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CEO network centrality and bond ratings

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ABSTRACT

This study examines the impact of Chief Executive Officer (CEO) network centrality on bond ratings at the firm level. Using multiple dimensions of social connectedness, we find a significant positive relation between CEO network centrality and bond ratings, suggesting that firms with better connected CEOs are more likely to receive high bond ratings. Our results still hold after a battery of additional tests. We also find that firms with better connected CEOs experience lower cost of debt. Overall, our study supports the notion in social science research that well-connected individuals can bring benefits to their firms.

1. Introduction

The sequential rank order tournament theory (i.e., Lazear & Rosen, 1981; Knoeber, 1989; Becker & Huselid, 1992; Knoeber & Thurman, 1994; Lazear, 1999; Connelly, Tihanyi, Crook, & Gangloff, 2014) states that an organization's hierarchy is modeled as a multiple-stage and winner-take-all tournament and the Chief Executive Officer (CEO) is the ultimate winner, suggesting that the CEO is the best performer and perhaps the most influential individual in the organization. Given the importance of a CEO, recent years have witnessed a rapidly increasing interest in whether and how CEO characteristics and performance contribute to firm performance and other outcomes. In particular, CEO network centrality, an important CEO characteristic, has received tremendous attention in recent accounting and finance literature. The purpose of our study is to investigate the impact of CEO network centrality on bond credit ratings at the firm level.

CEO network centrality refers to the degree of centrality of a CEO's position in a social network hierarchy. A high centrality CEO is regarded as a socially well-connected CEO. Recent research has focused on the impact of having high centrality CEOs on various firm-level outcomes, and it is still not clear whether having such CEOs can lead to positive outcomes. Some studies argue that high centrality CEOs can have better access to valuable and even private information, relative to low centrality CEOs. This information advantage may lead to positive outcomes for firms with well-connected CEOs. Furthermore, Tsai and Ghoshal (1998) argue that social capital, largely derived from social ties in a network, can improve a firm's ability to create value, suggesting a positive relation between social ties and firm performance. For example, it is documented that firms with well-connected CEOs or other executives enjoy better loan treatment from their banks (Engelberg, Gao, & Parsons, 2012), receive favorable treatment from the government (Bertrand, Kramarz, Schoar, & Thesmar, 2005), demonstrate superior operating performance and experience high stock returns (Larcker, So, & Wang, 2013), and have a lower likelihood of engaging in questionable or unethical accounting practices (Omer, Shelley, & Tice, 2016). However, other studies argue that high centrality CEOs can weaken an effective corporate governance mechanism, adopt questionable or unethical corporate practices, and abuse their social influence and power, leading to negative outcomes. For instance, Fracassi and Tate (2012) find that high centrality CEOs lead to more value-decreasing acquisitions. Chidambaran, Kedia, and Prabhala (2012) suggest that high centrality CEOs may increase the likelihood of corporate fraud. Prior research (e.g., Chiu, Teoh, & Tian, 2012; Brown & Drake, 2014; Cai, Dhaliwal, Kim, & Pan, 2014) find that high centrality CEOs are more likely to adopt questionable accounting practices such as aggressive earnings management and tax avoidance activities.

Despite the surge of attention on the impact of having high centrality CEOs, there is little empirical research on whether and how CEOs' centrality influences a firm's bond ratings, a key determinant of a firm's overall credit worthiness. Extant studies find that bond ratings convey significant information to investors (Dichev & Piotroski, 2001), and bond ratings are determined by a firm's operating performance and overall financial conditions (Pogue & Soldofsky, 1969) and other firm characteristics such as corporate governance (Ashbaugh-Skaife, Collins,

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& LaFond, 2006). In this study, we posit a positive relation between CEO network centrality and bond credit ratings because prior literature links high centrality CEOs to better firm performance and value, a (positive) key determinant of bond ratings.[1]

Using a sample of 5857 firm-year observations based on 716 unique U.S. firms from 2004 to 2014, we find a significant positive relation between CEO network centrality[2] and bond ratings, suggesting that firms with high centrality CEOs receive high bond ratings. Our results support the information advantage view of network centrality and also the notion in Tsai and Ghoshal (1998) that more social capital leads to more positive outcomes. We conduct a battery of additional tests to mitigate concerns about possible endogeneity issues and the robustness of our primary findings. First, we perform a changes analysis to investigate whether an increase (a decrease) can lead to an increase (a decrease) in bond ratings. Second, we use lagged CEO network centrality measures (i.e., in year t-1). Third, we perform a firm fixed effect regression and a two-stage OLS regression. Lastly, we repeat our main analysis using alternative measures of bond rating and CEO network centrality and alternative samples. We obtain consistent results in these additional tests, lending support to our primary findings that link high CEO centrality to high bond ratings.

Our study makes several important contributions. First, our study contributes to a rapidly growing literature in accounting and finance using social network theory (i.e., graph theory) to better understand the information flows and social ties in a social network hierarchy. Second, we join the debate on whether having well-connected executives is beneficial or detrimental to an organization. Our findings suggest that it is beneficial to have high-centrality CEOs. Our results are also in line with the notion in Tsai and Ghoshal (1998) that social capital can lead to positive outcomes. More importantly, we strengthen the validity of Tsai and Ghoshal (1998) by providing empirical evidence. Third, a large body of prior literature (e.g., Palmer, Friedland, & Singh, 1986; Haunschild, 1993; Gulati & Westphal, 1999; Chiu et al., 2012; Brown & Drake, 2014; Cai et al., 2014) only focuses on one single connectedness dimension (degree centrality or interlock) and ignores other dimensions of social connectedness. We extend these previous studies by using more social connectedness dimensions. Thus, our study should lead to a more comprehensive understanding of the concept of social connectedness. Next, our study obviously contributes to bond rating studies. Although we do not attempt to construct a prediction model of firm-level bond ratings, our study can inform various stakeholders of the impact of socially well-connected CEOs on bond ratings. Lastly, our findings should be of interest to investors, managers, and academics who are interested in the impact of being socially connected on various firm-level outcomes. In particular, our findings may encourage managers to become more socially connected. Our study should also interest bond credit ratings agencies when they design and implement guideline on the determinants of bond ratings.

