



Firm performance and boardroom gender diversity: A quantile regression approach



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ABSTRACT

We investigate the relation between firm performance and boardroom gender diversity using quantile regression methods. Using annual data on over 3000 US firms from 2007 to 2014, we show that the presence of women on the board has a positive effect on firm performance, and this effect varies at different parts of the performance distribution. Critically, we demonstrate that the presence of women directors alters the dispersion of firm performance. Our quantile regression results suggest that female directors have a significantly larger positive impact in high-performing firms relative to low-performing firms. The board gender diversity effect is not homogeneous as assumed in previous research. In addition, we account for the endogenous selection of women to the board. Using instrumental variable quantile regression, we find that in general there is a positive correlation between firm performance and board gender diversity. Overall, we suggest that boardroom gender diversity has an effect on both the conditional mean and the dispersion of firm performance, and quantile regression adds value to the empirical examination of the performance impact of board gender diversity.

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1. Introduction

The issue of women representation on corporate boards has attracted considerable interest among practitioners, policymakers, and researchers in recent years. In part, this is due to the relatively low representation of women on boards compared to their presence in the general population at large and in the corporate world in general. Terjesen, Aguilera, and Lorenz (2015), in a recent comprehensive review of the literature, document that female boardroom representation is only 10.3% across 67 countries. In the United States, a MSCI (2014) survey concludes that the average proportion of women directors on boards of S&P 1500 firms is about 15.8% in 2014 and approximately 81.4% of these companies have at least one woman director.

The academic literature has hypothesized a number of organizational level benefits associated with gender diversity in the boardroom. These include improved board decision making quality

(Milliken & Martins, 1996), more effective board strategic control (Nielsen & Huse, 2010), more stringent board monitoring (Adams & Ferreira, 2009), and better firm financial performance (Terjesen, Sealy, & Singh, 2009). The empirical evidence in support of these claims however has been mixed, especially regarding the performance impact of board gender diversity (Ferreira, 2015; Larcker & Tayan, 2011; Post & Byron, 2015). Although some studies have documented that a higher proportion of female directors on boards is associated with positive accounting or market performance (Campbell & Miguez-Vera, 2008; D. Carter, Simkins, & Simpson, 2003), other studies have found exactly the opposite by showing a negative association between female director representation and firm performance (Ahern & Dittmar, 2012; Matsa & Miller, 2013), while another studies have concluded that there is no clear relationship between female board representation and firm performance (Adams & Ferreira, 2009; D. A. Carter, D'Souza, Simkins, & Simpson, 2010; Jurkus, Park, & Woodard, 2011). Mixed findings in the literature may result from differences in empirical specifications and methodologies in terms of performance measures, statistical models, time horizons, omitted variables, etc. (Adams, Haan, Terjesen, & Ees, 2015; Ferreira, 2015). In an attempt to reconcile such inconclusive evidence, Post and Byron (2015) further suggest that it is essential

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to consider conditions and contexts that may affect the impact of female board members on firm performance.

This study augments the extant literature by introducing an important contingency factor, namely firm performance to the investigation of board gender diversity. We predict and demonstrate that the effect of board gender diversity on firm performance is not constant across the performance distribution as assumed by the prior literature. In sharp contrast, we show for the first time that the influence of board gender diversity is quantitatively larger in magnitude for better performing firms compared to worse performing firms. We draw upon threat-rigidity theory (Gladstein & Reilly, 1985; Staw, Sandelands, & Dutton, 1981) in social psychology and job sorting and matching theories in labor economics (Kremer & Maskin, 1996; Wheeler, 2001) to explain this phenomenon from two different angles. We argue that women directors' unique perspectives and experiences are less likely to be utilized in low performing firms as a result of group dynamic changes in response to threats posed by declining performance, which in turn undermines their contribution to firm performance. We also suggest that job sorting and matching result in differences in female directors' quality and firms' capability to utilize gender related talent between low performing and high performing firms, and consequently lead to the differential impact of board gender diversity on firm performance. To the best of our knowledge, no prior empirical literature has utilized and integrated these theories to explain heterogeneity of gender diversity effect on firm financial performance. Empirically, we use a novel research technique, quantile regression method, to investigate the connection between board gender diversity and firm performance at different firm performance levels. The prior empirical literature has commonly applied standard linear regressions using the conditional means method built on the assumption that the average gender effect in the boardroom is constant. We propose and demonstrate that such an assumption is highly disputable. Instead, we show that women on boards also influence the dispersion of firm performance, and thus generate distinct effects at different parts of the performance distribution. As a result, the conditional mean regression method used in prior studies conceals significant parameter heterogeneity in the link between board gender diversity and organizational performance, which is unmasked using the quantile regression method. Specifically, we show that because the effect of board gender diversity is not constant across the performance distribution, it is quite easy to inadvertently miss the true effect of female directors on corporate performance. From this perspective, our paper also makes a significant methodological contribution toward a deeper understanding of boardroom gender diversity effects.

The rest of this paper is organized as follows. The next section synthesizes extant literature to develop our hypotheses. Section 3 discusses the quantile regression method and its key merits. Section 4 describes our data and empirical models. Section 5 presents the empirical findings. Lastly, Section 6 offers some concluding remarks.

2. Literature review and hypothesis development

As a primary monitoring and advisory group, the board of directors plays an essential role in protecting and promoting shareholder interests, guiding the firm's strategic directions, and influencing firm performance (Finkelstein, Hambrick, & Cannella, 2009; Hambrick, 2007; Hambrick & Mason, 1984). In recent years a growing number of studies have investigated the influence of board diversity on firm level outcomes (Terjesen et al., 2009) and especially gender diversity measured by the presence of women directors on the board (Hillman, 2015; Post & Byron, 2015). Extant academic research not only indicates that there are few women on boards relative to their presence in the population, but also suggests that board gender diversity can

give rise to several beneficial organizational outcomes, arising from differences in human and social capital as well as decision making styles between men and women (e.g. Burgess & Tharenou, 2002; Simpson, Carter, & D'Souza, 2010; Terjesen et al., 2015).

First of all, a gender diverse board is argued to be associated with better quality decisions compared to a homogeneous male only board (Milliken & Martins, 1996). Because male and female directors often differ systematically in their core values, risk attitudes, backgrounds, and perspectives, gender diversity is associated with cognitive diversity (Adams & Funk, 2012; Perryman, Fernando, & Tripathy, 2016; Simpson et al., 2010). For example, D. A. Carter et al. (2010) suggest that female directors tend to hold more college degrees and are more likely to hold advanced degrees compared to their male counterparts. Additionally, female directors likely possess more marketing and sales experiences, are more prudent to risks, and pay more attention to corporate social responsibility and philanthropy (Burgess & Tharenou, 2002; Post & Byron, 2015). Female board members also have different socialization experiences and are connected with distinct social networks compared to their male counterparts (Simpson et al., 2010). As a result, a gender diverse board may benefit firms through these unique knowledge, information, experiences, skills, and networks of women directors (Hillman, Shropshire, & Cannella, 2007; Miller & del Carmen Triana, 2009). Moreover, Post and Byron (2015) point out that women directors are prone to value different opinions, elicit information from all board members, and adopt a cooperative decision-making approach to stimulate collaboration within the group. Gender diversity can also help reduce 'groupthink', which is the tendency for individuals acting in groups to succumb to consensus decisions without an appropriate critical evaluation of alternative ideas or viewpoints (Janis, 1972). While the problem of 'groupthink' tends to be more severe in a homogeneous group, a gender diverse board is more likely to consider different perspectives of board-level problems, and subsequently improves the quality of board decision-making (Conyon & Mallin, 1997). As a result of improved board decision quality, extant literature has associated board gender diversity with more corporate innovation (Miller & del Carmen Triana, 2009), enhanced firm capability to utilize firm resource and investments (Triana, Miller, & Trzebiatowski, 2013), better understanding of the marketplace and the firm's stakeholders (Carter et al., 2003), more effective board strategic control (Nielsen & Huse, 2010), more stringent board monitoring (Adams & Ferreira, 2009), and ultimately superior firm performance (Campbell & Miguez-Vera, 2008; Carter et al., 2003).

Set against the potential benefits of board diversity are possible costs. Boards that are too dissimilar might lack sufficient cohesion and unity. This in turn might increase the likelihood of team conflicts and thus impede the speed and quality of decision making (Pelled, Eisenhardt, & Xin, 1999). Board diversity may also foster social categorization within boards that is disruptive to board effectiveness. Li and Hambrick (2005), for example, suggest that demographic diversity may cause undesirable in-group versus out-group stereotyping, and subsequently disrupts the board decision-making processes. In addition, diversity might result in unintended tokenism and lead to the hiring of people based not necessarily on the grounds of merit (Larcker & Tayan, 2011; Torchia, Calabrò, & Huse, 2011). For example, in their study of mandatory gender quotas in Norwegian boards, Ahern and Dittmar (2012) argue that the 40% female board representation quota results in the appointment of younger and less experienced women directors to the boardroom, and negatively influences firm performance. Theoretically, Baranchuk and Dybvig (2009) discuss how consensus may be achieved when individual directors have different preferences over various courses of action. As a result, corporate decisions may not be optimal but reflect trade-offs of board bargaining.

