designed to adapt to unforeseeable events as they occur (Li et al., 2021).

With a few notable exceptions, the finance literature has mostly disregarded the potential significance of corporate culture. This is particularly striking three decades after the revolution of the “incomplete contract” (Grossman & Hart, 1986; Guiso et al., 2015). If contracts are insufficient, culture and values may undoubtedly contribute to minimizing the inefficiencies caused by the insufficiency of the contractual environment (Guiso et al., 2015; Likitapiwat et al., 2022).

A few significant studies on corporate culture have been conducted. Guiso et al. (2015), for example, utilize a unique data set developed by the Great Place to Work Institute (GPTWI), which performs large surveys of employees at over 1000 U.S. businesses. They show that high levels of perceived integrity are positively linked with beneficial results, such as

increased production, profitability, better labor relations, and attractiveness to prospective job candidates. Li, Mai, Shen, and Yan (2020) use the most modern machine learning technologies and earnings conference call transcripts to extract corporate culture values for a large sample of firms from 2003 to 2017. They discover that firms that prioritize innovation are more likely to be acquirers, but companies that prioritize quality and respect are less likely to be acquirers. They show that organizations with comparable cultural values, such as innovation, quality, or collaboration, are more likely to execute an M&A deal together than firms with differing cultural values.

Similarly, using one of the most advanced machine learning techniques—the word embedding model—and 209,480 earnings call transcripts, Li et al. (2020) measure the five corporate culture values of innovation, integrity, quality, respect, and teamwork for 62,664 firm-year observations from 2001 to 2018.¹ Their findings show that an innovative culture involves more than traditional business innovation measures like R&D spending and patents. They also show that corporate culture is linked to business outcomes including operational efficiency, risk-taking, earnings management, executive compensation design, firm value, and deal-making, and that the link between culture and performance is stronger during tough economic times. Finally, Likitapiwat et al. (2022) report that more female board representation enhances innovation considerably by fostering a stronger innovative culture.²

Corporate culture can be viewed as a distinct aspect of firm performance. While distinct, corporate culture has been shown to be related to financial performance. A strong corporate culture creates a competitive advantage not only by increasing motivation and facilitating coordination and control, but also by putting the firm in a stronger position to respond to investment opportunities that are conducive to the financial performance (Sorensen, 2002). Similarly Rashid, Sambasivan, and Johari (2003) argue for a positive impact of corporate culture on firm performance. These studies reinforce Guiso et al. (2015), who also find that a strong corporate culture improves financial performance.

2.3. Board gender diversity and firm performance

The effect of board gender diversity on corporate performance can be explained through several theories, such as resource dependence theory and agency theory. According to the resource dependence theory, companies aim to recruit and hire board members who complement their current resource profile and can contribute new kinds of human and social capital to the organization (Salancik & Pfeffer, 1978; Sicaliano, 1996; Brahma et al., 2020). Additionally, this theory argues that increasing the size and diversity of the board of directors can foster a strong connection between businesses and their external environment (Brahma et al., 2020; Goodstein, Gautam, & Boeker, 1994; Pfeffer, 1973). Female directors bring unique perspectives and experiences to the board. These are valuable resources that should improve the functioning of the board as a corporate governance mechanism. Firm performance improves with better board effectiveness.

Conflicts of interest between principals (e.g., shareholders) and agents (e.g., managers) are addressed in agency theory, as is the role of

¹ Li et al. (2021) select the keywords for their analysis by using the seed words provided by Guiso, Sapienza, and Zingales (2015) and all other words clustered with the original seed words. A comprehensive list of all the keywords adopted in the textual analysis can be found in Li et al. (2021). Some of the keywords used in the analysis are as follows. For innovation, innovative, innovation, technology, creativity. For integrity, accountability, transparency, ethic. For quality, reliability, commitment, dedication. For respect, talent, empower, respect. For teamwork, collaborate, cooperative, partnership.

² Additional recent studies related to corporate culture include Zhao, Teng, and Wu (2018), Laio (2018), Islam, Tseng, and Karia (2019), and Fiordelisi, Renneboog, Ricci, and Lopes (2019), Marshall and Adamic (2010), Klein (2011), Iglesias, Sauquet, and Montaña (2011), Mueller (2011), and Han (2012).

the corporate board in monitoring and resolving these conflicts (Fama & Jensen, 1983; Jensen & Meckling, 1976). According to agency theory, diversity strengthens the monitoring role of the board of directors. Carter et al. (2003), Adams and Ferreira (2009), and Adams, Gray, and Nowland (2011), for example, use agency theory to investigate the relationship between gender diversity on the board and firm value and document a positive relationship between gender diversity and firm performance. Female directors have greater monitoring abilities because they think independently, according to Adams and Ferreira (2009) and Adams et al. (2011), and board gender diversity also enhances management responsibility, such as boosting board meeting attendance and CEO accountability (Brahma et al., 2020). The improvement in board oversight that can be ascribed to board gender diversity enhances firm performance.

There are some arguments against board gender diversity. Organizations may choose boards with gender diversity for the sake of appearance, yet they may not properly utilize the various contributions available (Abdullah, Ku Ismail, & Nachum, 2014; Hillman, Shropshire, & Cannella, 2007). Some researchers suggest that gender diversity in boardrooms might lead to possible disputes on the board, which could harm board cohesiveness, hurting firm performance and competitive advantage (Jurkus, Park, & Woodard, 2011; Post & Byron, 2015; Roberson & Park, 2007; Triana, Miller, & Trzebiatowski, 2014). Also, women may not be given the power they need to make successful choices on some boards, which might lead to poor performance (Shoham, Lee, Khan, Tarba, & Ahammad, 2020).

The empirical evidence on the effect of board gender diversity on firm performance is somewhat ambiguous (Li and Chen, 2016). Many studies demonstrate positive relationships (e.g., Arun et al., 2015; Campbell & Mínguez-Vera, 2007; Carter et al., 2003; Erhardt et al., 2003; Kim & Starks, 2016; Lückerath-Rovers, 2011; Reguera-Alvarado et al., 2015; Sabatier, 2015), while other studies find no link (e.g., Carter et al., 2010; Rose, 2007; Wang & Clift, 2009) or even a negative link (e.g., Adams & Ferreira, 2009; Ahern & Dittmar, 2012; Terjesen et al., 2015). Due to the ambiguous nature of the empirical evidence, the debate over the costs and benefits of board gender diversity remains. We aptly contribute to this crucial debate by investigating the impact of board gender diversity on one important, yet often overlooked, aspect of corporate performance, i.e., corporate culture.³

2.4. Hypothesis development

Several prior studies document the beneficial effects of board gender diversity. Two competing hypotheses can be advanced regarding the effect of board gender diversity on corporate culture. First, to the extent that board gender diversity improves the effectiveness of the board of directors, higher board gender diversity should lead to corporate outcomes and policies that are advantageous to the firm and ultimately to the shareholders. This view therefore suggests that higher board diversity motivates managers to build a strong positive corporate culture. This hypothesis is referred to as the outcome hypothesis as a strong corporate culture is expected to be an outcome of greater board gender diversity. By contrast, it could be argued that board gender diversity improves the board of directors, which is a formal monitoring mechanism, to the point where there is less room for informal mechanisms such as corporate culture. In other words, strong boards substitute for the necessity for strong corporate culture. According to this view, more

³ Additional research on board gender diversity include Brieger, Francoeur, Welzel, and Ben-Amar (2017), Al-Shaar and Zaman (2016), Wahid (2018), Kılıç and Kuzey (2016), Ye, Deng, Liu, Szweczyk, and Chen (2019), Ben-Amar, Chang, and McKenny (2015), García Lara, García Osma, Mora, and Scapin (2017), Green and Homroy (2018), Elmagrhi, Ntim, Elamer, and Zhang (2018), Gulamhussen and Santa (2015), Conyon and He (2016), Baker, Pandey, Kumar, and Haldar (2020), Perryman et al. (2016), and Upadhyay and Zeng (2014).

women on the board lead to weaker corporate culture. This view is labeled the substitution hypothesis.