The remainder of the paper is organized as follows. Section 2 reviews related literature and develops our hypothesis. Section 3 presents research design. Section 4 reports the primary findings, and Section 5 presents the results of additional tests. Section 6 concludes the study.

2. Literature review and hypothesis development

2.1. CEO network centrality

Based on the graph theory (e.g., Proctor & Loomis, 1951; Sabidussi, 1966; and many others), a network is established by a set of units (nodes) and the links (relationships) between them. The units are usually not equal, thus creating a network hierarchy in social relationships. The links in a social network are regarded as channels by which information and knowledge are exchanged, existing relationships are reinforced, and new relationships are developed. Prior research argues that individuals, who reside higher in the social network hierarchy (i.e., better connected individuals), can better gather and process important information, and gain access to private information in a less costly way, leading to positive outcomes. For example, Engelberg et al. (2012) find that firms, where senior executives (i.e., CEO) have informal relationships with executives in their banks, receive loans with lower interest rates and less restrictive covenants. Using French companies, Bertrand et al. (2005) find that CEOs with personal relationships with governmental officials receive additional benefits (e.g., favorable tax treatment). Cohen, Frazzine, and Malloy (2010) find that sell-side analysts make more-accurate stock recommendations when these analysts are socially connected with senior managers and/or board members of the firms that they cover. Larcker et al. (2013) find that firms with better connected board members (i.e., CEO) earn higher future stock returns and show better operating performance. Omer et al. (2016) find that firms with better connected board members are less likely to engage in questionable accounting practices. El-Khatib, Jandik, and Jandik (2017) find that well-connected CEOs are associated with positive abnormal returns (more personal gains) when these CEOs purchase (sell) their company's stocks. From the social capital perspective, Tsai and Ghoshal (1998) find that a high level of social relationships (ties) results in more social capital, which brings more benefits and positive outcomes to firms.

On the other hand, prior research argues that well-connected individuals including managers and board members may lead to negative consequences such as interfering with and weakening an effective corporate governance mechanism, sharing and adopting questionable accounting practices, and abusing their social influence and power. For example, Hwang and Kim (2009) find that CEOs that are socially connected to board members have higher compensation, lower pay-performance sensitivity, and lower turnover ratio, relative to CEOs that are not socially connected to board members. Fracassi and Tate (2012) find that firms with more CEO-director relationships lead to more value-decreasing acquisitions, suggesting that these well-connected CEOs weaken the mechanism of board monitoring and internal control. Similarly, El-Khatib, Fogel, and Jandik (2015) find that well-connected CEOs are associated with higher frequency of acquisitions and more value-decreasing acquisitions, suggesting that these CEOs abuse their social influence and power to push for deal completion. Chidambaran et al. (2012) find that well-connected CEOs may increase the likelihood of corporate fraud. Some studies (e.g., Brown & Drake, 2014; Cai et al., 2014; Chiu et al., 2012) suggest that social network facilitates the spreading of questionable or unethical accounting practices such as aggressive earnings management and tax avoidance activities, and firms with these well-connected board members are more likely to adopt or mimic those accounting practices.

[1] It is possible that a negative relation may exist between CEO network centrality and bond ratings because prior research suggests that high-centrality CEOs weaken corporate governance, a (negative) key determinant of bond ratings.

[2] Consistent with prior research (e.g., Larcker et al., 2013; Omer et al., 2016), we use five commonly-used network centrality measures (namely, degree centrality, eigenvector centrality, closeness centrality, betweenness centrality, and composite centrality) to capture the level of CEO network centrality. Degree centrality captures the number of a CEO's direct ties and is calculated as the number of direct links between a CEO and other directors (i.e., interlocks). Eigenvector centrality captures whether a CEO is well-connected and is calculated as the degree to which a CEO is related to other well-connected directors. Closeness centrality captures how closely a CEO is related to other directors and is calculated as the number of steps in the shortest path between a CEO and other directors. Betweenness centrality captures the importance of a CEO in a social network and is calculated as the number of ties a CEO lies in the path between a pair of other directors. The last measure, composite centrality, is an aggregated measure (based on the four individual network measures), which is calculated by using a principal component analysis. Using the above five network measures offers several advantages. First, these measures are objective, not based on survey or opinions, and can be easily calculated. Second, it allows us to investigate a diverse and large sample of firms. Third, it allows us to capture not only each unique dimension of network centrality, but also the overall syntactic centrality of a firm's CEO in a social network hierarchy.

2.2. Bond rating

Prior research on bond ratings can be classified into two categories. The first category investigates the market reactions to bond ratings. For example, Pinches and Singleton (1978) find abnormal (monthly) stock returns prior to a bond rating change. Similarly, Hand, Holthausen, and Leftwich (1992) document negative (positive) excess stock and bond returns when the rating agency announce downgrade (upgrade). Goh and Ederington (1993) and Choy, Gray, and Ragunathan (2006) suggest that the market only reacts to bond rating downgrade that are caused by poor firm operating performance. Jorion, Liu, and Shi (2005) find that the market reacts to downgrades (both downgrades and upgrades) before (after) the introduction of SEC's Fair Disclosure Regulation.

The second category investigates the determinants of bond ratings. Since the early studies (i.e., Pogue & Soldofsky, 1969), it appears that a firm's operating performance and financial conditions affect its bond rating (e.g., Blume, Lim, & MacKinlay, 1998; Ederington, 1985; Ederington, Yawitz, & Roberts, 1987). Bhojraj and Sengupta (2003) find that firms with stronger corporate governance (i.e., greater institutional ownership) receive higher bond ratings. Similarly, Ashbaugh-Skaife et al. (2006) also find that many corporate governance attributes influence bond credit ratings, suggesting that corporate governance plays an important role in determining bond ratings.