Given board gender diversity is a double-edged sword, it is essential to investigate the conditions when the benefits from gender diversity

might outweigh the potential costs, and vice versa. The extant literature has explored various contingencies that might influence the efficacy of a gender diverse board, from a number of different angles. First of all, national contexts matter. In their meta-analysis, [Post and Byron \(2015\)](#) find that female board representation is related to more positive accounting performance in countries with better shareholder protection. They argue that stronger shareholder protection in these countries enables boards to better value and utilize female directors' knowledge and experience. They also show that board gender diversity tends to generate positive market performance in countries with better gender parity. They attribute this effect to the higher possibility of women directors in these countries to possess appropriate human capital to make greater contributions to boards as well as a higher market assessment of female directors' quality in these countries. Second, organizational contexts also matter. [Dwyer, Richard, and Chadwick \(2003\)](#) find in their study of US banks that board gender diversity is more likely to contribute to positive firm performance in an organization with a clan culture that emphasizes teamwork, cohesiveness, informal governance, and held together through employee loyalty, morale, and commitment. They suggest that such an organizational culture will help reduce intra-group conflicts as well as other downsides associated with a diverse team and largely strengthen contributions of female members. In addition, [Adams and Ferreira \(2009\)](#) find that although a gender diverse board is associated with more stringent board monitoring, it might not translate into better firm performance. Gender diversity only enhances value of those firms with weaker shareholder rights when additional board monitoring is beneficial, while it is detrimental to companies with stronger shareholder rights. [Jurkus et al. \(2011\)](#) likewise examine the moderating role of corporate governance on the effectiveness of gender diversity. Using a sample of Fortune 500 firms, they find that a gender diverse top management team is more likely to reduce agency costs, measured by free cash flows, when strong external governance is absent in a less competitive product market.

Importantly, [Triana et al. \(2013\)](#) argue that firm performance itself is a critical contingency that affects the efficacy of board gender diversity. Specifically, low performance poses a threat for firms and consequently changes informational and decision making processes of the board ([Staw et al., 1981](#)). According to threat-rigidity theory, groups may react to threats by restricting information processing ([Gladstein & Reilly, 1985](#); [Staw et al., 1981](#)). As a result, these groups often experience a decrease in the degree of information exchange in terms of less information being shared among group members, less utilization of certain communication channels, and less information being used for decision making ([Gladstein & Reilly, 1985](#)). Threats will also increase pressures toward uniformity and likely intensify the groupthink problem ([Janis, 1972](#)). [Janis \(1982\)](#), for example, posits that groups experiencing external threats tend to consider and discuss fewer alternatives and censor the inputs of dissenting opinions. We thereby expect that boards are more likely to restrict information and centralize authority so as to simplify decision making when there is a threat of low firm performance. As a result, women directors' diverse perspectives are less likely to be considered in a low performing firm with strong pressure toward uniformity of ideas and opposition to expressions of candid opinions. Therefore, benefits of board gender diversity are less likely to materialize in low performing firms. In contrast, when a firm has performed well, there is less pressure to suppress ideas of women directors, which in turn would result in better utilization of their knowledge, expertise, and unique perspectives, and give rise to higher quality board decisions. In addition, the costs of gender diversity in terms of prolonged decision-making time and internal conflicts may be exaggerated in the case of low firm performance. [Triana et al. \(2013\)](#) for instance document that a gender diverse board is less likely to undertake strategic changes, particularly when firm performance has been low. By the same token, we expect that the downside of board gender

diversity may intensify in a low-performing firm and prohibit the firm from improving its performance.

Above we assert that women directors' unique perspectives and talents are less likely to be utilized in a low performing firm, thus their contributions to firm performance may be smaller in a low performing firm compared to a high performing firm. Another heterogeneity that has been neglected by extant literature is women directors' quality. That is variation among women in distinguishing characteristics, traits, skills and talents. From the perspective of labor economics, boards of directors are recruited from a competitive labor market ([Kaplan & Rauh, 2013](#)). On the demand side of this market firms compete with each other to recruit managerial talent, and the supply side of the market contains potential candidates seeking board positions. The "product" transacted in this market is board members' human capital consisting of their expertise, knowledge, and skills as well as their social capital existing in their network relationship ([Haynes & Hillman, 2010](#)). In this market, board members differ with each other in terms of their human and social capital, and firms also vary in their ability to utilize managerial talent ([Sorensen & Sorenson, 2007](#)). An important mechanism in the labor market is job matching and quality sorting ([Jovanovic, 1979](#); [Kremer & Maskin, 1996](#); [Stevens, 2003](#)). Under this mechanism, individuals with varied abilities and attributes will find different employers that value them. High quality board members match with those firms best capable of utilizing their talents, while less able members tend to find employment with less productive firms ([Wheeler, 2001](#)). The job matching and quality sorting argument therefore suggests that female directors in better performing firms may possess more human and social capital and their hiring firms may also have superior capability to utilize their talents. As a result, these female directors are able to exert stronger positive influence on their firms' performance than their counterparts in low performing firms. We thus expect that larger female representation in a high performing firm is more likely to generate positive performance impact than that in a low performing firm. That is, heterogeneity in director quality and firm capability will give rise to the differential impact of board gender diversity on firm performance at different parts of firm performance distribution. Taken together, we make the following prediction:

H1: Board gender diversity has a significantly larger positive impact on firm performance in high-performing firms than in low-performing firms.

This hypothesis is tested by utilizing a novel technique, namely quantile regression. Since the method is comparatively new in the management literature and has not been used in prior studies examining board gender diversity, the next section provides a brief outline of main advantages of quantile regression as well as its applications in extant literature. We also contrast this method with conditional mean regressions applied in prior studies and argue that some of the mixed results in existing studies can be better understood in the framework of quantile regression.

3. Quantile regression

Quantile regression is a method to estimate conditional quantile functions ([Chernozhukov & Hansen, 2005](#); [Koenker, 2007](#); [Koenker & Gilbert, 1978](#); [Koenker & Hallock, 2001](#); [Powell, 2016](#)).¹ An important benefit of the quantile regression technique, compared to the standard ordinary least squares (OLS) estimator, is that it yields a comprehensive characterization of the relationship between

¹ In the Appendix we provide a brief overview of the quantile regression method.

an outcome variable Y and an input variable X . In addition, quantile regression estimates are robust to the presence of outliers in one's data set. In consequence, quantile estimates are less prone to the influence of extreme data points. But, as noted, the most important rationale for using quantile regression is that a more complete picture of the relationship between a dependent and independent variable can be quantified.

The classical OLS model predicts the average (i.e. conditional mean) relationship between an input variable X and the outcome quantity Y . In sharp contrast, the quantile regression method can be used to predict parts of the distribution of the outcome variable, such as the conditional median effect on Y of a change in the independent variable X . However, the approach goes far beyond predicting just measures of central tendency. One can estimate a whole family of quantile regressions. Quantile regression method can be used to predict the 25th percentile of the outcome variable or the 75th percentile of the outcome variable or, indeed, any quantile that the researcher is interested in. Accordingly, it is a powerful method to characterize the effect of some independent variable, X , of interest and an outcome quantity, Y . Since an ensemble of conditional quantile functions is analyzed, quantile regression provides a comprehensive account of the relationship between a random dependent variable and a set of independent variables. In this sense, conditional quantile regression provides a more complete picture of the regression function compared to the standard conditional mean regression found in much of applied research. In our case, we focus on the effect of women on boards (input) on the performance of firms (outcome).

Why is this important? Often researchers are interested in effects of some covariates on different parts of the distribution of the response variable other than the average. For example, labor economists have used this method to examine the returns to schooling and education at different parts of the wage distribution (Buchinsky, 1994; Lemieux, 2006). Financial economists have explored the influence of bank regulation on banking risks at different risk levels (Klomp & Haan, 2012), the impact of diversification on firm performance across performance levels (Lee & Li, 2012), and studied agency costs in the use of jet aircraft conditional on the jet size distribution (Edgerton, 2012). Health care researchers have applied this method to examine the differential effect of mothers who smoke on conditionally low birthweight babies compared to high birthweight babies (Koenker & Hallock, 2001). Or sociologists might be interested in the variation in the motherhood penalty conditional on the earnings distribution (Budig & Hodges, 2010).

In the same spirit corporate governance researchers are interested in whether a given governance attribute has a quantitatively different effect across the distribution of the response variable. Hallock, Madalozzo, and Reck (2010), for example, demonstrate that the CEO pay-for-performance link is stronger in conditionally high CEO wage firms. Similarly, Chen and Ying (2011) use quantile regression to investigate the relation between mutual fund performance and Morningstar's fiduciary grades, showing that managerial incentives have larger impact on fund performance at the right tail of the fund performance distribution. In addition, Li (2015) uses this approach to investigate compensation differences between male and female CEOs. He finds no evidence of a female CEO wage discount when using standard linear regression methods and limited pay differences at the median of the pay distribution. In contrast, at around the 95th quantile women CEOs earn significantly less than male CEOs. Together, these studies show the importance of using empirical techniques that extend beyond isolating the average effect of input variables on an outcome variable of interest.

Pertinent to our context, prior studies have predominantly used the conditional mean regression to test the relation between firm performance and women on boards. Typically, the outcome measure is firm performance (either accounting performance or market performance) and the independent variable is a measure of gender

diversity on the board (e.g. percentage of women on the board). Studies we cited above all share a common assumption that the effect of board gender diversity is constant across the performance distribution. Our hypothesis suggests that this assumption is problematic and should be tested. Our study, then, is methodologically different from these prior studies in two significant ways. First, we investigate the effect of boardroom gender diversity for conditionally high performing firms compared to low performing firms and show that there is significant parameter heterogeneity in the effect of women on boards on corporate performance. Second, we further account for the endogenous selection of women to the board by using a generalized quantile regression (GQR) estimator (Powell, 2016).

4. Data and methods

4.1. Data

To test the relation between boardroom gender diversity and organizational performance we construct a panel of data from 2007 to 2014 inclusive. The final data set consists of over 18,000 firm-year observations on over 3000 publicly traded US firms per year (described below). Our primary outcome variable is firm performance measured by both Tobin's Q (a market-based performance measure) and return on assets ratios (an accounting-based performance measure). Our main input variable is the percentage of women on boards. We test whether there is a positive correlation between these variables and whether there is heterogeneity in the estimated effect across the firm performance distribution.