3. Sample construction and data description

3.1. Sample selection

The data on corporate culture is from Li et al. (2021). The Institutional Shareholder Services (ISS) provides the data on directors and director-specific characteristics. Firm-specific attributes are from COMPUSTAT. Outliers are excluded where appropriate. The final sample is comprised of 16,658 firm-year observations from 2001 to 2018 from 1579 unique firms. Following the recent literature, we measure board gender diversity using the percentage of female directors on the board (Chatjuthamard, Jiraporn, Lee, Uyar, & Kilic, 2021; Jumreongwong et al., 2021; Ongsakul, Jaroenjitrkam, Treepongkaruna, & Jiraporn, 2021; Papangkorn, Chatjuthamard, Jiraporn, & Chueykamhang, 2019).

3.2. Measuring corporate culture using machine learning

Word embedding, an artificial neural network-based natural language model, can learn the context-specific meanings of words and phrases, according to Li et al. (2021). Using this model, they propose an innovative semi-supervised machine learning technique for generating a culture vocabulary and measuring corporate culture values. They use this technique to analyze 209,480 earnings call transcripts from 2001 to 2018 and create scores for the top five corporate culture qualities identified by Guiso et al. (2015): innovation, integrity, quality, respect, and teamwork. They also undertake several empirical analyses to validate their unique measure and illustrate the superiority of their approach over a range of other methodologies (Li et al., 2021). Li et al. (2021) measure the degree to which each corporate culture characteristic exists in each firm-year by dividing the total number of words in the document by the weighted count of words associated with each culture attribute. Li et al. (2021) go into further detail on how textual analysis and machine learning can be used to measure corporate culture.

We use two metrics to measure corporate culture. Our first metric is the corporate culture score, which is calculated as the total of the values assigned to the five culture traits in Guiso et al. (2015). This is the same metric used by Li et al. (2021) to assess corporate culture as a whole. Second, we run a principal component analysis on the scores for the five cultural characteristics and extract the first component. This statistic is referred to as the corporate culture index. To recap, we employ two alternate measures of corporate culture: the corporate culture score and the corporate culture index.

3.3. Additional variables

We also include several variables that may influence corporate culture. In particular, we include firm size (Ln of total assets), profitability (EBIT/total assets), leverage (total debt/total assets), investments (capital expenditures/total assets), intangible assets (R&D/total assets and advertising expense/total assets), cash holdings (cash holdings/total assets) and dividend payouts (total dividends/total assets), and asset tangibility (fixed assets/total assets). The definitions of all the variables are displayed in the Appendix. Furthermore, to control for the variations across time and industries, we include year and industry fixed effects. Industry classification is based on the first two digits of SIC. Table 1 shows the summary statistics for the corporate culture metrics, board attributes, and firm-specific characteristics.

4. Results

4.1. Main regression results

Table 2 displays the regression results where the dependent variables are the two alternate measures of corporate culture, the corporate culture score and the corporate culture index. Standard errors are clustered by firm and industry.⁴ The coefficients of board gender diversity (% of female directors) are positively significant in all models, suggesting that higher gender diversity on the board brings about more robust corporate culture. The findings are consistent with the notion that board gender diversity raises the effectiveness of board monitoring, compelling managers to take actions that enhance shareholder wealth in the long run, including fostering strong positive corporate culture.

It may be suggested that a firm-fixed-effects regression analysis should be performed to account for any unobservable time-invariant characteristics, as this technique only captures the variations in the variables across time. While this is generally the case, it may not be applicable in the context of our research. The reason for this is that our key variables show little change over time, making a firm-fixed-effects analysis difficult. To verify that this is the case, we calculate the standard deviations of our key variables both across firms and over time and find that the cross-sectional variations between firms are at least 50% higher than the variations in the variables over time. Consequently, a fixed-effects analysis probably would not be appropriate. However, we run a fixed-effects analysis and, consistent with our expectations, the results are not significant.

As for economic significance, we estimate the effect of board gender diversity on corporate culture as follows. One standard deviation of the percentage of female directors is 10.55. The coefficient of board gender diversity in Model 3 in Table 2 is 0.011. So a rise in board gender diversity by one standard deviation produces an increase in the strength of corporate culture by 10.55 times 0.011, which is 0.116. Because one standard deviation of the corporate culture score is 2.443, an increase of 0.116 represents a 4.748% improvement in corporate culture. Alternatively, another way to put into perspective the magnitude of the effect of board gender diversity is to compare its effect to the effect of a control variable. For instance, firm size, as proxied by total assets, has a positive effect on corporate culture. Larger firms exhibit stronger corporate culture. We calculate the standardized coefficients of all the variables in Model 3 and find that, in comparison to the effect of firm size on corporate culture, the effect of board gender diversity is almost twelve times stronger. Therefore, the effect of board gender diversity is hardly trivial.

4.2. Propensity score matching (PSM)

We employ propensity score matching to corroborate our findings (Lennox, Francis, & Wang, 2011; Ongsakul, Chatjuthamard, et al., 2021; Rosenbaum & Rubin, 1983). The sample is split into quartiles based on the gender diversity of the board. The treatment group consists of observations from the top quartile of the distribution (highest gender diversity). Then, based on twelve firm characteristics (i.e., the twelve control variables included in the regression analysis), we select the most comparable observation from the rest of the sample for each observation in the treatment group. Our treatment and control firms are therefore almost identical in every observable attribute, with the exception of board gender diversity.

To ensure the validity of our matching, we conduct diagnostic testing. Table 3 Panel A summarizes the findings. Model 1 is a logistic regression with a binary dependent variable equal to one if the firm is in

⁴ The results remain consistent when we cluster standard errors by firm, industry, or year or by any combination of the three variables or by all three variables.

Table 1
Descriptive statistics.

	Mean	S.D.	25th	Median	75th
Corporate Culture Metrics					
Corporate Culture Score	5.481	2.443	3.714	5.004	6.764
Corporate Culture Index	-0.029	1.385	-1.029	-0.300	0.702
Board Attributes					
% Female Directors	13.265	10.548	0.000	12.500	20.000
% Independent Directors	77.142	12.923	70.000	80.000	87.500
Board Size	9.123	2.146	8.000	9.000	10.000
Firm-specific Characteristics					
Total Assets	10,000.000	33,000.000	789.667	2201.862	7063.758
Total Debt/Total Assets	0.234	0.181	0.079	0.227	0.348
EBIT/Total Assets	0.097	0.081	0.054	0.091	0.138
Capital Expenditures/Total Assets	0.049	0.048	0.019	0.035	0.062
Advertising Expense/Total Assets	0.013	0.029	0.000	0.000	0.009
R&D Expense/Total Assets	0.027	0.046	0.000	0.000	0.037
Cash Holdings/Total Assets	0.149	0.157	0.031	0.092	0.216
Dividends/Total Assets	0.015	0.022	0.000	0.006	0.020
Fixed Assets/Total Assets	0.535	0.391	0.215	0.429	0.803

Board gender diversity is the percentage of female directors on the board. We use two metrics to measure corporate culture. Our first metric is the corporate culture score, which is calculated as the total of the values assigned to the five culture traits in Guiso et al. (2015). This is the same technique used by Li et al. (2021) to assess corporate culture as a whole. Second, we run a principal component analysis on the scores for the five cultural characteristics and extract the first component. This statistic is referred to as the corporate culture index. The other variable definitions are described in the Appendix.

the treatment group (with the greatest gender diversity) and zero otherwise. Model 1 includes the whole sample (pre-match). The results show that the treatment companies differ considerably from the rest of the sample in a variety of areas. In particular, the treatment firms have more independent directors, are larger in size, make less capital investments, spend more on advertising, and pay larger dividends. It is important to account for these significant differences since they have the potential to confound our analysis.