2.3. Hypothesis development

Based on prior research, high centrality CEOs (i.e., well-connected CEOs) can possess many advantages in the social network, relative to low centrality CEOs (less-connected CEOs). Specifically, high-centrality CEOs can have better access to valuable and even private information about their firms and peer firms. This valuable information can help these CEOs make better decisions, leading to high shareholder value and superior firm performance. Prior research (e.g., Larcker et al., 2013) documents a positive association between CEO network centrality and firm value and performance, an important factor in determining bond credit ratings. In addition, using survey data, Tsai and Ghoshal (1998) suggest that a firm's social capital, which is largely derived from social relationships (ties) in a social network, can increase the firm's ability to create value. On the other hand, high centrality CEOs have high reputation cost and thus are less likely to engage in fraudulent activities or default their debt (Burt, 1997). Taken together, if high centrality CEOs can have a positive impact on their firms' performance, we expect that these firms with well-connected CEOs receive high bond ratings from rating agencies. Therefore, we propose the following hypothesis.[3]

H1. CEO network centrality is positively related to bond ratings.

3. Research design

3.1. Measurement of bond ratings

Three major bond credit rating agencies exist in the U.S. including Standard and Poor's (S&P), Fitch, and Moody's Investing Service. Following prior research (e.g., Attig, Ghoul, Guedhami, & Suh, 2013; Liu & Jiraporn, 2010), we use S&P ratings in this study for the following two reasons. First, S&P's bond credit rating data is publicly available in Compustat database and has been used extensively in accounting and finance literature. Second, prior research (i.e., Beaver, Shakespeare, & Soliman, 2006) compare the ratings from the above three major agencies and find that these ratings are fairly similar and consistent, suggesting that relying on one bond rating agency is sufficient.

S&P rates bonds from AAA to D. Each letter is known as a 'class'. S&P also assigns modifiers (e.g., BBB +, BBB −) for the AA to CCC classes. Following Klock, Mansi, and Maxwell (2005) and Liu and Jiraporn (2010), we compute bond ratings using a conversion process in which AAA-rated bonds are assigned a value of 22 and D-rated bonds a value of 1. For example, a firm with a BBB + (CCC-) rating from S&P would receive a score of 15 (4). Please refer to Appendix 2 for the bond rating conversion process.

3.2. Measurement of CEO network centrality

Following recent accounting and finance literature (e.g., Larcker et al., 2013; Omer et al., 2016), we use the five commonly-used social network centrality measures, namely degree centrality, eigenvector centrality, closeness centrality, betweenness centrality, and composite centrality to capture unique connectedness dimensions characterized by individuals' locations in a social network. Wasserman and Faust (1994) suggest that social network studies should not just focus on any single centrality measure because each measure has its unique utility. Hence, consistent with recent research, we use all five centrality measures in this study.

Degree centrality (DEGREE) is defined as the number of direct links a CEO has with other board members in the network. Better connected CEOs should have more direct links to other directors. In other words, the more direct links or connections a CEO has, the more central this CEO is in the social network. If x_{ij} denotes an indicator that CEO_i and other $director_j$ is linked through interlock employment, for a given CEO_i in the network, the formula to compute DEGREE is listed below:

$$DEGREE_i = \sum_{j \neq i} x_{ij} \tag{1}$$

Eigenvector centrality (EIGENVECTOR) is defined as the extent to which a CEO is linked with other highly connected board directors. A high (low) eigenvector value suggests that the CEO is related to better-connected (less-connected) directors. Assume G is an adjacency matrix. $g_{ij} = 1$ if CEO i and director j are directly linked. λ is the proportionality factor, representing the largest eigenvalue of the adjacency matrix G.

$$CENTRALITY_i = \frac{1}{\lambda} \sum_j g_{ij} \bullet CENTRALITY_j \tag{2}$$

EIGENVECTOR is solved by satisfying the following equation. The elements of *EIGENVECTOR* are individual director's Eigenvector centrality.

$$\lambda \bullet EIGENVECTOR = G \bullet EIGENVECTOR \tag{3}$$

Closeness centrality (CLOSENESS) measures how easily or quickly a CEO can reach other directors in the social network. This measure is defined as the inverse of the average distance between a CEO and any other board members. Let d_{ij} denotes the number of steps in the shortest path between CEO_i and $director_i$. n is the total number of directors in the connected group. The formula to compute CLOSENESS is listed below:

$$CLOSENESS_i = \frac{n-1}{\sum_{i \neq j} d_{ij}} \tag{4}$$

Betweenness centrality (BETWEENNESS) measures how often a CEO lies on the shortest paths between other nonadjacent directors in the network. This measure reflects how much control a CEO can have on the information flow in the social network. A CEO's betweenness

[3] On the other hand, high centrality CEOs may also have some disadvantages to their firms. Specifically, information (received by these high centrality CEOs) may include knowledge and ideas about questionable or unethical corporate practices such as earnings management and tax avoidance, leading to possible fraud. More importantly, high centrality CEOs may abuse their social influence and power, leading to CEO entrenchment and more agency problems. Opportunistic managerial behaviors are priced negatively by the markets (Boubakri & Ghouma, 2014). This line of research documents that high-centrality CEOs weaken corporate governance and internal control. Together, we can also expect a negative relation between CEO network centrality and bond ratings because prior research (e.g., Ashbaugh-Skaife et al., 2006) links weakened corporate governance to lower bond ratings.

centrality is calculated as the average proportion of shortest paths between every pair of directors in the network that a CEO lies on. Let θ_{yz} denotes the total number of shortest paths between director y and director z. $\theta_{yz}{}^{i}$ denotes the number of shortest paths between director y and director z that pass through CEOi. The formula to compute BETWEENNESS is listed below:

$$BETWEENNESS_i = \frac{2}{(n-1)(n-2)} \sum \frac{\theta_{yz}^{CEOi}}{\theta_{yz}} \quad (5)$$

In addition to the above four centrality measures, we follow recent studies (e.g., Omer et al., 2016) and use principal component analysis to construct a composite score (COMPOSITE), which is a linear combination of the four centrality measures. We do not simply average the four measures because the appropriate weights of each measure is unknown and each measure differs substantially by magnitude. In sum, we use five centrality measures, namely DEGREE, EIGENVECTOR, CLOSENESS, BETWEENNESS, and COMPOSITE.