Two main data sets are used in our analysis. First, we use GMI Ratings data for corporate governance variables including our main input variable of board gender diversity. GMI collects corporate governance information annually on the 3000 constituent firms that make up the Russell 3000 Index. The index includes firms in the S&P500 as well as small-cap and mid-cap firms. This data set thus allows us to investigate the effect of women-on-boards using a much larger set of US firms than is typically used in previous studies. For example, other data sources such as RiskMetrics provided by the Institutional Shareholder Services (ISS) also collect information on governance variables including board gender diversity, but do so for fewer firms. The sampling frame for RiskMetrics is the S&P 1500 firms which is a subset of the GMI firms.² Second, we use the Compustat data to construct corporate performance measures and other firm level control variables.

We assemble a panel of data from fiscal year 2007 to 2014. This allows us to test for parameter heterogeneity using quantile regression functions for both cross-section and time series data. We require complete information on firm performance and a set of independent covariates. The final data set consists of 18,549 firm-year observations and 3634 unique firms. As with many data sets of this kind, the data are unbalanced such that there are a different number of time-series observations per firm. Approximately, 40% of sample firms have data for all eight years between 2007 and 2014 (i.e. are balanced). About 50% of sample firms have 5 to 7 years of time-series data. The data set therefore is comprehensive and as representative as possible of the US equity market over a reasonably time period.

² Our interest in this paper is with board gender diversity. Accordingly, we checked the integrity of the data by comparing the GMI and ISS gender diversity measures for those firms that are in both data sets. Both the number and percentage of women on boards figures supplied by GMI and ISS data are the same, with only a few small coding differences across the two data sets. For example, the correlation between the percentage of female directors calculated by ISS and GMI is 0.99.

4.2. Empirical models

Our goal is to compare estimates from the classical least squares (OLS) estimator to those produced from the quantile regression functions. First, we estimate the conditional mean regression (Greene, 2012),

$$E(Y_{it}|X_{it}) = y_{it} = \alpha + \beta G_{it} + \gamma_1 x_{1,it} + \dots + \gamma_k x_{k,it} + \epsilon_{it} \quad (1)$$

where y_{it} is the i 'th firm performance in year t . The dependent and model covariates are indexed by firm i and time period t . Our main firm performance term is Tobin's Q, namely the ratio of firm value to replacement cost of assets. The term G is the main corporate governance variable of interest. In our case this is measured by percentage of women on the corporate board; and $x_1 \dots x_k$ are a set of firm level control variables (described below). We report t -statistics based on heteroscedastic robust standard errors. We present panel data least squares estimates results and then compare these to a set of conditional quantile regressions (Koenker & Hallock, 2001),

$$Q_\tau(Y_{it}|X_{it}) = \alpha_\tau + \beta_\tau G_{it} + \gamma_{\tau,1} x_{1,it} + \dots + \gamma_{\tau,k} x_{k,it} + \epsilon_{it} \quad (2)$$

where $Q_\tau(Y_{it}|X_{it})$ is the τ th quantile regression function. In the result tables reported below we estimate quantile functions at the median of the performance distribution (50th percentile) and the interquartile regressions (25th and 75th percentiles). That is, we estimate quantile regression functions: $Q(0.25)$, $Q(0.5)$, $Q(0.75)$. In addition, we present plots of the coefficients from the quantile regression functions for both performance measures in steps of 0.05 from the 5th to the 95th percentiles.

4.3. Variable definitions

The paper uses both accounting and market-based performance measures as the dependent variable, and is consistent with extant studies (Cannella, Finkelstein, & Hambrick, 2008; Core, Holthausen, & Larcker, 1999; McGuire, Sundgren, & Schneeweis, 1988). The first dependent variable is Tobin's Q. It is the sum of market equity and the book value of debt divided by total assets. Specifically, the numerator is the sum of market equity measured as the year-end closing stock price multiplied by common shares outstanding [PRCC_F $\times$ CSHO] plus firm debt defined as firm's assets minus common equity [AT-CEQ]; and the denominator is total firm assets [AT] (Adams & Ferreira, 2009). The second outcome variable is accounting performance measured by the return on assets ratio (ROA) and is defined as net income [NI] divided by total assets [AT] (Core et al., 1999). The main independent variable is the percentage of women on boards [DirectorsWomenPct]. We also provide sensitivity analysis by substituting this main measure with an indicator variable capturing the presence of at least one woman director on the board [DirectorsWomen]. Both measures have been used in prior studies on board gender diversity (Adams & Ferreira, 2009; Hillman et al., 2007; Nielsen & Huse, 2010; Post & Byron, 2015).

Based on previous research, we include a number of board, ownership, and firm level control variables that may potentially affect firm performance (Cannella et al., 2008; Core et al., 1999; Yermack, 1996). Board size is measured as the total number of directors on the board (denoted as Board size). 'Institutional control' indicates whether or not a majority of outstanding shares are held by institutional shareholders. Firm size is measured as the logarithm of total sales (denoted as Log sales). Market leverage reflects cross-firm differences in capital structure and is defined as total debt divided by the sum of debt and market equity. The numerator is total debt defined as the sum of total current liabilities plus total long-term debt [DLC + DLTT] and the denominator is total debt plus

market value [(DLC + DLTT) + PRCC_F $\times$ CSHO]. A dummy variable, S&P500, is included to control for whether the firm is a constituent of the S&P500 or not. We also control for potential firm life-cycle effects by including a company age variable calculated as the current year minus founding year and plus one. In addition, we include a dummy variable 'Delaware' to indicate whether the firm is incorporated in the State of Delaware or not. For completeness the statistical models also control for differences in operation and technologies across industries. Manufacturing is a manufacturing dummy variable [=1 if 2-digit SIC ≥ 10 and 2-digit SIC ≤ 39 ; =0 otherwise]; Utility is a utility dummy variable [=1 if 2-digit SIC = 49; =0 otherwise]; Finance is a finance dummy variable [=1 if 2-digit SIC ≥ 60 and 2-digit SIC ≤ 69 ; =0 otherwise].

5. Empirical results

5.1. Firm performance and board gender diversity

Table 1 contains the basic descriptive statistics for our sample. Average Tobin's Q is approximately 2.18 with a median of 1.55. Average ROA is 0.02 with the median being 0.03. The mean percentage of women on the board is about 12% and the median is 11%. 68% of companies have at least one woman director. The average board size is 8.8 directors and the median is 9. The average market leverage ratio is 21%. A typical company in our sample is approximately 39 years old with the median being 26 years. About 60% of the firms are incorporated in Delaware. About 17% of the firms are constituents of the S&P500 and 27% of firms are controlled by institutional shareholders.

Table 1
Descriptive statistics of key variables.

Variables	Average	st. dev.	Median
Tobin's Q	1.42	1.01	1.14
Return on assets	0.02	0.09	0.03
Women on board (%)	0.11	0.10	0.11
Women on board ≥ 1	0.66	0.47	1.00
Board size	9.07	2.48	9.00
Combined CEO	0.47	0.50	0.00
Outsider percent	0.71	0.16	0.75
Female CEO	0.04	0.20	0.00
Log sales	6.97	1.83	6.91
Market leverage	0.24	0.23	0.18
Company age	39.55	40.14	26.00
S&P500	0.17	0.38	0.00
Institution control	0.25	0.43	0.00
Manufacturing	0.41	0.49	0.00
Finance	0.17	0.38	0.00
Utility	0.04	0.20	0.00
Delaware	0.59	0.49	1.00

Notes: Tobin's Q is the sum of market equity and the book value of debt divided by total assets. It is the sum of market equity, measured as the year-end closing stock price multiplied by common shares outstanding [PRCC_F $\times$ CSHO], plus firm debt, defined as firm's assets minus common equity [AT-CEQ]; and the denominator is total firm assets [AT]. Return on assets (ROA) is calculated as net income divided by total assets [NI/AT]. Women on boards is the percentage of women on boards [DirectorsWomenPct]. Women on board ≥ 1 is an indicator variable equal to one if the at least one woman on the board, zero otherwise. Board size is measured as the total number of directors on the board [directorstotal]. CEO is chair is an indicator=1 if the CEO is also the chair of the board. Outsider % is the percentage of outsiders on the board. Female CEO is equal to one if the CEO is female, zero otherwise. Firm size is measured as the logarithm of total sales [SALE]. Market leverage is calculated as total debt divided by the sum of debt and market equity. The numerator is total debt defined as the sum of total current liabilities plus total long-term debt [DLC+DLTT]. The denominator is total debt plus market value [(DLC+DLTT)+PRCC_F $\times$ CSHO]. Firm age is the age of the firm in years. S&P500 is an indicator if the firm is a constituent of the S&P500 index. Institutional control: indicates whether or not a majority of outstanding shares are held by institutional shareholders [InstitutionalMajority]. Industry effects are dummy variables. These include: manufacturing [=1 if 2-digit SIC ≥ 10 and 2-digit SIC ≤ 39 ; =0 otherwise]; Utility [=1 if 2-digit SIC=49; =0 otherwise]; Finance [=1 if 2-digit SIC ≥ 60 and 2-digit SIC ≤ 69]; Delaware incorporation variable [=1 if Delaware, 0 otherwise].