Model 2 is a logistic regression for the propensity-score matched sample (post-match). Model 2 has no statistically significant coefficients. As a consequence, our treatment and control firms have statistically similar observable attributes. To the extent that board gender diversity is unimportant, the levels of corporate culture in our treatment and control firms should be comparable. Table 3 Panel B displays the regression findings for the propensity-score matched sample. The coefficients of board gender diversity are significantly positive in both Model 1 and Model 2, suggesting that greater board gender diversity enhances corporate culture significantly. Because the PSM results are consistent, it is unlikely that our conclusion is driven by endogeneity.

4.3. Entropy balancing

Earlier research has mostly relied on the observable selection assumption. We circumvent this assumption by using Hainmueller, 2012 entropy balancing methodology, a variant on traditional matching algorithms. Entropy balancing compensates for self-selection produced by observable characteristics by accounting for a wide variety of variables that may have different impacts on the treatment and control groups. Entropy balancing in particular provides a high degree of covariate balance by directly including it into the weight function applied to the sample units (Hainmueller, 2012; Balima, 2020; Ongsakul, Chatjuthamard, et al., 2021).

Entropy balancing imposes a number of equilibrium criteria, one of which is that the matching covariate distributions in the preprocessed data for the treatment and control groups must match exactly at all prespecified moments (Balima, 2020; Hainmueller, 2012). Hainmueller (2012) explains the concept of entropy balancing. This new matching approach has recently gained popularity in the literature (Bol, Giani, Blais, & Loewen, 2020; Freier, Schumann, & Siedler, 2015; Glendening, Mauldin, & Shaw, 2019; McMullin & Schonberger, 2020; Neuenkirch & Neumeier, 2016; Neuenkirch & Tillmann, 2016; Ongsakul, Chatjuthamard, et al., 2021).

The following describes our method for balancing entropy. We

choose firms in the top quartile of board gender diversity as our treatment group. The remaining sample constitutes the control group. Following that, we use entropy balancing to match the mean, variance, and skewness of the observations in the two groups. The regression results for the entropy-balanced sample are shown in Table 4. The coefficients of board gender diversity remain positive and significant, confirming once more the notion that board gender diversity induces managers to improve corporate culture.

4.4. Instrumental-variable analysis (IV)

To further minimize endogeneity, we conduct an instrumental variable (IV) analysis. To lessen the chances of reverse causality, we utilize the value of board gender diversity in the first year of each firm as our instrumental variable. The idea is that board gender diversity in the earliest year could not have resulted from the degree of corporate culture in any of the subsequent years, therefore avoiding reverse causality.

Table 5 summarizes the IV results. Model 1 is a first-stage regression in which the dependent variable is board gender diversity. As anticipated, the coefficient of board gender diversity in the earliest year is significantly positive. Model 2 is a second-stage regression using the corporate culture score as the dependent variable. The coefficient of board gender diversity instrumented from the first stage is positive and significant. The result for Model 3, where the dependent variable is the corporate culture index, is also similar.

One criticism that may be raised at this method is that board gender diversity is sticky, changing relatively slowly over time. As a result, the value in the initial year may be pretty similar to the value in any subsequent year. To address this problem, we calculate the standard deviation of each firm's board gender diversity over time. Then, for all observations with a standard deviation larger than the median, we run a regression analysis. In essence, we focus only on those companies with more volatile board gender diversity over time. The regression findings are shown in Table 6 in Model 1 and Model 2. Again, the board gender diversity coefficients are significantly positive. Thus, even when we limit our analysis to cases where board gender diversity is less sticky, we still find consistent results. In addition, we also execute propensity score matching (PSM) on top of an instrumental-variable analysis (IV). The results, shown in Model 3 and Model 4, remain consistent. Finally, we also conduct entropy balancing on top of the IV analysis. The results based on entropy balancing, shown in Model 5 and Model 6, again remain similar.

For further robustness, we also employ alternative instrumental

Table 2
The effect of board gender diversity on corporate culture.

	(1)	(2)	(3)	(4)
	Corporate Culture Score	Corporate Culture Index	Corporate Culture Score	Corporate Culture Index
% Female Directors (Board Gender Diversity)	0.010***	0.004**	0.011***	0.006***
	(2.611)	(2.052)	(2.869)	(2.625)
% Independent Directors			0.006**	0.003**
Board Size			(2.054)	(2.069)
Ln (Total Assets)			0.308	0.171
Total Debt/Total Leverage			(1.638)	(1.600)
EBIT/Total Assets			0.006	-0.003
Capital Expenditures/Total Assets			(0.192)	(-0.155)
Advertising Expense/Total Assets			-0.708***	-0.368***
R&D Expense/Total Assets			(-3.344)	(-3.132)
Cash Holdings/Total Assets			-0.965**	-0.831***
Dividends/Total Assets			(-2.219)	(-3.446)
Fixed Assets/Total Assets			-0.191	-0.144
Constant	5.350***	-0.086**	(-0.235)	(-0.314)
Industry Fixed Effects	(85.250)	(-2.432)	5.448***	1.417
Year Fixed Effects	Yes	Yes	(3.289)	(1.595)
Observations	16,658	16,658	5.280***	2.950***
Adjusted R-squared	0.324	0.304	(4.341)	(4.483)
Robust t-statistics in parentheses			2.139***	1.257***
			(7.256)	(7.484)
			-0.122	-0.134
			(-0.072)	(-0.140)
			-0.766***	-0.467***
			(-5.202)	(-5.803)
			4.275***	-0.579**
			(10.136)	(-2.431)
			Yes	Yes
			Yes	Yes
			16,658	16,653
			0.374	0.355

Board gender diversity is the percentage of female directors on the board. We use two metrics to measure corporate culture. Our first metric is the corporate culture score, which is calculated as the total of the values assigned to the five culture traits in Guiso et al. (2015). This is the same technique used by Li et al. (2021) to assess corporate culture as a whole. Second, we run a principal component analysis on the scores for the five cultural characteristics and extract the first component. This statistic is referred to as the corporate culture index. The other variable definitions are described in the Appendix.

variables based on geographic locations. We exploit the insight in Knyazeva, Knyazeva, and Masulis (2013), who find that the local supply of directors is an important factor in determining board composition. Companies tend to recruit directors locally and thus share the same pool of potential directors. Firms located nearby share the same pool of potential female directors and thus should exhibit a similar degree of board gender diversity. We use the average degree of board gender diversity for all firms within a three-digit zip code as our instrument. To minimize endogeneity, we omit firm i from the calculation of the average. Also, the location of a company's headquarters was often determined long ago, early in the existence of the organization, and it very seldom changes over time (Pirinsky & Wang, 2006). As a result, the

Table 3
Propensity score matching (PSM).