3.3. Empirical specification

We use the following equation to investigate the influence of CEO network centrality on bond ratings.

$$\begin{aligned} BRi, t = {} & \beta 0 + \beta 1CENTRALITYi, t + \beta 2SIZEi, t + \beta 3LEVi, t \\ & + \beta 4MTBi, t + \beta 5ROAi, t + \beta 6OCFi, t + \beta 7LOSSi, t \\ & + \beta 8ZSCOREi, t + \beta 9MARANKi, t + \beta 10BVOLi, t \\ & + \beta 11CGOVi, t + \beta 12CSRi, t + \beta 13AGEi, t \\ & + \beta 14CEOPOWERi, t + \text{Industry Indicators} + \text{Year Indicators} \\ & + \varepsilon i, t \end{aligned} \quad (6)$$

The dependent variable, BR, measures the level of bond ratings. The highest (lowest) value of BR is 22 (1), representing a rating of AAA (D). The primary independent variable of interest, CENTRALITY, alternatively represents one of the five measures of CEO network centrality. To test our hypothesis (H1), we analyze the coefficient on CENTRALITY. If high-centrality CEOs can have a significant and positive impact on bond ratings, we expect a significant positive coefficient on CENTRALITY.

In addition to the above variables of interest, we control for factors that may be associated with bond ratings. Specifically, we control for commonly-used firm performance variables including total assets (SIZE), leverage ratio (LEV), firm growth (MTB), and return on assets (ROA). We also control for operating cash flows (OCF) and whether a firm reports a net loss (LOSS) because the above variables may negatively impact a firm's operating performance and its ability to make interest payments on their loans. Moreover, prior research (i.e., Pogue & Soldofsky, 1969) suggests that bond ratings largely rely on a firm's operating performance and overall financial conditions. Thus, we use Altman's *Z*-Score (ZSCORE) to control for a firm's overall financial conditions.

We also control for managerial ability (MARANK) because prior research (e.g., Bonsall, Holzman, & Miller, 2016) finds that high ability managers lead to high bond ratings. Ghosh and Olsen (2009) suggest that business volatility may affect a firm's financial performance and managerial behavior. Thus, we control for business volatility (BVOL). Attig et al. (2013) find that corporate social responsibility performance has a positive impact on a firm's bond rating. Hence, we control for corporate social responsibility (CSR). Consistent with Ashbaugh-Skaife et al. (2006), we control for corporate governance (CGOV).[4] We also control for the age of firms (AGE) in the Compustat database. Lastly, consistent with Liu and Jiraporn (2010), we control for CEO power (CEOPOWER) in our model.

[4] Data on CSR and CGOV are obtained from *Msc*I's ESG database.

Following prior studies on bond ratings (e.g., Ashbaugh-Skaife et al., 2006; Liu & Jiraporn, 2010), we use ordered probit regression as our primary regression. We include the year and industry dummy variables and winsorize continuous variables at the 1% and 99% levels in the regression analysis. In addition to the main analysis, we also perform a test on the relation between bond yield (YIELD) and CEO network centrality. All variables are defined in Appendix 1.

3.4. Sample selection and descriptive statistics

We begin with our sample selection process by downloading data on directors from the BoardEx database, which collects and consolidates data on directors and senior managers of public companies from various sources. For each director covered, BoardEx reports the director's educational background, past and current employment, and other relevant information. Using data from BoardEx from 2004 to 2014, we construct an annual board social network for each year and calculate directors' network centrality measures. Because our study focuses on the CEO's network centrality, we obtain CEO data from ExecuComp and match it to the above dataset. The initial sample from the interaction of BoardEX and ExecuComp consists of 20,257 observations from 2004 to 2014. Next, we delete 7334 observations with missing data on corporate social responsibility and governance performance when we merge the initial dataset with the dataset from *Msc*I's Environmental, Social and Governance (ESG) database. We then remove 2108 observations with missing managerial data.[5] We delete another 4958 observations with missing data on S&P bond ratings and control variables from the Compustat database. The final sample with complete data consists of 5857 firm-year observations from 2004 to 2014, representing 716 unique U.S. firms. Please refer to Panel A of Table 1 for the detailed sample selection process.

Panel B of Table 1 shows the sample distribution of firm-year observations and firms by fiscal year. For example, there are 443 (638) observations and 378 (28) firms in 2004 (2014). Overall, there is an upward trend in the number of observations from 2004 to 2014. Panel C of Table 1 presents the sample distribution of firm-year observations and firms by industry (based on the first two digits of the SIC code). For instance, there are 548 observations and 70 unique firms in the Chemical industry and 359 observations and 58 unique firms in the Business Service industry. Many observations concentrate in the following industries: Oil and Gas Extraction (SIC 13), Chemicals (SIC 28), Industrial Machinery (SIC 35), and Business Services (SIC 73).

Table 2 displays the sample summary statistics. The mean and median values of BR is 12.922 and 13.000, respectively. The mean values of DEGREE, EIGENVECTOR, CLOSENESS, BETWEENNESS, and COMPOSITE are 14.301, 0.000, 0.118, 0.000, and 0.944, respectively. Because the values of EIGENVECTOR and BETWEENNESS are small, we present the percentile ranks of the five centrality measures in Table 2. The mean values of DEGREE_RANK, EIGENVECTOR_RANK, CLOSENESS_RANK, BETWEENNESS_RANK, and COMPOSITE_RANK are 69.048, 61.372, 78.289, 63.813, and 74.283, respectively. Overall, the descriptive statistics of CEO centrality measures are in line with recent research. The mean and median values of SIZE are 8.613 and 8.537, respectively. The mean value of ZSCORE is 3.081, indicating that, on average, our sample firms are financially healthy. The mean (median) values of ROA is 0.054 (0.056), suggesting that our sample firms demonstrate normal operating performance.