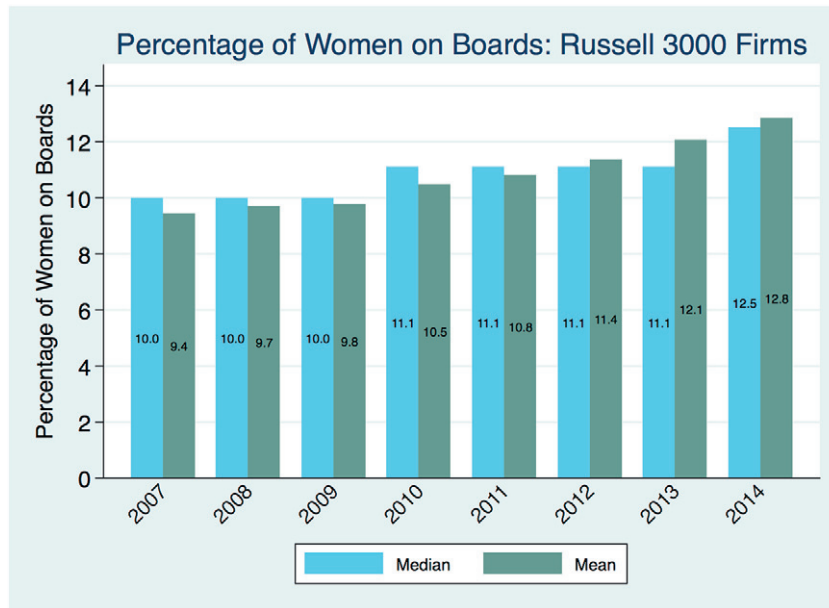


Fig. 1. Percentage of women on boards: 2007 to 2014.
Notes: Median and average estimates plotted from 2007 to 2014.

Since this paper focuses on board gender diversity, it is interesting to see how this has changed over time. Fig. 1 plots the median and average percentage of women on boards between 2007 and 2014 in our data set. We find that the median percentage of women on board is 10% in 2007 and it increases to about 12.5% in 2014. The average percentage of women on boards in 2007 is 9.4% and is 12.8% in 2014. A simple linear regression of the percentage of women on boards on a time trend yields a statistically significant positive coefficient estimate of 0.49 (standard error is 0.03). We conclude that although the percentage of women on US boards remains low relative to the percentage of women in the general population, female representation on corporate boards has experienced an upward trend in recent history.

Table 2 presents baseline estimates of the relation between firm performance and the percentage of women on boards. The determinants of Tobin's Q are presented in columns 1 & 2 and the determinants of the firm's return on assets are given in columns 3 & 4. Columns 1 and 3 contain OLS estimates whereas columns 2 and 4 control for firm-level fixed effects. We find that in the OLS models there is a positive and statistically significant correlation between Tobin's Q and the percentage of women on boards, whereas a negative and statistically significant association is identified when ROA is the performance measure. We therefore conclude that empirical results from OLS models yield mixed findings on the statistical relation between firm performance and board gender diversity, at least for this sample of firms and over this period of time.

Part of the issue might be that the OLS models do not control for unobserved but fixed firm heterogeneity. The findings in columns 2 and 4 of Table 2 show that controlling for firm level fixed effects is indeed important. Including fixed-effects reduces the estimated magnitude of the board gender diversity variable as well as making it statistically insignificant. This result however does not imply that board gender diversity is unimportant. One reason may be that the presence of women on boards is correlated with the firm fixed effect itself (such as differences in corporate culture or board decision-making styles) and so its observed effect disappears once the firm-level fixed effects are controlled for. In addition, the within-firm variation in board gender diversity is low, hence controlling for

firm fixed effects in the performance equation tends to swamp the women-on-boards effect.

Both OLS and firm fixed-effects results demonstrate the conditional mean effects of board gender diversity (the percentage of women on the board) on firm performance (Tobin's Q or ROA). The mixed empirical evidence is consistent with previous academic studies using these methods. However, as we argue above, the assumption in these models that the board gender effect is constant across the performance distribution is not valid. We next report our quantile regression findings in Table 3. Columns 1 to 3 use Tobin's Q as the dependent variable. Columns 4 to 6 use the firm's return on assets (ROA) as the outcome variable. Consider first the relation between Tobin's Q and the percentage of women on boards. At the 25th, median and 75th percentile we isolate a positive and significant relation between Tobin's Q and board gender diversity. Importantly, the estimated magnitude is larger at the 75th percentile compared to the median. The median effect is also larger compared to the effect at the 25th percentile. Consider next the relation between the firm's return on assets and the percentage of women on boards. We find that the effect is negative and significant at the 25th percentile, insignificant at the median and positive and significant at the 75th percentile. The estimated magnitude, then appears to be larger at the 75th percentile compared to the median; and the median effect is also larger compared to the gender diversity effect at the 25th percentile. The results for Tobin's Q and return on assets thus suggest that there is heterogeneity in the impact of board gender diversity on firm performance. Specifically, board gender diversity has a significantly larger positive impact on firm performance in high-performing firms relative to low-performing firms as we predict in Hypothesis 1.

The control variables in the regressions are of interest too. For each of the performance measures, the signs and significance are largely similar. However, the effects are sometimes different between measures. For example, Tobin's Q has a negative relation to firm size measured as the logarithm of total sales (columns 1 to 3), while the association between ROA and firm size (columns 4 to 6) is consistently positive. This might be due to the fact Tobin's Q is a market-based measure, whereas ROA is an accounting-based

Table 2
Firm performance and women on boards: OLS and fixed effects models.

	(1) Tobin's Q OLS	(2) Tobin's Q Firm fixed effects	(3) ROA OLS	(4) ROA Firm fixed effects
Women on board (%)	0.595*** (0.072)	−0.057 (0.121)	−0.020*** (0.007)	0.006 (0.016)
Board size	−0.009*** (0.003)	−0.009* (0.005)	−0.003*** (0.000)	−0.002*** (0.001)
CEO is chair	−0.004 (0.013)	0.009 (0.018)	0.006*** (0.001)	−0.001 (0.002)
Outsider %	−0.235*** (0.045)	−0.109*** (0.041)	−0.022*** (0.004)	−0.008 (0.005)
Female CEO	−0.059 (0.036)	−0.036 (0.059)	0.002 (0.003)	−0.011 (0.007)
Log sales	−0.115*** (0.006)	0.005 (0.029)	0.024*** (0.001)	0.048*** (0.004)
Market leverage	−1.482*** (0.030)	−1.380*** (0.063)	−0.136*** (0.003)	−0.209*** (0.008)
Firm age	−0.001*** (0.000)	−0.000 (0.000)	0.000*** (0.000)	0.000 (0.000)
S&P500	0.462*** (0.021)	0.002 (0.024)	−0.015*** (0.002)	−0.003 (0.002)
Institution control	−0.036** (0.015)	−0.000 (0.013)	0.006*** (0.001)	0.002 (0.001)
Constant	2.870*** (0.054)	1.940*** (0.210)	−0.053*** (0.005)	−0.221*** (0.029)
Industry effects	Yes	No	Yes	No
Firm fixed effects	No	Yes	No	Yes
Time effects	Yes	Yes	Yes	Yes
Observations	16,149	16,149	16,149	16,149
R-squared	0.347	0.182	0.260	0.173
Number of firms		3265		3265

Notes: Tobin's Q is the sum of market equity and the book value of debt divided by total assets. It is the sum of market equity, measured as the year-end closing stock price multiplied by common shares outstanding [PRCC_F×CSHO], plus firm debt, defined as firm's assets minus common equity [AT−CEQ]; and the denominator is total firm assets [AT]. Return on assets (ROA) is calculated as net income divided by total assets [NI/AT]. Women on boards is the percentage of women on boards [DirectorsWomenPct]. Board size is measured as the total number of directors on the board [directorstotal]. CEO is chair is an indicator=1 if the CEO is also the chair of the board. Outsider % is the percentage of outsiders on the board. Female CEO is equal to one if the CEO is female, zero otherwise. Firm size is measured as the logarithm of total sales [SALE]. Market leverage is calculated as total debt divided by the sum of debt and market equity. The numerator is total debt defined as the sum of total current liabilities plus total long-term debt [DLC+DLTT]. The denominator is total debt plus market value [(DLC+DLTT)+PRCC_F×CSHO]. Firm age is the age of the firm in years. S&P500 is an indicator if the firm is a constituent of the S&P500 index. Institutional control: indicates whether or not a majority of outstanding shares are held by institutional shareholders [InstitutionalMajority]. Industry effects include: manufacturing [=1 if 2-digit SIC≥10 and 2-digit SIC≤39; =0 otherwise]; Utility [=1 if 2-digit SIC=49; =0 otherwise]; Finance [=1 if 2-digit SIC≥60 and 2-digit SIC≤69]; Delaware incorporation variable [=1 if Delaware, 0 otherwise].

* $p < 0.10$.

** $p < 0.05$.

*** $p < 0.01$.

one. Other variables such as market leverage have the same negative sign for both performance measures. Yet other variables, such as board size are significant only in the ROA regressions (negative) and less well-determined in the Tobin's Q regressions. In general, we are currently agnostic about the signs of these controls in this study and leave a full analysis of these variables on firm performance, within the quantile regression framework, for future research.

We next explore heterogeneity in the board gender diversity effect in Figs. 2 and 3. Estimates are presented for an ensemble of quantile regressions for both Tobin's Q and return on assets. For each dependent variable, we estimated nineteen separate quantile regressions for the quantiles, τ , ranging from 0.05 to 0.95. The estimated effect of the board gender diversity variable is given for 5% incremental steps from the 5th percentile to the 95th percentile inclusive. The horizontal x-axis in each figure shows the quantile scale and the vertical y-axis shows the board gender effect on Tobin's Q (Fig. 2) and return on assets (Fig. 3). Namely, the y-scale of each figure is the value of the estimated coefficient at a given quantile on the x-scale. The solid line shows the estimate for each τ and the shaded area represents the 90% point-wise confidence interval from the regression estimates. The quantile point estimates are interpreted as the effect of a one unit change of board gender diversity on firm performance holding each of the other variables in the statistical model fixed. The dashed horizontal line in each of the figures shows

the OLS estimate from the conditional mean regression. The non-continuous dotted lines above and below it are the 95% confidence bounds.