Panel A: Diagnostic testing		
	(1)	(2)
	Pre-Match Treatment (High Board Gender Diversity)	Post-Match Treatment (High Board Gender Diversity)
% Female Directors (Board Gender Diversity)	0.035***	-0.001
	(8.812)	(-0.280)
% Independent Directors	0.307	-0.120
	(1.279)	(-0.414)
Board Size	0.175***	0.011
	(5.070)	(0.299)
Ln (Total Assets)	0.203	0.040
	(0.806)	(0.144)
Total Debt/Total Leverage	0.721	0.246
	(1.411)	(0.403)
EBIT/Total Assets	-3.330***	-0.745
	(-3.106)	(-0.540)
Capital Expenditures/Total Assets	8.821***	-0.655
	(6.358)	(-0.442)
Advertising Expense/Total Assets	-1.039	0.894
	(-0.727)	(0.634)
R&D Expense/Total Assets	-0.177	-0.130
	(-0.503)	(-0.349)
Cash Holdings/Total Assets	5.177***	0.770
	(3.001)	(0.365)
Dividends/Total Assets	0.154	0.131
	(1.098)	(0.781)
Fixed Assets/Total Assets	-6.331***	0.206
	(-11.648)	(0.318)
Industry Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Pseudo R-squared	0.072	0.001
Observations	16,653	7272
Robust z-statistics in parentheses		
*** p < 0.01, ** p < 0.05, * p < 0.1		
Panel B: The effect of board gender diversity on corporate culture with propensity score matching		
	(1)	(2)
	Corporate Culture Score	Corporate Culture Index
% Female Directors (Board Gender Diversity)	0.017***	0.008***
	(3.771)	(3.368)
% Independent Directors	0.007	0.003
	(1.560)	(1.384)
Board Size	0.344	0.167
	(1.257)	(1.103)
Ln (Total Assets)	0.055	0.029
	(1.291)	(1.194)
Total Debt/Total Leverage	-0.948***	-0.526***
	(-3.352)	(-3.401)
EBIT/Total Assets	-1.244**	-0.902***
	(-2.021)	(-2.636)
Capital Expenditures/Total Assets	-0.259	-0.269
	(-0.193)	(-0.351)
Advertising Expense/Total Assets	5.481***	1.540
	(2.843)	(1.480)
R&D Expense/Total Assets	2.092	1.403
	(1.295)	(1.605)
Cash Holdings/Total Assets	2.292***	1.342***
	(5.449)	(5.702)
Dividends/Total Assets	2.817	1.495
	(1.311)	(1.215)
Fixed Assets/Total Assets	-0.782***	-0.471***
	(-4.448)	(-4.657)
Constant	3.844***	-0.769**
	(6.079)	(-2.187)

(continued on next page)

Table 3 (continued)

Panel B: The effect of board gender diversity on corporate culture with propensity score matching

	(1)	(2)
	Corporate Culture Score	Corporate Culture Index
Industry Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Observations	7271	7271
Adjusted R-squared	0.381	0.353
Robust t-statistics in parentheses		
*** p < 0.01, ** p < 0.05, * p < 0.1		

Board gender diversity is the percentage of female directors on the board. We use two metrics to measure corporate culture. Our first metric is the corporate culture score, which is calculated as the total of the values assigned to the five culture traits in Guiso et al. (2015). This is the same technique used by Li et al. (2021) to assess corporate culture as a whole. Second, we run a principal component analysis on the scores for the five cultural characteristics and extract the first component. This statistic is referred to as the corporate culture index. The other variable definitions are described in the Appendix.

Table 4
Entropy balancing.

	(1)	(2)
	Corporate Culture Score	Corporate Culture Index
% Female Directors (Board Gender Diversity)	0.014*** (3.162)	0.007*** (2.952)
% Independent Directors	0.006 (1.522)	0.003 (1.491)
Board Size	0.359 (1.313)	0.184 (1.228)
Ln (Total Assets)	0.061 (1.480)	0.031 (1.330)
Total Debt/Total Leverage	-0.742*** (-2.621)	-0.402*** (-2.644)
EBIT/Total Assets	-1.085* (-1.678)	-0.834** (-2.418)
Capital Expenditures/Total Assets	-0.563 (-0.428)	-0.382 (-0.519)
Advertising Expense/Total Assets	8.373*** (4.323)	2.874*** (2.859)
R&D Expense/Total Assets	1.891 (1.225)	1.216 (1.475)
Cash Holdings/Total Assets	2.478*** (5.832)	1.453*** (6.198)
Dividends/Total Assets	1.344 (0.650)	0.616 (0.557)
Fixed Assets/Total Assets	-0.698*** (-4.288)	-0.415*** (-4.542)
Constant	3.780*** (6.026)	-0.853** (-2.481)
Industry Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Observations	16,653	16,653
R-squared	0.385	0.358
Robust t-statistics in parentheses		
*** p < 0.01, ** p < 0.05, * p < 0.1		

Board gender diversity is the percentage of female directors on the board. We use two metrics to measure corporate culture. Our first metric is the corporate culture score, which is calculated as the total of the values assigned to the five culture traits in Guiso et al. (2015). This is the same technique used by Li et al. (2021) to assess corporate culture as a whole. Second, we run a principal component analysis on the scores for the five cultural characteristics and extract the first component. This statistic is referred to as the corporate culture index. The other variable definitions are described in the Appendix.

headquarters location is most likely exogenous to the firm's contemporaneous characteristics. In addition, zip codes are assigned to maximize efficiency in mail delivery and are unlikely related to corporate

Table 5

Instrumental-variable analysis based on board gender diversity in the earliest year.

	(1)	(2)	(3)
	% Female Directors	Corporate Cultural Score	Corporate Cultural Index
% Female Directors (Earliest Year)	0.606*** (31.984)		
Board Gender Diversity (Instrumented)		0.025*** (8.075)	0.013*** (7.227)
% Independent Directors	0.087*** (9.365)	0.004*** (2.826)	0.002*** (2.768)
Board Size	3.242*** (4.680)	0.215** (2.265)	0.122** (2.232)
Ln (Total Assets)	0.688*** (5.933)	-0.010 (-0.692)	-0.011 (-1.406)
Total Debt/Total Leverage	-1.611** (-2.052)	-0.700*** (-6.853)	-0.364*** (-6.188)
EBIT/Total Assets	1.395 (0.987)	-0.989*** (-4.568)	-0.844*** (-6.773)
Capital Expenditures/Total Assets	-4.585 (-1.579)	-0.077 (-0.158)	-0.084 (-0.299)
Advertising Expense/Total Assets	14.249** (2.469)	5.161*** (8.271)	1.267*** (3.526)
R&D Expense/Total Assets	5.017 (1.236)	5.205*** (11.399)	2.910*** (11.073)
Cash Holdings/Total Assets	-2.429** (-2.397)	2.154*** (16.313)	1.264*** (16.636)
Dividends/Total Assets	11.196* (1.792)	-0.399 (-0.497)	-0.278 (-0.603)
Fixed Assets/Total Assets	0.805 (1.533)	-0.787*** (-11.783)	-0.478*** (-12.437)
Constant	-18.410*** (-9.960)	3.506*** (6.228)	-0.960*** (-2.964)
Industry Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Observations	16,653	16,653	16,653
Adjusted R-squared	0.517	0.372	0.353
Robust t-statistics in parentheses			
*** p < 0.01, ** p < 0.05, * p < 0.1			

Board gender diversity is the percentage of female directors on the board. We use two metrics to measure corporate culture. Our first metric is the corporate culture score, which is calculated as the total of the values assigned to the five culture traits in Guiso et al. (2015). This is the same technique used by Li et al. (2021) to assess corporate culture as a whole. Second, we run a principal component analysis on the scores for the five cultural characteristics and extract the first component. This statistic is referred to as the corporate culture index. The other variable definitions are described in the Appendix.

policies or outcomes. This method, which is based on geographic location, has recently gained popularity in the literature (Chintrakarn, Jiraporn, & Davidson, 2017; Chintrakarn, Jiraporn, Tong, & Chatjuthamard, 2015; Jiraporn, Jiraporn, Boeprasert, & Chang, 2014).

Table 7 displays the regression results. Model 1 is a first-stage regression in which board gender diversity serves as the dependent variable. The coefficient of the average degree of board gender diversity of all firms in the same 3-digit zip code is significantly positive, as expected. Model 2 is a second-stage regression with the corporate culture score as the dependent variable. Board gender diversity, which is instrumented from the first stage, has a significantly positive coefficient. The result in Model 3, where the dependent variable is the corporate culture index, is also similar. Because an IV analysis is much less susceptible to endogeneity, our conclusion appears to be robust, suggesting that greater board gender diversity is not only associated with, but rather brings about stronger corporate culture. In Table 8, we perform

Table 6
Instrumental-variable analysis based on board gender diversity in the earliest year (Robustness checks).