Table 3 reports the Pearson and Spearman correlations between the selected variables. Specifically, Table 3 reports the correlation coefficient value and (two-tailed) p-value for each pair of variables. Both correlations show that bond ratings (BR) is positively associated with

[5] http://faculty.washington.edu/pdemerj/data.html
The initial managerial ability dataset excludes firms in the financial industry (SIC: 6000–6999).

Table 1
Sample distribution.

Panel A: sample selection process

	Observations
Total observations with complete CEO network centrality measures from the interaction of BoardEx and ExecuComp from 2004 to 2014	20,257
Less observations	
with corporate social responsibility and governance data not available on *Msc*I's ESG database	(7334)
with managerial ability data not available	(2108)
with insufficient data from Compustat to calculate bond ratings and control variables	(4958)
Final Sample	5857

Panel B: sample distribution by year

Year	Number of observations	Percent	Number of unique firms	Percent
2004	443	7.56%	378	52.79%
2005	445	7.60%	38	5.31%
2006	492	8.40%	55	7.68%
2007	534	9.12%	50	6.98%
2008	510	8.71%	23	3.21%
2009	526	8.98%	23	3.21%
2010	515	8.79%	27	3.77%
2011	559	9.54%	39	5.45%
2012	567	9.68%	35	4.89%
2013	628	10.72%	20	2.79%
2014	638	10.89%	28	3.91%
	5857	100.00%	716	100.00%

This panel presents sample distribution by year. The full sample (5857 firm-year observations) includes 716 unique firms from 2004 to 2014.

Panel C: sample distribution by industry

2 SIC	Description	Obs.	Firms	2 SIC	Description	Obs.	Firms
01	Agricultural Crops	34	3	40	Railroad	71	5
07	Agricultural Services	9	1	41	Local/Suburban Transit	5	1
10	Metal Mining	53	6	42	Motor Freight	72	4
12	Coal Mining	1	1	44	Water Transportation	56	7
13	Oil & Gas Extraction	414	50	45	Air Transportation	108	11
14	Mining	30	3	47	Transportation Services	9	1
16	Heavy Construction	36	4	48	Communications	248	31
17	Special Construction	15	2	50	Wholesale Durable	203	18
20	Food	232	34	51	Wholesale Nondurable	95	11
21	Tobacco	29	4	52	Building Materials	20	2
22	Textile	25	5	53	General Stores	99	13
23	Apparel	70	10	54	Food Stores	37	6
24	Lumber	31	4	55	Automotive Service	89	5
25	Furniture	49	6	56	Apparel Stores	88	12
26	Paper	197	20	57	Furniture Stores	35	5
27	Printing	61	6	58	Eating & Drinking	108	12
28	Chemicals	548	70	59	Miscellaneous Retail	117	13
29	Petroleum	121	10	70	Hotels	24	3
30	Rubber	49	7	72	Personal Services	43	4
31	Leather	8	2	73	Business Services	359	58
32	Stone Clay Glass	47	5	75	Auto Repair	25	2
33	Primary Metal	158	19	78	Motion Pictures	3	1
34	Fabricated Metal	113	12	79	Amusement	73	8
35	Industrial Machinery	449	58	80	Health Services	127	18
36	Electronic Equipment	354	45	82	Educational Services	4	1
37	Transportation Equipment	191	23	83	Social Services	3	1
38	Measuring Instruments	293	38	87	Engineering & Accounting	69	9
39	Other Manufacturing	50	6		Total	5857	716

This panel presents sample distribution by industry, based on the first two digits of the Standard Industrial Classification (SIC) code. The full sample (5857 firm-year observations) includes 716 unique firms from 2004 to 2014.

Table 2
Sample descriptive statistics.

Variable	N	Mean	Std Dev	25th Pctl	Median	75th Pctl
BR	5857	12.922	2.930	11.000	13.000	15.000
DEGREE	5857	14.301	7.552	8.000	12.000	19.000
DEGREE_RANK	5857	69.048	24.405	49.000	73.000	91.000
EIGENVECTOR	5857	0.000	0.000	0.000	0.000	0.000
EIGENVECTOR_RANK	5857	61.372	22.475	47.000	47.000	92.000
CLOSENESS	5857	0.118	0.031	0.113	0.125	0.134
CLOSENESS_RANK	5857	78.289	21.480	69.000	86.000	95.000
BETWEENNESS	5857	0.000	0.000	0.000	0.000	0.000
BETWEENNESS_RANK	5857	63.813	25.353	41.000	42.000	91.000
COMPOSITE	5857	0.944	1.390	− 0.022	0.343	1.722
COMPOSITE_RANK	5857	74.283	21.035	63.000	78.000	91.000
SIZE	5857	8.613	1.185	7.709	8.537	9.387
LEV	5857	0.249	0.144	0.147	0.228	0.325
MTB	5857	3.066	2.741	1.528	2.410	3.735
ROA	5857	0.054	0.059	0.027	0.056	0.087
OCF	5857	0.107	0.057	0.068	0.103	0.141
LOSS	5857	0.123	0.328	0.000	0.000	0.000
ZSCORE	5857	3.081	1.691	1.899	2.872	4.020
MARANK	5857	0.545	0.308	0.300	0.500	0.800
BVOL	5857	0.617	0.414	0.314	0.508	0.796
CGOV	5857	− 0.375	0.761	− 1.000	0.000	0.000
CSR	5857	0.686	2.963	− 1.000	0.000	2.000
AGE	5857	3.173	0.388	2.944	3.296	3.466
CEOPOWER	5857	0.585	0.493	0.000	1.000	1.000
YIELD	1148	1.443	1.427	0.602	1.305	1.860