The patterns in each of the figures reinforce the results in Table 3 and provide additional support for our Hypothesis 1. There are two key findings. First, there is parameter heterogeneity in the effect of board gender diversity on firm performance. This is the case no matter we use Tobin's Q or the firm's return on assets as performance measures. Second, the magnitude of the impact of women on boards on firm performance is greater at higher quantiles of the performance distribution as we predict in Hypothesis 1. Specifically, Fig. 1 demonstrates that the effect of board gender diversity on Tobin's Q is quantitative smaller at lower percentiles compared to higher percentiles. Similarly, we find that the effect of board gender diversity on ROA is also quantitative smaller at lower quantiles compared to higher ones as illustrated in Fig. 2.

5.2. Inter-quantile regression results

The findings, so far, suggest the board gender diversity effect at the 25th percentile is different, say, to the median effect. But are these differences statistically significant? Namely, we test whether the presence of women on boards at a low quantile is different from

Table 3
Firm performance and women on boards: quantile regressions.

Variables	(1) Tobin's Q Q(25)	(2) Tobin's Q Q(50)	(3) Tobin's Q Q(75)	(4) ROA Q(25)	(5) ROA Q(50)	(6) ROA Q(75)
Women on board (%)	0.124*** (0.026)	0.405*** (0.039)	0.805*** (0.092)	−0.034*** (0.007)	0.005 (0.004)	0.012*** (0.004)
Board size	0.001* (0.001)	0.000 (0.002)	−0.008** (0.004)	−0.001*** (0.000)	−0.001*** (0.000)	−0.002*** (0.000)
CEO is chair	0.008* (0.004)	−0.001 (0.006)	0.028* (0.016)	0.007*** (0.001)	0.002*** (0.001)	−0.001 (0.001)
Outsider %	−0.052*** (0.013)	−0.049** (0.022)	−0.319*** (0.062)	−0.015*** (0.004)	−0.009*** (0.002)	−0.011*** (0.003)
Female CEO	−0.073*** (0.022)	−0.067*** (0.025)	0.094 (0.075)	0.004* (0.002)	−0.003** (0.002)	−0.002 (0.002)
Log sales	−0.026*** (0.002)	−0.071*** (0.003)	−0.159*** (0.007)	0.019*** (0.000)	0.009*** (0.000)	0.006*** (0.000)
Market leverage	−0.473*** (0.009)	−0.958*** (0.014)	−1.719*** (0.030)	−0.111*** (0.003)	−0.099*** (0.001)	−0.123*** (0.001)
Firm age	−0.000*** (0.000)	−0.001*** (0.000)	−0.002*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
S&P500	0.143*** (0.008)	0.293*** (0.013)	0.507*** (0.023)	−0.016*** (0.002)	0.000 (0.001)	0.008*** (0.001)
Institution control	−0.009** (0.004)	−0.029*** (0.008)	−0.074*** (0.019)	0.006*** (0.001)	0.002*** (0.001)	0.000 (0.001)
Constant	1.293*** (0.019)	2.040*** (0.031)	3.581*** (0.068)	−0.071*** (0.004)	0.023*** (0.002)	0.087*** (0.003)
Industry effects	Yes	Yes	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,149	16,149	16,149	16,149	16,149	16,149

Notes: Tobin's Q is the sum of market equity and the book value of debt divided by total assets. It is the sum of market equity, measured as the year-end closing stock price multiplied by common shares outstanding [PRCC_F×CSHO], plus firm debt, defined as firm's assets minus common equity [AT−CEQ]; and the denominator is total firm assets [AT]. Return on assets (ROA) is calculated as net income divided by total assets [NI/AT]. Women on boards is the percentage of women on boards [DirectorsWomenPct]. Board size is measured as the total number of directors on the board [directorstotal]. CEO is chair is an indicator=1 if the CEO is also the chair of the board. Outsider % is the percentage of outsiders on the board. Female CEO is equal to one if the CEO is female, zero otherwise. Firm size is measured as the logarithm of total sales [SALE]. Market leverage is calculated as total debt divided by the sum of debt and market equity. The numerator is total debt defined as the sum of total current liabilities plus total long-term debt [DLC+DLTT]. The denominator is total debt plus market value [(DLC+DLTT)+PRCC_F×CSHO]. Firm age is the age of the firm in years. S&P500 is an indicator if the firm is a constituent of the S&P500 index. Institutional control: indicates whether or not a majority of outstanding shares are held by institutional shareholders [InstitutionalMajority]. Industry effects include: manufacturing [=1 if 2-digit SIC≥10 and 2-digit SIC≤39; =0 otherwise]; Utility [=1 if 2-digit SIC=49; =0 otherwise]; Finance [=1 if 2-digit SIC≥60 and 2-digit SIC≤69]; Delaware incorporation variable [=1 if Delaware, 0 otherwise].

* $p < 0.10$.

** $p < 0.05$.

*** $p < 0.01$.

that at a high quantile. To do this we present inter-quantile regressions. These are simply regressions of the difference-in-quantiles. The estimated variance-covariance matrix of the estimators is obtained using bootstrapping methods. Concretely, consider a quantile regression model (where for brevity we drop the time t subscript, but the panel still uses the stacked data when the models are estimated) such that the τ^{th} quantile is given by,

$$Q_{\tau}(y_i) = \alpha_{\tau} + \beta_{\tau}G_i + \gamma_{\tau,1}x_{1,i} + \dots + \gamma_{\tau,k}x_{k,i} + \epsilon_i \quad (3)$$

where, for instance, the 75th and the 50th quantiles for the Tobin's Q regression are written as:

$$\begin{aligned} Q_{0.75}(y_i) &= \alpha_{0.75} + \beta_{0.75}G_i + \gamma_{0.75,1}x_{1,i} + \dots + \gamma_{0.75,k}x_{k,i} + \epsilon_i \\ Q_{0.50}(y_i) &= \alpha_{0.50} + \beta_{0.50}G_i + \gamma_{0.50,1}x_{1,i} + \dots + \gamma_{0.50,k}x_{k,i} + \epsilon_i \end{aligned} \quad (4)$$

then the difference-in-quantiles estimate is simply,

$$\begin{aligned} Q_{0.75}(y_i) - Q_{0.5}(y_i) &= (\alpha_{0.75} - \alpha_{0.5}) + (\beta_{0.75} - \beta_{0.5})G_i \\ &\quad + (\gamma_{0.75,1} - \gamma_{0.5,1})x_{1,i} + \dots \\ &\quad + (\gamma_{0.75,k} - \gamma_{0.5,k})x_{k,i} + \epsilon_i \end{aligned} \quad (5)$$

The reported coefficients in the quantile difference-equation are exactly the difference in coefficients of two quantile regressions estimated separately. For example, the coefficient $(\beta_{0.75} - \beta_{0.5})$ is

the differential effect of G between the 75th percentile and the median. As noted, the appropriate standard errors for the difference in coefficients are obtained using bootstrapping methods.

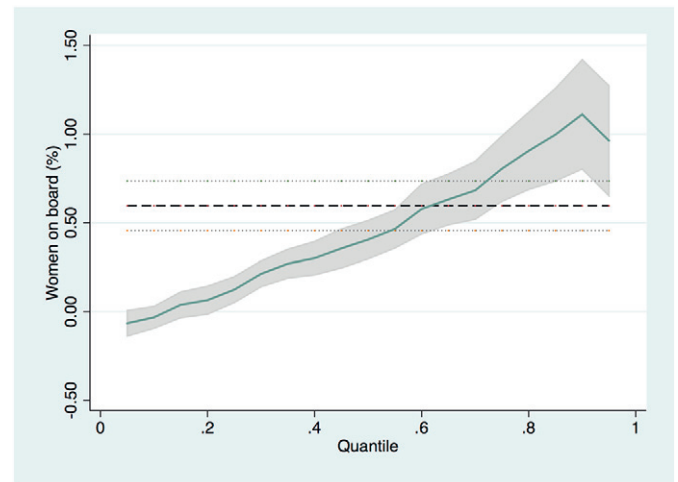


Fig. 2. Tobin's Q and board gender diversity - quantile estimates.

Notes: Y-axis is the percentage of women on boards. X-axis is quantile of firm performance measured by Tobin's Q. The horizontal dashed line is the (constant) OLS estimate. The connected line in the shaded (confidence level) region are the separate quantile regression estimates.

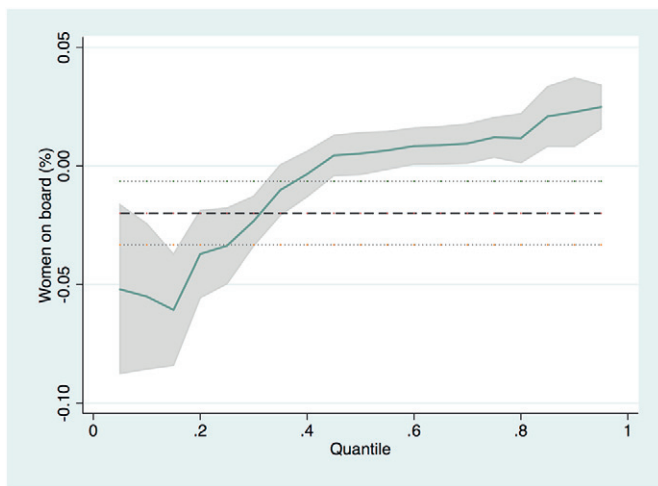


Fig. 3. Return on assets (ROA) and board gender diversity - quantile estimates.