	(1)	(2)	(3)	(4)	(5)	(6)
	Corporate Culture Score	Corporate Culture Index	Corporate Culture Score	Corporate Culture Index	Corporate Culture Score	Corporate Culture Index
Board Gender Diversity (Instrumented)	0.029***	0.015***	0.032***	0.016***	0.033***	0.018***
	(5.775)	(5.448)	(7.564)	(6.673)	(10.883)	(10.291)
% Independent Directors	0.001	0.001	0.006**	0.003**	0.005***	0.003***
	(0.627)	(0.528)	(2.477)	(2.113)	(3.194)	(2.993)
Board Size	0.421***	0.254***	0.291*	0.140	0.315***	0.159**
	(3.018)	(3.182)	(1.862)	(1.564)	(2.857)	(2.531)
Ln (Total Assets)	0.023	0.002	0.047**	0.025**	0.051***	0.026***
	(1.141)	(0.140)	(2.320)	(2.152)	(3.768)	(3.296)
Total Debt/Total Leverage	-0.566***	-0.303***	-0.897***	-0.499***	-0.695***	-0.376***
	(-3.748)	(-3.500)	(-5.786)	(-5.631)	(-6.610)	(-6.264)
EBIT/Total Assets	-1.355***	-1.024***	-1.288***	-0.926***	-1.115***	-0.851***
	(-4.314)	(-5.688)	(-3.482)	(-4.373)	(-4.359)	(-5.833)
Capital Expenditures/Total Assets	-0.104	-0.240	-0.219	-0.248	-0.441	-0.313
	(-0.143)	(-0.577)	(-0.245)	(-0.484)	(-0.693)	(-0.863)
Advertising Expense/Total Assets	9.269***	3.501***	5.627***	1.616***	8.321***	2.844***
	(10.075)	(6.643)	(6.901)	(3.465)	(14.096)	(8.449)
R&D Expense/Total Assets	3.073***	1.745***	1.873**	1.289***	1.723***	1.122***
	(4.790)	(4.748)	(2.405)	(2.894)	(3.534)	(4.036)
Cash Holdings/Total Assets	2.592***	1.523***	2.335***	1.364***	2.506***	1.469***
	(13.525)	(13.870)	(10.643)	(10.869)	(16.648)	(17.112)
Dividends/Total Assets	-1.418	-0.847	2.741**	1.456**	1.250	0.563
	(-1.169)	(-1.220)	(2.315)	(2.149)	(1.466)	(1.159)
Fixed Assets/Total Assets	-0.548***	-0.317***	-0.821***	-0.491***	-0.727***	-0.431***
	(-5.510)	(-5.561)	(-7.568)	(-7.912)	(-10.051)	(-10.464)
Constant	3.133***	-1.145***	2.411**	-1.533***	1.926***	-1.830***
	(4.318)	(-2.755)	(2.540)	(-2.823)	(3.319)	(-5.530)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8403	8403	7272	7272	16,653	16,653
Adjusted R-squared	0.366	0.348	0.377	0.350	0.376	0.349
z-statistics in parentheses						
*** p < 0.01, ** p < 0.05, * p < 0.1						

Board gender diversity is the percentage of female directors on the board. We use two metrics to measure corporate culture. Our first metric is the corporate culture score, which is calculated as the total of the values assigned to the five culture traits in Guiso et al. (2015). This is the same technique used by Li et al. (2021) to assess corporate culture as a whole. Second, we run a principal component analysis on the scores for the five cultural characteristics and extract the first component. This statistic is referred to as the corporate culture index. The other variable definitions are described in the Appendix.

propensity score matching and entropy balancing on top of the instrumental-variable analysis based on zip codes. All the results in Table 8 remain consistent.

To further ensure that our results are robust, we employ cities instead of zip codes. Table 9 shows the results based on the city where each firm’s headquarters is located. Table 10 displays the results based on PSM and entropy balancing in addition to the IV analysis based on city locations. All the results remain consistent, suggesting that companies where women comprise a greater proportion of directors exhibit significantly stronger corporate culture. As our results survive so many robustness checks, our conclusion appears to be remarkably robust and is highly unlikely tainted by endogeneity.

4.5. Lewbel (2012) heteroscedastic identification

We also perform Lewbel (2012) heteroscedastic identification to corroborate the results. This new technique does not need the use of an instrumental variable. Lewbel (2012) identification does not rely on any exclusion restrictions, but rather on heteroskedasticity. Without applying any exclusion restrictions, identification is possible if there is a vector of exogenous variables Z and the errors are heteroskedastic. The Z vector can be a subset of the exogenous X vector used in the regression or even Z = X. The first stage involves regressing each endogenous variable on the Z vector to produce the vector of residual \hat{e} . These estimated residuals are then used to create instruments (Z- Z-bar) \hat{e} , where Z-bar is

the mean of Z. Identification requires heteroskedastic error terms in the first-stage regression (Lewbel, 2012; Withisuphakorn & Jiraporn, 2018). Lewbel (2012) provides more comprehensive explanations on this approach. The regression results are presented in Table 11, where the coefficients of board gender diversity remain positive and statistically significant.

4.6. Oster (2017) testing for coefficient stability

Furthermore, to verify that our results are not influenced by the omitted-variable bias, we apply Oster (2017) insight and estimate how big the effect of the unobservables would have to be to overpower the effect of the observables, rendering our conclusions less valid (Chintrakarn, Jiraporn, Tong, Jiraporn, & Proctor, 2020). Using Oster (2017) method on our regressions in Table 2, we discover that the influence of the unobservables must be >1.11–1.26 times larger than the effect of the observables to invalidate our conclusions. The results are typically regarded as robust in the literature if the ratio is larger than one. As a result, our findings do not appear to be susceptible to the omitted-variable bias.

4.7. Testing the critical mass theory

Additionally, we investigate the prediction of the critical mass theory, which argues that the effects of female directors may not be

Table 7
Instrumental-variable analysis based on zip code assignments.

	(1)	(2)	(3)
	% Female Directors	Corporate Cultural Score	Corporate Cultural Index
% Female Directors (Zip Code Average)	0.110** (1.984)		
Board Gender Diversity (Instrumented)		0.176*** (2.895)	0.091*** (2.694)
% Independent Directors	0.140*** (8.468)	-0.018** (-2.090)	-0.009* (-1.935)
Board Size	7.199*** (6.115)	-0.714 (-1.488)	-0.343 (-1.291)
Ln (Total Assets)	1.278*** (6.856)	-0.228*** (-2.812)	-0.123*** (-2.747)
Total Debt/Total Leverage	-1.103 (-0.924)	-0.581*** (-3.232)	-0.331*** (-3.324)
EBIT/Total Assets	2.703 (1.207)	-1.119*** (-2.917)	-0.862*** (-4.053)
Capital Expenditures/Total Assets	-8.795** (-1.997)	0.566 (0.588)	0.176 (0.330)
Advertising Expense/Total Assets	15.114* (1.659)	-0.643 (-0.460)	-1.763** (-2.277)
R&D Expense/Total Assets	3.815 (0.570)	5.556*** (7.408)	3.015*** (7.255)
Cash Holdings/Total Assets	-1.846 (-1.080)	2.306*** (9.580)	1.305*** (9.784)
Dividends/Total Assets	13.848 (1.452)	-6.854*** (-4.292)	-3.841*** (-4.341)
Fixed Assets/Total Assets	1.329* (1.689)	-1.141*** (-8.420)	-0.682*** (-9.086)
Constant	-23.584*** (-7.870)	7.551*** (6.298)	1.115* (1.678)
Industry Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Observations	9874	9874	9874
Adjusted R-squared	0.320	0.057	0.100
Robust t-statistics in parentheses			
*** p < 0.01, ** p < 0.05, * p < 0.1			

Board gender diversity is the percentage of female directors on the board. We use two metrics to measure corporate culture. Our first metric is the corporate culture score, which is calculated as the total of the values assigned to the five culture traits in Guiso et al. (2015). This is the same technique used by Li et al. (2021) to assess corporate culture as a whole. Second, we run a principal component analysis on the scores for the five cultural characteristics and extract the first component. This statistic is referred to as the corporate culture index. The other variable definitions are described in the Appendix.

observable until the number of female directors reaches a certain threshold (Kanter, 1977). Prior research suggests that there should be at least three female directors on the board for them to have sufficient voice as a group (Brahma et al., 2020; Joecks et al., 2012; Liu et al., 2014). Several other studies have also investigated the critical mass theory as applicable to female directors on the board (Dobija et al., 2021; Nuber & Velte, 2021; Redor, 2018; Torchia et al., 2011; Vaillant & Lafuente, 2019; Wiley & Monllor-Tormos, 2018; Yarram & Adapa, 2021). While previous studies have examined the critical mass theory, our study is the first to investigate this theory using corporate culture.