This table presents the descriptive statistics of the sample variables. Specifically, this table reports the number of observations, pooled means, standard deviations, 25th percentile, median, and 75th percentile of the dependent variable, independent variables of interest, and control variables. The sample consists of 5857 firm-year observations from 2004 to 2014, representing 716 individual firms. All continuous variables are winsorized at 1% and 99% percentiles. Refer to Appendix 1 for variable definition.

the five CEO centrality measures (DEGREE, EIGENVECTOR, CLOSENESS, BETWEENNESS, and COMPOSITE) at a significant level. For example, the Pearson matrix shows that the correlation coefficient between BR and DEGREE (EIGENVECTOR) is 0.228 (0.079) with a p-value of < 0.0001. The correlation coefficient between BR and CLOSENESS (BETWEENNESS) is 0.214 (0.107) with a p-value of < 0.0001. The correlation coefficient between BR and COMPOSITE is 0.195 with a p-value of < 0.0001. Overall, the above evidence suggests that CEO network centrality is highly correlated with bond ratings, lending initial support to our hypothesis.

Table 3 also shows that the values of many correlation coefficients are reasonably small, suggesting that multicollinearity is not a major concern in our study. In addition, most of the control variables are significantly associated with both BR and CEO centrality measures, highlighting the importance of estimating our model in a multivariate setting and controlling for all these variables in the regression analysis.

4. Main results

Panel A of Table 4 reports the primary regression (ordered probit) results of estimating Eq. (6). The coefficient on DEGREE (EIGENVECTOR) is 0.013 (1815.800) with a p-value of < 0.0001. The coefficient on CLOSENESS (BETWEENNESS) is 5.212 (159.100) with a p-value of < 0.0001 (p-value = 0.046). Where the primary independent variable of interest is the composite score of the four individual centrality measures, the coefficient on COMPOSITE is 0.066 with a p-value of < 0.0001. Together, results indicate a significant positive relation between BR and all five CEO centrality measures, suggesting that firms with high centrality CEOs have high bond ratings.

In the last column of Panel A, results show that BR is positively related to SIZE, MTB, ROA, OCF, ZSOCRE, CSR, and AGE, and negatively related to LEV, LOSS, BVOL, and CEOPOWER. The above relations between BR and control variables are in line with general expectations. For example, the positive relation between BR and OCF suggests that firms with sufficient operating cash flows have high bond ratings because the ability to make timely interest payments is an important factor in determining bond ratings. The negative relation between BR and LEV suggests that firms with high leverage (more debt) receive low bond ratings. The negative relation between BR and CEOPOWER is consistent with the findings in Liu and Jiraporn (2010).

We further examine the concern about multicollinearity in the regression analysis by calculating Variance Inflation Factor (VIF) values. In untabulated results, we find that the VIF value of each variable is fairly small (less than five), suggesting that multicollinearity is not a major concern. Our results are economically meaningful. For example, based on the results where the independent variable is COMPOSITE, a one standard deviation increase of the COMPOSITE score is associated with an increase of BR by a notch. In addition, the results are also economically significant. Our regression model including COMPOSITE and all control variables explains approximately 64% of the variation in bond ratings.

Following prior research (e.g., Bhojraj & Sengupta, 2003; Liu & Jiraporn, 2010), we also investigate the relation between CEO network centrality and bond yield (YIELD), which is calculated as the difference between the bond's (at-issue) yield and a U.S. Treasury bond with similar maturity. This measure captures the cost of debt. In concept, firms with higher bond ratings should experience lower cost of debt. This test provides some evidence on whether CEO network centrality also affects bond yields. Consistent with Liu and Jiraporn (2010), we collect data on bond issues from the SDC New Issues database. If a firm has more than one bond issue in one year, we then use the weighted-average of all issues as a proxy for the bond yield of the firm in that year (e.g., Anderson, Mansi, & Reeb, 2004). Merging the bond yield dataset with the dataset used in our main analysis yields a sample of 1148 observations. In addition to the control variables in Eq. (6), we also control for bond ratings (BR) in this test. Specifically, we regress YIELD

Table 3
Correlation matrix.