Notes: Y-axis is the percentage of women on boards. X-axis is the quantile of firm performance measured by ROA. The horizontal dashed line is the (constant) OLS estimate. The connected line in the shaded (confidence level) region are the separate quantile regression estimates.

Table 4 shows the difference in quantile regression estimates for a range of inter-quantile regressions: $Q(50/25) = Q_{0.50}(y_i) - Q_{0.25}(y_i)$, $Q(75/50) = Q_{0.75}(y_i) - Q_{0.50}(y_i)$, and $Q(75/25) = Q_{0.75}(y_i) - Q_{0.25}(y_i)$. The estimates are shown for each covariate in the inter-quantile regression. The key variables is the inter-quantile estimate of board gender diversity on Tobin's Q (columns 1 to 3) and ROA (columns 4 to 6). In all cases the board gender diversity effect is estimated to be positive and (importantly) significant. This confirms that the presence of women on the board affects not only the conditional mean but also the dispersion of Tobin's Q and return on assets in a statistically significant way. Considering Tobin's Q, the difference between the 75th percentile and the 25th percentile ($Q(75/25)$) is 0.68 and is statistically significant. Next consider return on assets, the difference between the 75th percentile and the 25th percentile is 0.46 and again is statistically significant. In each case, women on boards have a bigger quantitative impact in conditionally high performing firms compared to conditionally low performing firms, which confirms our prediction in Hypothesis 1.

Overall, our empirical findings show that women on boards not only affect the conditional average performance of firms (Table 2) but also impact the dispersion of firm performance (Tables 3 and 4 and Figs. 1 and 2). Specifically, the effect of board gender diversity is greater in conditional high performing firms. This latter set of findings has not been demonstrated before by previous studies.

As a diagnostic sensitivity check on our main results we re-estimated the main statistical models in Tables 3 and 4 as well as Figs. 2 and 3 using instead the presence of at least one woman on the board as the primary independent variable. The (non-tabulated) results are qualitatively similar and our general conclusions remain, therefore, unchanged. For example, when firm performance is measured using Tobin's Q, the coefficient of board gender diversity measured by the female director dummy variable on firm performance is 0.055 at the 25th percentile of performance distribution and is 0.145 at the 75th percentile of performance distribution. In addition, all coefficients are statistically significant at least at the 0.05 level and our results are actually slightly better determined in terms of significance compared to our earlier findings.

5.3. Endogenous selection of women to the board of directors

Or next sensitivity test is to address the potential endogeneity of board gender diversity. The empirical results up to this point are

based on the assumption that the percentage of women on boards is exogenous (or at least pre-determined). This is also an implicit assumption made in several prior studies investigating the effect of board gender diversity on organizational outcomes. However, this maintained assumption might not be valid. Based on the exogeneity assumption we have, thus far, the effect of board gender diversity is shown to be heterogeneous. But can we also control for the endogenous selection of women to boards? The answer is 'yes'.

To allow for the endogenous determination of board gender diversity we utilize the generalized quantile regression (GQR) estimator developed by Powell (2016). The estimator explicitly allows for the estimation of treatment effects on an outcome variable of interest. The GQR estimator is developed within an instrumental variable framework and provides a way to estimate counterfactual quantiles of the outcome distribution for different values of the treatment variables. As discussed in Powell (2016), the generalized quantile regression nests quantile regression (Koenker & Gilbert, 1978) and instrumental variable quantile regression (Chernozhukov & Hansen, 2005). Our study is the first to investigate the relation between board gender diversity and firm performance using endogenous quantile regression methods.

When treating the percentage of women on boards as endogenous, an important question then becomes what is a good instrument? As is well-known, an instrument needs to satisfy two conditions: the relevance criteria and the exclusion restriction (Larcker & Rusticus, 2010). In our case the former requires an instrument to be correlated with the endogenous variable, namely the presence of women on the board. The latter requires the instrument to be uncorrelated with the performance equation error, which is a much more difficult criterion to satisfy. The first relevance criterion can be checked (e.g. by a simple regression of the endogenous variable on the proposed instrument). The latter cannot be empirically 'proven', but instead requires some articulated justification as to the reason why the instrument is independent of performance equation error terms.³ The instrument we use is the percentage of female residents in the US state where the given company has its headquarter, following the suggestion of Jurkus et al. (2011). This choice satisfies the relevance criteria, namely the instrumental variable is correlated with women on the board (the endogenous variable).⁴ There is also considerable variation in the firm's headquarter location. For example, about 15% of firms are headquartered in California, 10% in Texas, 9% in New York, and between 4% and 5% of firms are headquartered in each of Illinois, Massachusetts, Pennsylvania, Ohio, New Jersey, and Florida.

Our results are contained in Table 5, which shows the estimated relation between firm performance and the presence of women on boards where board gender diversity is treated as endogenous. Estimates for Tobin's Q are given in columns 1 to 3 and estimates for the firm's return on assets are shown in columns 4 to 6. The instrumental variable regressions confirm our previous findings. Generally, we find a positive correlation between firm performance (either Tobin's Q or ROA) and the presence of women on boards. For both Tobin's Q and ROA we find that the estimated quantitative impact of women on boards is smaller in lower quantiles compared to

³ The exogeneity restriction is satisfied, of course, if we had access to some random variable that is equally likely to be assigned to high-performing and low-performing firms. But such randomization is rare in social sciences. Instead, one needs to provide reasons why any instrument might be 'good enough'.

⁴ A simple regression of the percentage of female residents in the population in the state of the firm's headquarter and a dummy variable indicating at least one woman member on the board yielded a coefficient estimate of 0.0011 and associated *t*-statistic of 4.55. Plausibly, it also satisfies the exclusion criteria, namely the percentage of women in a US state where the firm's headquarter locates is unlikely to be correlated with the disturbance term in the organizational performance equation. The data are available from the US Census Bureau (<http://www.census.gov>).

Table 4
Firm performance and women on boards: inter-quantile regressions.

Variables	(1) Q(50/25) Tobin's Q	(2) Q(75/50) Tobin's Q	(3) Q(75/25) Tobin's Q	(4) Q(50/25) ROA	(5) Q(75/50) ROA	(6) Q(75/25) ROA
Women on board (%)	0.281*** (0.046)	0.400*** (0.100)	0.681*** (0.093)	0.039*** (0.008)	0.007* (0.004)	0.046*** (0.006)
Board size	−0.001 (0.002)	−0.009*** (0.003)	−0.010*** (0.003)	0.000 (0.000)	−0.001*** (0.000)	−0.001** (0.000)
CEO is chair	−0.009 (0.012)	0.029*** (0.011)	0.020 (0.022)	−0.005*** (0.001)	−0.003*** (0.001)	−0.008*** (0.001)
Outsider %	0.003 (0.020)	−0.270*** (0.043)	−0.267*** (0.056)	0.007* (0.004)	−0.002 (0.003)	0.005 (0.004)
Female CEO	0.006 (0.036)	0.160*** (0.060)	0.167** (0.081)	−0.007** (0.003)	0.002 (0.002)	−0.006** (0.003)
Log sales	−0.045*** (0.003)	−0.088*** (0.009)	−0.133*** (0.006)	−0.010*** (0.001)	−0.003*** (0.000)	−0.013*** (0.001)
Market leverage	−0.485*** (0.022)	−0.761*** (0.029)	−1.246*** (0.046)	0.012*** (0.003)	−0.024*** (0.001)	−0.012*** (0.003)
Firm age	−0.001*** (0.000)	−0.001*** (0.000)	−0.001*** (0.000)	−0.000*** (0.000)	−0.000*** (0.000)	−0.000*** (0.000)
S&P500	0.150*** (0.017)	0.214*** (0.029)	0.364*** (0.033)	0.016*** (0.002)	0.008*** (0.001)	0.024*** (0.002)
Institution control	−0.020** (0.008)	−0.045* (0.024)	−0.065*** (0.013)	−0.004*** (0.001)	−0.002 (0.001)	−0.006*** (0.001)
Constant	0.747*** (0.033)	1.541*** (0.070)	2.288*** (0.072)	0.094*** (0.006)	0.064*** (0.003)	0.158*** (0.005)
Observations	16,149	16,149	16,149	16,149	16,149	16,149

Notes: Tobin's Q is the sum of market equity and the book value of debt divided by total assets. It is the sum of market equity, measured as the year-end closing stock price multiplied by common shares outstanding [PRCC_F × CSHO], plus firm debt, defined as firm's assets minus common equity [AT−CEQ]; and the denominator is total firm assets [AT]. Return on assets (ROA) is calculated as net income divided by total assets [NI/AT]. Women on boards is the percentage of women on boards [DirectorsWomenPct]. Board size is measured as the total number of directors on the board [directorstotal]. CEO is chair is an indicator = 1 if the CEO is also the chair of the board. Outsider % is the percentage of outsiders on the board. Female CEO is equal to one if the CEO is female, zero otherwise. Firm size is measured as the logarithm of total sales [SALE]. Market leverage is calculated as total debt divided by the sum of debt and market equity. The numerator is total debt defined as the sum of total current liabilities plus total long-term debt [DLC + DLTT]. The denominator is total debt plus market value [(DLC + DLTT) + PRCC_F × CSHO]. Firm age is the age of the firm in years. S&P500 is an indicator if the firm is a constituent of the S&P500 index. Institutional control: indicates whether or not a majority of outstanding shares are held by institutional shareholders [InstitutionalMajority]. Industry effects include: manufacturing [= 1 if 2-digit SIC ≥ 10 and 2-digit SIC ≤ 39; = 0 otherwise]; Utility [= 1 if 2-digit SIC = 49; = 0 otherwise]; Finance [= 1 if 2-digit SIC ≥ 60 and 2-digit SIC ≤ 69]; Delaware incorporation variable [= 1 if Delaware, 0 otherwise].