We construct a binary variable equal to one if there are at least three female board members and zero otherwise. This variable captures the effect of the critical mass. Then, we create an interaction term between the percentage of female directors and this critical mass binary variable. The prediction of the critical mass theory is that the effect of board gender diversity should be more pronounced when there are at least three female directors on the board. Therefore, the coefficient of the

Table 8
Instrumental-variable analysis based on zip code assignments with propensity score matching and entropy balancing.

	Propensity Score Matching		Entropy Balancing	
	(1)	(2)	(3)	(4)
	Corporate Cultural Score	Corporate Cultural Index	Corporate Cultural Score	Corporate Cultural Index
Board Gender Diversity (Instrumented)	0.095*	0.051*	0.197***	0.111***
% Independent Directors	(1.880)	(1.784)	(3.401)	(3.385)
Board Size	0.007*	0.003	-0.002	-0.002
Ln (Total Assets)	(1.663)	(1.284)	(-0.562)	(-0.830)
Total Debt/Total Leverage	0.161 (0.602)	0.074 (0.484)	-0.053 (-0.224)	-0.028 (-0.211)
EBIT/Total Assets	0.002 (0.037)	0.002 (0.063)	-0.050 (-1.139)	-0.031 (-1.267)
Capital Expenditures/Total Assets	-0.984*** (-3.543)	-0.554*** (-3.507)	-0.415 (-1.567)	-0.215 (-1.430)
Advertising Expense/Total Assets	-1.008* (-1.838)	-0.725** (-2.326)	-1.228*** (-2.743)	-0.863*** (-3.400)
R&D Expense/Total Assets	0.378 (0.261)	0.045 (0.055)	1.073 (0.865)	0.419 (0.596)
Cash Holdings/Total Assets	5.036*** (3.179)	1.557* (1.729)	6.634*** (5.832)	2.112*** (3.275)
Dividends/Total Assets	2.794** (2.405)	1.805*** (2.735)	2.656*** (3.177)	1.573*** (3.319)
Fixed Assets/Total Assets	2.208*** (6.796)	1.233*** (6.678)	2.601*** (8.867)	1.481*** (8.903)
Constant	-0.898 (-0.543)	-0.638 (-0.678)	-3.169** (-2.111)	-1.913** (-2.247)
Industry Fixed Effects	-1.141*** (-5.783)	-0.676*** (-6.029)	-0.960*** (-7.097)	-0.573*** (-7.477)
Year Fixed Effects	3.027*** (2.877)	-1.226** (-2.051)	1.777 (1.626)	-2.024*** (-3.266)
Observations	Yes	Yes	Yes	Yes
Adjusted R-squared	Yes	Yes	Yes	Yes
z-statistics in parentheses	4333	4333	9874	9874
*** p < 0.01, ** p < 0.05, * p < 0.1	0.312	0.297	-0.102	-0.131

Board gender diversity is the percentage of female directors on the board. We use two metrics to measure corporate culture. Our first metric is the corporate culture score, which is calculated as the total of the values assigned to the five culture traits in Guiso et al. (2015). This is the same technique used by Li et al. (2021) to assess corporate culture as a whole. Second, we run a principal component analysis on the scores for the five cultural characteristics and extract the first component. This statistic is referred to as the corporate culture index. The other variable definitions are described in the Appendix.

interaction term is expected to be significantly positive.

The regression results are shown in Table 12. The coefficients of the interaction term are significantly positive both in Model 1 and Model 2. The effect of greater board gender diversity is significantly more pronounced when the number of female directors reaches three on the board, corroborating the prediction of the critical mass theory. The findings also support the argument in prior research that suggests three female directors as the sufficient threshold.

Table 9
Instrumental-variable analysis based on cities.

	(1)	(2)	(3)
	% Female Directors	Corporate Cultural Score	Corporate Cultural Index
% Female Directors (City Average)	0.260**		
	(2.297)		
Board Gender Diversity (Instrumented)		0.122**	0.067**
		(2.517)	(2.448)
% Independent Directors	0.108*** (3.955)	-0.004 (-0.641)	-0.003 (-0.820)
Board Size	5.667*** (2.611)	-0.152 (-0.383)	-0.046 (-0.204)
Ln (Total Assets)	1.425*** (4.506)	-0.216*** (-2.749)	-0.119*** (-2.671)
Total Debt/Total Leverage	0.179 (0.092)	-0.876*** (-3.157)	-0.548*** (-3.485)
EBIT/Total Assets	9.274** (2.098)	-1.504** (-2.127)	-1.086*** (-2.710)
Capital Expenditures/Total Assets	-5.109 (-0.859)	-0.072 (-0.063)	-0.086 (-0.131)
Advertising Expense/Total Assets	27.536 (0.994)	3.433 (1.462)	-0.199 (-0.150)
R&D Expense/Total Assets	-5.220 (-0.416)	9.641*** (7.869)	4.943*** (7.117)
Cash Holdings/Total Assets	-0.145 (-0.045)	1.509*** (4.023)	0.800*** (3.763)
Dividends/Total Assets	-25.617 (-1.640)	-1.664 (-0.679)	-0.345 (-0.248)
Fixed Assets/Total Assets	0.897 (0.747)	-1.367*** (-8.108)	-0.807*** (-8.438)
Constant	-16.515*** (-3.185)	5.208*** (3.988)	-0.221 (-0.298)
Industry Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Observations	3253	3253	3253
Adjusted R-squared	0.410	0.342	0.327
Robust t-statistics in parentheses			
*** p < 0.01, ** p < 0.05, * p < 0.1			

Board gender diversity is the percentage of female directors on the board. We use two metrics to measure corporate culture. Our first metric is the corporate culture score, which is calculated as the total of the values assigned to the five culture traits in Guiso et al. (2015). This is the same technique used by Li et al. (2021) to assess corporate culture as a whole. Second, we run a principal component analysis on the scores for the five cultural characteristics and extract the first component. This statistic is referred to as the corporate culture index. The other variable definitions are described in the Appendix.

4.8. Possible interaction between board gender diversity and an external governance mechanism

We also explore the effect of board gender diversity in combination with an external governance mechanism. The takeover market, often known as the market for corporate control, has long been recognized as one of the most crucial instruments of external governance (Fama, 1980; Lel & Miller, 2015; Cain, McKeon, & Solomon, 2017). It has been reported in recent research that the takeover market stifles a strong corporate culture (Chatjuthamard & Jiraporn, 2022). Essentially, takeover vulnerability induces managers to be more myopic as their job security is reduced in the presence of takeover threats. Consequently, they are hesitant to make significant investments in building a strong corporate culture in the long run. Managerial myopia is not uncommon and has been discussed and documented in prior research (Bhojraj & Libby, 2005; Laverty, 1996, 2004; Lundstrum, 2002; Mizik, 2010).

To gain more insights, we investigate the effect of board gender

Table 10
Instrumental-variable analysis based on cities with propensity score matching and entropy balancing.