	Variable	1	2	3	4	5	6	7	8	9
1	BR		0.252	0.240	0.337	0.120	0.248	0.549	− 0.408	0.352
	p-value		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
2	DEGREE	0.228		0.343	0.691	0.863	0.962	0.293	− 0.098	0.075
	p-value	< 0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
3	EIGENVECTOR	0.079	0.138		0.548	0.279	0.382	0.198	− 0.116	0.130
	p-value	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
4	CLOSENESS	0.214	0.474	0.105		0.578	0.776	0.338	− 0.129	0.199
	p-value	< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
5	BETWEENNESS	0.107	0.841	0.145	0.362		0.893	0.147	− 0.067	0.014
	p-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001	0.278
6	COMPOSITE	0.195	0.955	0.152	0.569	0.937		0.275	− 0.097	0.080
	p-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001
7	SIZE	0.559	0.267	0.026	0.199	0.125	0.222		− 0.134	0.107
	p-value	< 0.0001	< 0.0001	0.047	< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001
8	LEV	− 0.437	− 0.094	− 0.04	− 0.056	− 0.065	− 0.083	− 0.150		− 0.033
	p-value	< 0.0001	< 0.0001	0.002	< 0.0001	< 0.0001	< 0.0001	< 0.0001		0.011
9	MTB	0.206	0.038	0.01	0.097	− 0.017	0.026	0.077	0.073	
	p-value	< 0.0001	0.003	0.423	< 0.0001	0.198	0.049	< 0.0001	< 0.0001	
10	ROA	0.477	0.042	0.016	0.069	0.005	0.033	0.100	− 0.291	0.268
	p-value	< 0.0001	0.002	0.219	< 0.0001	0.686	0.012	< 0.0001	< 0.0001	< 0.0001
11	OCF	0.351	− 0.028	0.003	− 0.02	− 0.048	− 0.040	0.053	− 0.149	0.262
	p-value	< 0.0001	0.034	0.8	0.124	0.000	0.002	< 0.0001	< 0.0001	< 0.0001
12	LOSS	− 0.355	− 0.055	− 0.014	− 0.036	− 0.029	− 0.045	− 0.101	0.231	− 0.099
	p-value	< 0.0001	< 0.0001	0.294	0.005	0.029	0.001	< 0.0001	< 0.0001	< 0.0001
13	ZSCORE	0.478	0.012	0.038	0.05	− 0.007	0.009	− 0.033	− 0.550	0.284
	p-value	< 0.0001	0.348	0.004	1E-04	0.592	0.511	0.013	< 0.0001	< 0.0001
14	MARANK	0.218	0.029	0.004	0.052	0.002	0.025	0.121	− 0.169	0.088
	p-value	< 0.0001	0.029	0.751	< 0.0001	0.869	0.060	< 0.0001	< 0.0001	< 0.0001
15	BVOL	− 0.225	− 0.119	− 0.045	− 0.098	− 0.080	− 0.112	− 0.059	0.048	− 0.063
	p-value	< 0.0001	< 0.0001	6E-04	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.000	< 0.0001
16	CGOV	0.02	− 0.003	− 0.06	− 0.016	− 0.028	− 0.019	− 0.024	0.039	0.059
	p-value	0.127	0.816	< 0.0001	0.23	0.030	0.155	0.064	0.003	< 0.0001
17	CSR	0.326	0.159	0.005	0.121	0.068	0.128	0.309	− 0.114	0.162
	p-value	< 0.0001	< 0.0001	0.706	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
18	AGE	0.256	0.201	− 0.013	0.119	0.097	0.162	0.266	− 0.139	0.012
	p-value	< 0.0001	< 0.0001	0.327	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.372
19	CEOPOWER	− 0.401	− 0.210	0.000	− 0.159	− 0.108	− 0.179	− 0.804	0.067	− 0.049
	p-value	< 0.0001	< 0.0001	0.971	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.000

	10	11	12	13	14	15	16	17	18	19
1	0.512	0.372	− 0.350	0.489	0.211	− 0.209	0.008	0.305	0.247	− 0.404
	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.541	< 0.0001	< 0.0001	< 0.0001
2	0.049	− 0.013	− 0.056	0.031	0.032	− 0.123	− 0.005	0.167	0.211	− 0.222
	0.000	0.326	< 0.0001	0.019	0.013	< 0.0001	0.716	< 0.0001	< 0.0001	< 0.0001
3	0.079	0.039	− 0.064	0.102	0.046	− 0.122	− 0.064	0.090	− 0.060	− 0.169
	< 0.0001	0.003	< 0.0001	< 0.0001	0.001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
4	0.106	− 0.007	− 0.087	0.110	0.065	− 0.173	− 0.001	0.216	0.158	− 0.270
	< 0.0001	0.608	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.935	< 0.0001	< 0.0001	< 0.0001
5	0.001	− 0.042	− 0.034	− 0.002	0.013	− 0.083	− 0.018	0.077	0.119	− 0.107
	0.962	0.001	0.009	0.878	0.326	< 0.0001	0.168	< 0.0001	< 0.0001	< 0.0001
6	0.044	− 0.024	− 0.054	0.036	0.035	− 0.125	− 0.015	0.160	0.183	− 0.212
	0.001	0.072	< 0.0001	0.006	0.007	< 0.0001	0.260	< 0.0001	< 0.0001	< 0.0001
7	0.094	0.062	− 0.099	− 0.039	0.103	− 0.062	− 0.021	0.294	0.271	− 0.853
	< 0.0001	< 0.0001	< 0.0001	0.003	< 0.0001	< 0.0001	0.108	< 0.0001	< 0.0001	< 0.0001

Table 3 *(continued)*

	10	11	12	13	14	15	16	17	18	19
8	− 0.322	− 0.176	0.217	− 0.549	− 0.186	0.014	0.058	− 0.114	− 0.084	0.075
	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.292	< 0.0001	< 0.0001	< 0.0001	< 0.0001
9	0.463	0.340	− 0.210	0.412	0.122	− 0.113	0.061	0.215	0.024	− 0.071
	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.068	< 0.0001
10		0.607	− 0.558	0.683	0.284	− 0.050	0.032	0.167	0.029	− 0.029
		< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.000	0.015	< 0.0001	0.027	0.027
11	0.553		− 0.292	0.459	0.265	− 0.024	0.014	0.140	− 0.072	− 0.019
	< 0.0001		< 0.0001	< 0.0001	< 0.0001	0.071	0.284	< 0.0001	< 0.0001	0.141
12	− 0.665	− 0.292		− 0.382	− 0.120	0.051	− 0.042	− 0.093	− 0.048	0.063
	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001	0.002	< 0.0001	0.000	< 0.0001
13	0.637	0.481	− 0.357		0.298	− 0.031	− 0.009	0.151	0.062	0.063
	< 0.0001	< 0.0001	< 0.0001		< 0.0001	0.016	0.468	< 0.0001	< 0.0001	< 0.0001
14	0.258	0.273	− 0.120	0.303		0.014	− 0.003	0.145	0.091	− 0.076
	< 0.0001	< 0.0001	< 0.0001	< 0.0001		0.284	0.813	< 0.0001	< 0.0001	< 0.0001
15	− 0.060	− 0.048	0.057	− 0.044	0.000		− 0.029	− 0.109	− 0.149	0.060
	< 0.0001	0.000	< 0.0001	0.001	0.998		0.025	< 0.0001	< 0.0001	< 0.0001
16	0.055	0.025	− 0.041	0.004	− 0.004	− 0.041		0.194	0.139	0.017
	< 0.0001	0.060	0.002	0.746	0.732	0.002		< 0.0001	< 0.0001	0.199
17	0.181	0.148	− 0.104	0.171	0.147	− 0.121	0.227		0.173	− 0.260
	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001
18	0.042	− 0.051	− 0.042	0.077	0.104	− 0.181	0.068	0.148		− 0.207
	0.001	< 0.0001	0.002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001		< 0.0001
19	− 0.043	− 0.009	0.063	0.052	− 0.080	0.061	0.027	− 0.275	− 0.192	
	0.001	0.495	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.039	< 0.0001	< 0.0001	

This table reports the Pearson (below the diagonal) and Spearman (above the diagonal) correlations for selected variables of the sample over the period of 2004–2014, representing 716 individual firms and 5857 firm-year observations. For each pair of variables, the Pearson and Spearman correlation coefficients and related (two-tailed) p-values are provided. All continuous variables are winsorized at the 1% and 99% percentiles before the correlation analysis. Refer to Appendix 1 for variable definitions.