* p < 0.10.

** p < 0.05.

*** p < 0.01.

higher quantiles. The coefficient estimates across the quantiles are generally significant, indicating the instrumental variable estimates are well determined. The empirical findings are in agreement with Jurkus et al. (2011). However, their study shows, in a non-quantile regression framework, that once the endogenous selection of women to the board is accounted for then the board gender diversity effect becomes much less well-determined. Our results further illustrate that the effect of board gender diversity, and the ability to isolate that effect, is heterogeneous within the instrumental variable quantile regression framework.

Finally, in non-tabulated results, we re-estimated the models in Table 5 using an alternative instrument: percentage of women who work in the given company's industry.⁵ The instrument is correlated with the endogenous variable-board gender diversity. We obtain qualitatively similar results when using this alternative instrumental variable. Namely, we are able to demonstrate a positive correlation between measures of firm performance and the percentage of women on boards, and this positive relationship is generally larger for high performing firms than low performing firms. We note, however, that the results were less precisely determined compared to the findings presented in Table 5. Naturally, future studies will experiment with other potential instruments to probe the sensitivity of our empirical findings. Overall, though, we show that there is a positive

correlation between firm performance and board gender diversity and that the board gender mix also impacts the distribution of firm performance.

6. Discussions and conclusions

In summary, this study investigates the link between firm performance and board gender diversity using quantile regression methods. We use a comprehensive longitudinal data set drawn from the constituent firms of the Russell 3000 Index from 2007 to 2014. First, we show that, in general, the presence of women on boards has a positive effect on organizational performance. Using both market-based and accounting-based measures of firm performance we are able to demonstrate that financial performance is positively correlated to measures of board gender diversity, such as the percentage of women in the boardroom. Second, we show that the effect of board gender diversity on market and accounting performance is heterogeneous across the performance distribution. More specifically, we find that female directors have a stronger quantitative impact on conditionally high performance firms compared to low performance firms. This finding is important since it challenges the underlying assumption used in prior studies of boardroom gender diversity that predicts a uniform effect of women directors on performance. Third, we use a generalized quantile regression (GQR) estimator to account for the potentially endogenous determination of gender diversity on the board of directors. Consistent with our main results, we show that the instrumental variable quantile regression also isolates a

⁵ We obtain industry gender diversity data from the Bureau of Labor Statistics (www.bls.gov/data/). We would like to thank Jean McGuire, the Associate Editor, for suggesting this second measure to us.

Table 5
Instrumental variable quantile regressions: board gender diversity effects.

Variables	(1) Tobin's Q Q(25)	(2) Tobin's Q Q(50)	(3) Tobin's Q Q(75)	(4) ROA Q(25)	(5) ROA Q(50)	(6) ROA Q(75)
Women on board (%)	0.125*** (0.003)	0.409*** (0.003)	0.807*** (0.002)	−0.033*** (0.000)	0.004*** (0.001)	0.011*** (0.001)
Board size	0.002*** (0.000)	0.001** (0.000)	−0.007*** (0.000)	−0.001*** (0.000)	−0.001*** (0.000)	−0.002*** (0.000)
CEO is chair	0.007*** (0.001)	0.001 (0.001)	0.025*** (0.001)	0.006*** (0.000)	0.002*** (0.000)	−0.001*** (0.000)
Outsider %	−0.048*** (0.002)	−0.042*** (0.003)	−0.293*** (0.005)	−0.017*** (0.001)	−0.010*** (0.000)	−0.012*** (0.000)
Female CEO	−0.077*** (0.001)	−0.072*** (0.006)	0.094*** (0.003)	0.003*** (0.000)	−0.003*** (0.000)	−0.002*** (0.000)
Log sales	−0.026*** (0.000)	−0.070*** (0.001)	−0.158*** (0.001)	0.018*** (0.000)	0.009*** (0.000)	0.006*** (0.000)
Market leverage	−0.472*** (0.002)	−0.963*** (0.003)	−1.713*** (0.003)	−0.114*** (0.000)	−0.099*** (0.000)	−0.122*** (0.000)
Firm age	−0.000*** (0.000)	−0.001*** (0.000)	−0.001*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
S&P500	0.145*** (0.001)	0.294*** (0.001)	0.499*** (0.003)	−0.012*** (0.000)	0.001*** (0.000)	0.008*** (0.000)
Institution control	−0.008*** (0.000)	−0.030*** (0.001)	−0.078*** (0.001)	0.008*** (0.000)	0.002*** (0.000)	0.001*** (0.000)
Constant	1.293*** (0.003)	2.025*** (0.003)	3.550*** (0.005)	−0.062*** (0.002)	0.028*** (0.001)	0.088*** (0.000)
Observations	16,149	16,149	16,149	16,149	16,149	16,149

Tobin's Q is the sum of market equity and the book value of debt divided by total assets. It is the sum of market equity, measured as the year-end closing stock price multiplied by common shares outstanding [$PRCC_F \times CSHO$], plus firm debt, defined as firm's assets minus common equity [$AT - CEQ$]; and the denominator is total firm assets [AT]. Return on assets (ROA) is calculated as net income divided by total assets [NI/AT]. Women on boards is the percentage of women on boards [DirectorsWomenPct]. Board size is measured as the total number of directors on the board [directorstotal]. CEO is chair is an indicator = 1 if the CEO is also the chair of the board. Outsider % is the percentage of outsiders on the board. Female CEO is equal to one if the CEO is female, zero otherwise. Firm size is measured as the logarithm of total sales [SALE]. Market leverage is calculated as total debt divided by the sum of debt and market equity. The numerator is total debt defined as the sum of total current liabilities plus total long-term debt [$DLC + DLTT$]. The denominator is total debt plus market value [$(DLC + DLTT) + PRCC_F \times CSHO$]. Firm age is the age of the firm in years. S&P500 is an indicator if the firm is a constituent of the S&P500 index. Institutional control: indicates whether or not a majority of outstanding shares are held by institutional shareholders [InstitutionalMajority]. Industry effects include: manufacturing [= 1 if 2-digit SIC ≥ 10 and 2-digit SIC ≤ 39 ; = 0 otherwise]; Utility [= 1 if 2-digit SIC = 49; = 0 otherwise]; Finance [= 1 if 2-digit SIC ≥ 60 and 2-digit SIC ≤ 69]; Delaware incorporation variable [= 1 if Delaware, 0 otherwise]. Estimation by instrumental variable quantile regression (Powell, 2016).

* $p < 0.10$.

** $p < 0.05$.

*** $p < 0.01$.

positive correlation between organizational performance and board gender diversity.

From a theoretical perspective, we predict that firm performance is an important contingency variable in the study of board gender diversity. We explain this phenomenon using two theoretical lenses, namely threat-rigidity theory and job sorting and matching theories. On the one hand, we argue that women directors' unique values are less likely to be utilized, or fully capitalized, in low performing firms due to changes in group dynamics in response to threats posed by declining performance (Staw et al., 1981). Thus, their contributions to firm performance may be smaller in low-performing firms than in high-performing firms. Our study thus provides additional empirical evidence to the influence of external threats on group decision making and organizational outcomes by investigating changes in the function and impact of boards of directors in response to inferior performance (e.g., Chattopadhyay, Glick, & Huber, 2001; Shimizu, 2007). On the other hand, we argue that heterogeneity in female director quality and the firm's capability to utilize such gender related talent may also result in a differential impact of board gender diversity on firm performance. Specifically, low-performing firms are less likely to attract highly qualified female directors and are also less effective in exploiting board members' human capital and social capital. From this viewpoint, our study also provides additional empirical support to the job sorting and matching theories by applying it to the selection and matching of boards of directors in the managerial labor market.

More importantly, our study emphasizes the merits of quantile regression in corporate governance and other management research. In contrast to the conditional mean regression model,

which minimizes the mean square error to predict only the conditional average of the outcome variable, quantile regression yields estimates from a complete range of conditional quantile functions. That is, rather than predicting only one part of the distribution of the outcome variable quantile regression allows researchers to characterize an ensemble of outcomes. More specifically, quantile regression can characterize the whole distribution of the response variable, including the tails of the distribution, say at the 10th or 90th percentile, that might be of interest in their own right. Since an ensemble of conditional quantile functions is analyzed, quantile regression provides a comprehensive account of the relationship between a random dependent variable and a set of independent variables. In this sense, it offers a more complete picture of the regression function compared to the standard conditional mean regression found in much of applied research. As Li (2015, p.72) indicates 'findings employing the conditional mean framework cannot always be generalized to the non-central locations in which the interests of management researchers sometimes reside...'. The quantile regression method thus is very important to management research, although it has rarely been used.