	Propensity Score Matching		Entropy Balancing	
	(1)	(2)	(3)	(4)
	Corporate Cultural Score	Corporate Cultural Index	Corporate Cultural Score	Corporate Cultural Index
Board Gender Diversity	0.093*	0.044*	0.121***	0.066***
	(1.950)	(1.669)	(2.901)	(2.798)
% Independent Directors	0.010	0.004	0.010**	0.004*
	(1.537)	(1.168)	(2.200)	(1.694)
Board Size	0.545 (1.218)	0.237 (0.951)	0.270 (0.733)	0.155 (0.749)
Ln (Total Assets)	-0.071 (-1.077)	-0.017 (-0.455)	-0.139** (-2.459)	-0.066** (-2.088)
Total Debt/Total Leverage	-0.920** (-2.168)	-0.626*** (-2.649)	-0.691** (-2.302)	-0.441*** (-2.612)
EBIT/Total Assets	-3.065** (-2.563)	-1.786*** (-2.682)	-4.236*** (-4.033)	-2.481*** (-4.200)
Capital Expenditures/Total Assets	-1.223 (-0.576)	-0.983 (-0.832)	-0.915 (-0.521)	-0.746 (-0.756)
Advertising Expense/Total Assets	7.084*** (3.077)	2.301* (1.794)	8.652*** (4.816)	2.637*** (2.610)
R&D Expense/Total Assets	6.831*** (3.192)	3.755*** (3.150)	6.887*** (5.161)	3.601*** (4.799)
Cash Holdings/Total Assets	3.254*** (5.411)	1.656*** (4.945)	2.977*** (6.403)	1.529*** (5.850)
Dividends/Total Assets	3.821 (0.895)	2.257 (0.950)	8.525** (2.004)	5.214** (2.179)
Fixed Assets/Total Assets	-1.293*** (-4.495)	-0.752*** (-4.696)	-1.269*** (-6.024)	-0.752*** (-6.346)
Constant	0.819 (0.569)	-2.318*** (-2.893)	1.677* (1.653)	-2.121*** (-3.717)
Industry Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	1531	1531	3253	3253
Adjusted R-squared	0.397	0.397	0.295	0.278
z-statistics in parentheses				
*** p < 0.01, ** p < 0.05, * p < 0.1				

Board gender diversity is the percentage of female directors on the board. We use two metrics to measure corporate culture. Our first metric is the corporate culture score, which is calculated as the total of the values assigned to the five culture traits in Guiso et al. (2015). This is the same technique used by Li et al. (2021) to assess corporate culture as a whole. Second, we run a principal component analysis on the scores for the five cultural characteristics and extract the first component. This statistic is referred to as the corporate culture index. The other variable definitions are described in the Appendix.

diversity on corporate culture while taking into account the effect of the takeover market, which constitutes a vital external governance mechanism. To capture the extent of takeover susceptibility, we employ the hostile takeover index invented by Cain et al. (2017). Principally based on the staggered enactment of anti-takeover state laws, this index is a novel measure of firm-specific takeover vulnerability and has been rapidly embraced in the recent literature (Cain et al., 2017; Chatjuthamard, Jiraporn, et al., 2021; Ongsakul, Chatjuthamard, et al., 2021). Basically, we create an interaction term between board gender diversity

Table 11
Lewbel's (2012) heteroscedastic identification.

	(1)	(2)
	Corporate Culture Score	Corporate Culture Index
Board Gender Diversity	0.011*** (6.518)	0.006*** (5.740)
% Independent Directors	0.006*** (4.332)	0.003*** (4.139)
Board Size	0.308*** (3.307)	0.171*** (3.180)
Ln (Total Assets)	0.006 (0.467)	-0.003 (-0.375)
Total Debt/Total Leverage	-0.708*** (-6.937)	-0.368*** (-6.263)
EBIT/Total Assets	-0.965*** (-4.467)	-0.831*** (-6.685)
Capital Expenditures/Total Assets	-0.191 (-0.392)	-0.144 (-0.512)
Advertising Expense/Total Assets	5.448*** (8.781)	1.417*** (3.965)
R&D Expense/Total Assets	5.280*** (11.593)	2.950*** (11.247)
Cash Holdings/Total Assets	2.139*** (16.235)	1.257*** (16.565)
Dividends/Total Assets	-0.122 (-0.153)	-0.134 (-0.291)
Fixed Assets/Total Assets	-0.766*** (-11.507)	-0.467*** (-12.189)
Constant	3.193*** (5.714)	-1.124*** (-3.493)
Industry Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Observations	16,653	16,653
Adjusted R-squared	0.374	0.355
z-statistics in parentheses		
*** p < 0.01, ** p < 0.05, * p < 0.1		

Board gender diversity is the percentage of female directors on the board. We use two metrics to measure corporate culture. Our first metric is the corporate culture score, which is calculated as the total of the values assigned to the five culture traits in Guiso et al. (2015). This is the same technique used by Li et al. (2021) to assess corporate culture as a whole. Second, we run a principal component analysis on the scores for the five cultural characteristics and extract the first component. This statistic is referred to as the corporate culture index. The other variable definitions are described in the Appendix.

and the hostile takeover index.

The results are shown in Table 13. First, the coefficient of the hostile takeover index is significantly negative, consistent with the findings in prior research that takeover susceptibility weakens corporate culture (Chatjuthamard & Jiraporn, 2022). The coefficient of the interaction term, however, is significantly positive, suggesting that female board representation softens the adverse impact of the takeover market on corporate culture. Takeover threats weaken corporate culture because they exacerbate managerial myopia (Chatjuthamard & Jiraporn, 2022). Our results imply that female board representation mitigates managerial myopia and induces managers to take actions that are beneficial to shareholders in the long run, such as promoting a strong corporate culture.

4.9. The effect of firm size on corporate culture

It is worth noting that in the regression analysis that we have reported so far, the effect of firm size on corporate culture is not significant. This is particularly surprising as large firms are probably more motivated to build a strong corporate culture. To explore this issue further, we execute additional analysis as follows. First, we explore an alternative proxy for firm size. Instead of the log of total assets, we utilize the log of market capitalization, which can also be used to

Table 12
Testing the critical mass theory of board gender diversity.

	(1)	(2)
	Corporate Culture Score	Corporate Culture Index
Board Gender Diversity × Female Critical Mass	0.014** (2.513)	0.007** (2.268)
Board Gender Diversity	0.003 (0.744)	0.001 (0.572)
Female Critical Mass	0.215** (2.156)	0.128** (2.240)
% Independent Directors	0.006** (2.191)	0.003** (2.198)
Board Size	0.251 (1.337)	0.139 (1.306)
Ln (Total Assets)	0.006 (0.195)	-0.003 (-0.165)
Total Debt/Total Leverage	-0.702*** (-3.326)	-0.364*** (-3.105)
EBIT/Total Assets	-0.941** (-2.174)	-0.819*** (-3.406)
Capital Expenditures/Total Assets	-0.245 (-0.303)	-0.170 (-0.373)
Advertising Expense/Total Assets	5.266*** (3.234)	1.323 (1.504)
R&D Expense/Total Assets	5.266*** (4.340)	2.938*** (4.472)
Cash Holdings/Total Assets	2.118*** (7.196)	1.246*** (7.429)
Dividends/Total Assets	-0.402 (-0.237)	-0.284 (-0.298)
Fixed Assets/Total Assets	-0.761*** (-5.183)	-0.465*** (-5.787)
Constant	4.446*** (10.536)	-0.485** (-2.029)
Industry Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Observations	16,653	16,653
Adjusted R-squared	0.376	0.357
Robust t-statistics in parentheses		
*** p < 0.01, ** p < 0.05, * p < 0.1		

Board gender diversity is the percentage of female directors on the board. We use two metrics to measure corporate culture. Our first metric is the corporate culture score, which is calculated as the total of the values assigned to the five culture traits in Guiso et al. (2015). This is the same technique used by Li et al. (2021) to assess corporate culture as a whole. Second, we run a principal component analysis on the scores for the five cultural characteristics and extract the first component. This statistic is referred to as the corporate culture index. The other variable definitions are described in the Appendix. Female Critical Mass is binary equal to one if there are at least three female board members and zero otherwise.

represent firm size. However, the effect of firm size on corporate culture is still insignificant when market capitalization is used.