Our findings also help explain inconsistent results in prior board gender diversity and corporate governance studies that may originate from research design issues. Generally, board gender diversity or broader corporate governance studies assume the effect of some corporate governance attribute G (e.g., female representation on board) has a constant effect on a response variable Y (e.g., firm performance). In our case we found that the effect of women directors in low performance firms was smaller than conditionally high performance firms, while in both cases the effect was positive

(e.g. $\beta_{0.75} > \beta_{0.25} > 0$) when Tobin's Q is used as the performance measure. The average effect of board gender diversity on Tobin's Q is thus significantly positive in the OLS model. In contrast, the effect G on Y is negative at low conditional Y and positive at high conditional Y (e.g. $\beta_{0.75} > 0$; $\beta_{0.25} < 0$) when ROA is used as the performance measure. In this case, the average effect of gender diversity on ROA is significantly negative in the OLS model. In another case, the average effect might be zero when positive and negative effects at various quantiles cancel out with each other. That is, the conditional mean (i.e. average) regression conceals important quantitative effects of the independent variable on the response variable, thus prevents researchers from identifying underlying relationship between these variables. Additionally, selected sample firms in one study may concentrate on low performing quantiles that tend to generate negative or negligible performance effect, while other researchers sample from high performing firms that are more likely to produce positive performance impact. Drastically different conclusions may be drawn in these two cases, although the underlying problem is that these studies neglect the moderating role of firm performance, which can be taken care of by utilizing the quantile regression method. Again, the challenges researchers face is that conditional mean regression provides only one characterization of the general ensemble of conditional regressions. Quantile regression helps overcome this limitation.

Like all studies our research is subject to a number of limitations and caveats. First, the outcome variable we focus on is firm performance, measured using market and accounting based metrics. Board gender diversity can, of course, influence many other strategic decisions made by the firm such as corporate innovation, resource utilization, long term investment, and stakeholder relationship (e.g., Miller & del Carmen Triana, 2009; Nielsen & Huse, 2010; Triana et al., 2013). Future research could further explore additional process and outcome variables that help untangle the performance impact of boardroom diversity. For example, studying the effect of board gender diversity on the boundaries and scope of the firm brought about by mergers and acquisitions could be a fruitful research avenue. Gender diversity not only influences firm bottom line, but also generates profound social impact. We thereby would like to echo the advocate of Ferreira (2015, p.110): 'When discussing policies that promote women in business, it is better to focus on potential benefits to society that go far beyond narrow measures of firm profitability.'

Second, our study uses data from the United States. The extant literature highlights differences in board gender diversity across cultures and countries (Adams et al., 2015). For example, Campbell and Mnguez-Vera (2008)'s study on Spanish boards identify positive performance impact of female directors using the OLS mean regression approach. Using a sample of Singapore firms, Kang, Ding, and Charoenwong (2010) find that stock markets respond positively to the appointment of female directors to boards. Liu, Wei, and Xie (2014)'s study on Chinese boards likewise indicates a positive and significant relation between board gender diversity and firm performance using the pooled OLS regression and the two-stage least square method. In contrast, Ahern and Dittmar (2012) document that Norwegian firms experience declined firm performance after the introduction of the gender balance quota for corporate boards. Using mean regression methods applied to UK data, Gregory-Smith, Main, and O'Reilly (2014) do not find any empirical evidence that more gender diverse boards enhance corporate performance either. We thereby recommend future research to investigate the effects of board gender diversity in other national contexts by utilizing the quantile regression approach advocated in this paper. A multi-country comparative study may also be valuable in exploring the role of institutional contexts in affecting antecedents and outcomes of board gender diversity.

Third, our study offers potential reasons why there is heterogeneity in the relation between board gender diversity and firm

performance. Drawing upon threat-rigidity theory and job-matching theory, we offer competing predictions of the same phenomenon, i.e., the impact of women directors on board is different at various firm performance levels. Future research could further distinguish between these two lenses to investigate whether the driving force of female directors' diverse performance impact across the performance distribution is variation in director quality, changes in group dynamics, or a combined influence of both factors. Researchers could also explore other potential reasons explaining heterogeneity in the relationship between board gender diversity and firm performance. More generally, management researchers using the quantile regression approach might want to engage in theorizing as to why the average effect of an independent variable on the dependent variable is different from the predicted median effect or other quantile effects.

To sum up, our study is the first to use quantile regression methods to investigate the heterogeneous effects of boardroom gender diversity on firm performance. We demonstrate that women on boards influence not only average firm performance but also the dispersion of firm performance. From a methodological perspective, we show that the conditional mean (i.e. average) regression conceals important quantitative effects of the independent variable on the response variable. The quantile regression approach has important merits in overcoming this limitation and provides a more thorough investigation of the relationship between independent and dependent variables conditional on the distribution of the outcome variable. We hope the results contained in this paper stimulate further research in this area.

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Appendix A. A brief introduction to the quantile regression framework

This appendix briefly outlines foundations of the quantile regression method, and explains the differences between it and classical ordinary least squares (OLS) methods. In the context of our paper the issue is the statistical association between firm performance (the outcome variable) and board gender diversity (the input variable). A more complete discussion of quantile regression methods can be found in Koenker and Gilbert (1978) and Koenker and Hallock (2001).

Quantile regression was introduced by Koenker and Gilbert (1978). Consider the real valued random variable Y that is characterized by the following distribution function,

$$F(y) = \Pr(Y \leq y) \quad (6)$$

then for any quantile τ , such that $0 < \tau < 1$ the τ -th quantile of Y is defined as:

$$Q(\tau) = \inf \{y : F(y) \geq \tau\} \quad (7)$$

The first decile is described as $Q(0.10)$, the ninetieth as $Q(0.90)$ and the median is $Q(0.50)$. The quantile function described above gives a complete characterization of the random variable Y . These quantiles can be characterized as a solution to an optimization problem. For $0 < \tau < 1$ the piecewise linear asymmetric loss or 'check' function is defined as:

$$\rho_{\tau}(u) = u(\tau - I(u < 0)) \quad (8)$$

where I is an indicator function and the ρ function. Minimizing the mathematical expectation of Y with respect to ξ yields the solution $\hat{\xi}(\tau)$ which is the minimum of $Q(\tau)$ above.

$$\hat{\xi}(\tau) = \arg \min_{\xi \in \mathbb{R}} E[\rho_{\tau}(Y - \xi)] \quad (9)$$

The sample analogue of the population $Q(\tau)$ is based on a random sample $\{y_1, \dots, y_n\}$ of Y 's and solves the minimand:

$$\arg \min_{\xi \in \mathbb{R}} \sum_{i=1}^n \rho_{\tau}(Y_i - \xi) \quad (10)$$

Couching the problem as a minimization program, as opposed to enumerating the order statistics, has the advantage that a comparison to the standard regression model context can be made. In the classical case, an optimal estimate of the unconditional mean can be derived as⁶:

$$\hat{\mu} = \arg \min_{\mu \in \mathbb{R}} \sum_{i=1}^n (Y_i - \mu)^2 \quad (11)$$

By extension the conditional mean function $E(Y|X = x) = m(x) = X_i\beta$ can be substituted for μ . This specifies the classical linear regression model. The optimal least squares estimator⁷ - as is known - minimizes the mean square error:

$$\hat{\beta} = \arg \min_{\beta \in \mathbb{R}} \sum_{i=1}^n (Y_i - X_i\beta)^2 \quad (12)$$

In a similar way the linear conditional quantile function, $Q_{\tau}(\tau|X = x) = X_i\beta(\tau)$, can be estimated by solving the minimand:

$$\hat{\beta}(\tau) = \arg \min_{\beta \in \mathbb{R}} \sum_{i=1}^n \rho_{\tau}(Y_i - X_i\beta) \quad (13)$$

where the term ρ is the loss function defined earlier $\rho_{\tau}(u)$. A useful model is the median regression. In this case setting $\tau = 0.5$ is equivalent to minimizing the sum of absolute values of the residuals. The minimization problem when couched as a linear function of parameters, can be solved by linear programming methods developed by Koenker and Hallock (2001). The important point is that a class of estimators can be found, one for each desired quantile. Accordingly, the conditional distribution of the outcome variable can be characterized showing the effect of each input variable on the outcome measure at the given quantile. This is different from the single estimate produced by the classical least squares estimator that gives the predicted conditional mean (average) outcome.

A.1. Interpretation

As noted, the conditional mean regression model predicts the average value of the outcome variable conditional on the independent variables. Namely, it is the mean of Y conditional on the covariates X . A feature of the mean regression is that only one single estimate is derived to summarize the (average) relationship between the outcome variable and the model covariates. The estimates of the correlation between the dependent variable and the model covariates are assumed constant at all parts of the conditional distribution. Two issues arise. First, the homogeneity assumption might not be valid and this restriction needs to be tested. Second, the investigator might be interested in outcomes other than the conditional mean.

In contrast, the quantile regression approach yields an estimator that predicts the conditional quantile of Y based on the set of covariates X . There are many quantile values one can choose for τ . For example, when the quantile is 50% (i.e. the median) then $\tau = 0.5$ and $= Q_{0.5}(Y_i|X_i)$ describes the median of outcome of the response variable Y_i (e.g. firm performance) conditional on X_i (e.g. corporate governance, firm level variables). So, in this case the median regression predicts the median outcome, conditional on X_i . This contrasts to the OLS case where the estimator predicts the average outcome, conditional on X_i . This approach is easily extended. When the quantile is set at, say, $\tau = 0.25$, then $Q_{0.25}(Y_i|X_i)$ predicts the 25th percentile of Y_i conditional on model covariates X_i . And when the quantile is $\tau = 0.75$, $Q_{0.75}(Y_i|X_i)$ predicts the 75th percentile of Y_i conditional on X_i . In principle, the range of quantiles $0 < \tau < 1$ can be chosen.

Importantly, quantile regression allows for a range of different estimates to be derived that describe the conditional distribution of the outcome variable. Unlike the conditional mean regression (such as OLS), the quantile regression does not require the assumption that the effect of covariate X is constant. In fact, quantile regression can be used to show those contexts when the conditional distribution is not homogenous. If the resulting estimates at different quantiles are significantly different from one another, the conditional distribution is shown not to be homogenous, contrary to what is assumed in classical least squares regression.

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⁶ See, for example, the exposition in Greene (2012).

⁷ Which assumes the Gauss-Markov axioms are satisfied, and importantly $E(\epsilon|X) = 0$.

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