Second, we conjecture that the effect of firm size on corporate culture may not be linear. To explore this possibility, we include the quadratic term for the logarithm of total assets. The results are shown in Table 14. The results show that the relationship is non-linear. In Model 1, the coefficient of the logarithm of total assets is negative and significant, whereas the coefficient of the quadratic term is significantly positive. The result in Model 2 is similar, where market capitalization is used to proxy for firm size.

As expected, large companies promote a more robust corporate culture. But before firm size has a favorable impact on corporate culture, the company must reach a specific threshold. This makes considerable sense. Due to the complexity of larger firms, corporate culture is likely one of the most essential issues to address. However, for smaller companies, corporate culture is likely not among the most critical concerns to address. Using the coefficients of the logarithm of total assets and its quadratic term in Model 1, we estimate that firm size starts having a positive effect on corporate culture when it reaches the 63rd percentile.

Table 13
Interaction between board gender diversity and the takeover market.

	(1)	(2)
	Corporate Culture Score	Corporate Culture Index
Board Gender Diversity × The Hostile Takeover Index	0.062** (2.005)	0.036* (1.962)
The Hostile Takeover Index (Cain et al., 2017)	-1.934*** (-2.820)	-1.113*** (-2.699)
Board gender diversity	0.000 (0.004)	-0.001 (-0.315)
% Independent Directors	0.005** (2.006)	0.003** (2.022)
Board Size	0.227 (0.833)	0.144 (0.943)
Ln (Total Assets)	-0.017 (-0.415)	-0.017 (-0.651)
Total Debt/Total Leverage	-0.757*** (-3.956)	-0.389*** (-3.976)
EBIT/Total Assets	-1.205** (-2.172)	-0.947*** (-2.811)
Capital Expenditures/Total Assets	-0.353 (-0.344)	-0.165 (-0.270)
Advertising Expense/Total Assets	3.549 (1.512)	0.497 (0.357)
R&D Expense/Total Assets	5.327*** (4.891)	2.995*** (6.120)
Cash Holdings/Total Assets	1.864*** (3.373)	1.104*** (3.477)
Dividends/Total Assets	0.242 (0.142)	0.180 (0.210)
Fixed Assets/Total Assets	-0.765*** (-5.427)	-0.490*** (-5.532)
Constant	4.875*** (8.309)	-0.295 (-0.942)
Industry Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Observations	11,156	11,156
Adjusted R-squared	0.325	0.321
Robust t-statistics in parentheses		
*** p < 0.01, ** p < 0.05, * p < 0.1		

Board gender diversity is the percentage of female directors on the board. We use two metrics to measure corporate culture. Our first metric is the corporate culture score, which is calculated as the total of the values assigned to the five culture traits in Guiso et al. (2015). This is the same technique used by Li et al. (2021) to assess corporate culture as a whole. Second, we run a principal component analysis on the scores for the five cultural characteristics and extract the first component. This statistic is referred to as the corporate culture index. The other variable definitions are described in the Appendix. Female Critical Mass is binary equal to one if there are at least three female board members and zero otherwise.

The non-linear effect of firm size on corporate culture is particularly interesting and warrants further investigation. We encourage future researchers to look more deeply into this issue.

5. Conclusions

Over the last decade, there has been a resurgence of interest in the effects of female representation on corporate boards (Brahma et al., 2020; Carter et al., 2010; Hillman et al., 2007; Joecks et al., 2012; Liu et al., 2014; Perryman, Fernando, & Tripathy, 2016; Rose, 2007). We contribute to this immense and crucial area of the literature by examining the effect of female directors on corporate culture. We exploit an innovative measure derived from machine learning and earnings conference calls (Li et al., 2021). Owing to advances in complex computer algorithms, machine learning and textual analysis has gained popularity in the recent literature. Given the difficulty in measuring the degree of corporate culture, this distinctive measure is particularly useful as it represents a notable step towards quantifying corporate culture.

Table 14
The effect of firm size on corporate culture.

	(1)	(2)
	Corporate Culture Score	Corporate Culture Score
Ln (Total Assets)	-0.710*** (-3.497)	
(Ln (Total Assets))²	0.043*** (3.572)	
Ln (Market Capitalization)		-0.542*** (-2.720)
(Ln (Market Capitalization))²		0.036*** (2.905)
Board Gender Diversity	0.012*** (2.991)	0.010*** (2.678)
% Independent Directors	0.005* (1.938)	0.005* (1.900)
Ln (Board Size)	0.341* (1.817)	0.188 (1.038)
Total Debt/Total Assets	-0.556** (-2.575)	-0.680*** (-3.257)
EBIT/Total Assets	-0.745* (-1.729)	-0.868* (-1.913)
Capital Expenditures/Total Assets	-0.249 (-0.307)	-0.198 (-0.250)
Advertising Expense/Total Assets	5.305*** (3.181)	5.246*** (3.156)
R&D Expense/Total Assets	5.038*** (4.170)	4.990*** (4.118)
Cash Holdings/Total Assets	2.000*** (6.842)	2.102*** (7.339)
Dividends/Total Assets	-0.865 (-0.508)	-1.202 (-0.692)
Fixed Assets/Total Assets	-0.767*** (-5.296)	-0.745*** (-5.080)
Constant	7.053*** (7.895)	6.630*** (7.414)
Observations	16,653	16,658
Adjusted R-squared	0.377	0.376
Robust t-statistics in parentheses		
*** p < 0.01, ** p < 0.05, * p < 0.1		

Board gender diversity is the percentage of female directors on the board. We use two metrics to measure corporate culture. Our first metric is the corporate culture score, which is calculated as the total of the values assigned to the five culture traits in Guiso et al. (2015). This is the same technique used by Li et al. (2021) to assess corporate culture as a whole. Second, we run a principal component analysis on the scores for the five cultural characteristics and extract the first component. This statistic is referred to as the corporate culture index. The other variable definitions are described in the Appendix. Female Critical Mass is binary equal to one if there are at least three female board members and zero otherwise.

Our empirical results corroborate the prediction of the outcome hypothesis, where greater board gender diversity produces stronger corporate culture. According to the resource dependence theory and agency theory, board gender diversity improves the functioning of the board, resulting in managers taking actions that are beneficial to shareholders in the long run, including fostering strong positive corporate culture. Cognizant of possible endogeneity, we execute a variety of robustness checks to mitigate endogeneity, including propensity score matching, entropy balancing, an instrumental-variable analysis, Lewbel (2012) heteroscedastic identification, and Oster (2017) testing for coefficient stability. Our results remarkably survive all the robustness checks and are therefore unlikely contaminated by endogeneity.

Furthermore, we test the critical mass theory and find that female directors have a considerably larger effect on corporate culture when there are at least three of them on the board. Lastly, we find that the presence of women on corporate boards mitigates the adverse effect of the takeover market on corporate culture. Our results make important

contributions to several crucial areas of the literature, including corporate governance, board gender diversity, agency theory, corporate culture, and machine learning and textual analysis. Notably, our research demonstrates that machine learning can be employed to produce a useful measure that captures the extent of an abstract value such as corporate culture.

Appendix A. Variable definitions

Variable	Definition
Corporate Culture Measures	
Corporate Culture Score	The sum of the scores for the five most important corporate culture qualities identified by Guiso et al. (2015)
Corporate Culture Index	The first component from a principal component analysis combining the five most important corporate culture qualities identified by Guiso et al. (2015)
Board Attributes	
Board Gender Diversity	% Female Directors
Board Independence	% Independent Directors
Board Size	Ln (Board Size)
Firm-specific Characteristics	
Firm Size	Ln (Total Assets)
Leverage	Total Debt/Total Assets
Profitability	EBIT/Total Assets
Capital Investments	Capital Expenditures/Total Assets
Advertising Intensity	Advertising Expense/Total Assets
R&D Intensity	R&D Expense/Total Assets
Cash Holdings	Cash Holdings/Total Assets
Dividend Payouts	Dividends/Total Assets
Asset tangibility	Fixed Assets/Total Assets

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