Table 4
CEO network centrality and bond rating main results.

Panel A: dependent variable = bond ratings

	Ordered Probit Regression; Dependent Variable = BR														
Parameter	Estimate	Chi-Square	Pr > ChiSq	Estimate	Chi-Square	Pr > ChiSq	Estimate	Chi-Square	Pr > ChiSq	Estimate	Chi-Square	Pr > ChiSq	Estimate	Chi-Square	Pr > ChiSq
DEGREE	0.013***	18.08	< 0.0001												
EIGENVECTOR				1815.800***	18.66	< 0.0001									
CLOSENESS							5.212***	45.45	< 0.0001						
BETWEENNESS										159.100**	3.97	0.046			
COMPOSITE													0.066***	16.41	< 0.0001
SIZE	1.337***	1309.77	< 0.0001	1.353***	1350.55	< 0.0001	1.330***	1301.40	< 0.0001	1.352***	1348.80	< 0.0001	1.342***	1324.11	< 0.0001
LEV	− 2.774***	205.55	< 0.0001	− 2.783***	207.10	< 0.0001	− 2.819***	212.33	< 0.0001	− 2.778***	206.09	< 0.0001	− 2.776***	205.79	< 0.0001
MTB	0.009**	4.33	0.038	0.010**	4.84	0.028	0.008*	3.12	0.077	0.010**	4.81	0.028	0.009**	4.44	0.035
ROA	4.869***	70.16	< 0.0001	4.929***	71.86	< 0.0001	4.753***	66.72	< 0.0001	4.901***	71.07	< 0.0001	4.870***	70.16	< 0.0001
OCF	4.598***	92.01	< 0.0001	4.517***	89.03	< 0.0001	4.752***	97.69	< 0.0001	4.540***	89.75	< 0.0001	4.611***	92.43	< 0.0001
LOSS	− 0.725***	56.96	< 0.0001	− 0.725***	57.03	< 0.0001	− 0.746***	60.23	< 0.0001	− 0.724***	56.79	< 0.0001	− 0.726***	57.08	< 0.0001
ZSCORE	0.411***	386.87	< 0.0001	0.407***	380.74	< 0.0001	0.407***	379.65	< 0.0001	0.409***	383.26	< 0.0001	0.410***	385.34	< 0.0001
MARANK	− 0.150*	3.43	0.064	− 0.152*	3.55	0.060	− 0.158*	3.85	0.050	− 0.153*	3.59	0.058	− 0.151*	3.52	0.061
BVOL	− 0.878***	271.61	< 0.0001	− 0.883***	275.67	< 0.0001	− 0.875***	270.25	< 0.0001	− 0.886***	277.10	< 0.0001	− 0.879***	272.44	< 0.0001
CGOV	0.042	1.75	0.186	0.044	1.93	0.165	0.043	1.87	0.171	0.040	1.61	0.205	0.042	1.79	0.180
CSR	0.052***	38.74	< 0.0001	0.055***	43.89	< 0.0001	0.052***	38.62	< 0.0001	0.054***	42.39	< 0.0001	0.052***	39.76	< 0.0001
AGE	0.312***	23.49	< 0.0001	0.351***	30.05	< 0.0001	0.317***	24.60	< 0.0001	0.338***	27.82	< 0.0001	0.320***	24.94	< 0.0001
CEOPOWER	− 0.589***	54.30	< 0.0001	− 0.589***	54.31	< 0.0001	− 0.577***	52.17	< 0.0001	− 0.596***	55.55	< 0.0001	− 0.592***	54.80	< 0.0001
Industry	Included			Included			Included			Included			Included		
Year	Included			Included			Included			Included			Included		
Observations	5857			5857			5857			5857			5857		
Adj. R^2	0.6387			0.6386			0.6404			0.6378			0.6386		

Panel B: dependent variable = bond yield

	Clustered Standard Errors OLS Regression; Dependent Variable = YIELD														
Parameter	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|
Intercept	6.781***	330.66	< 0.0001	6.779***	332.24	< 0.0001	6.816***	322.30	< 0.0001	6.780***	329.98	< 0.0001	6.781***	331.29	< 0.0001
DEGREE	− 0.0002*	− 1.72	0.085												
EIGENVECTOR				− 28.109**	− 2.51	0.0122									
CLOSENESS							− 0.268***	− 5.91	< 0.0001						
BETWEENNESS										− 3.701*	− 1.93	0.054			
COMPOSITE													− 0.002**	− 2.12	0.034
SIZE	0.001	0.59	0.555	0.001	0.56	0.575	0.001	0.88	0.380	0.001	0.49	0.627	0.001	0.52	0.604
LEV	− 0.089***	− 6.72	< 0.0001	− 0.088***	− 6.69	< 0.0001	− 0.090***	− 6.92	< 0.0001	− 0.088***	− 6.68	< 0.0001	− 0.089***	− 6.75	< 0.0001
MTB	− 0.0003	− 1.00	0.319	− 0.0003	− 1.15	0.252	− 0.0002	− 0.59	0.552	− 0.0003	− 1.12	0.263	− 0.0003	− 1.03	0.301
ROA	− 0.088**	− 2.14	0.032	− 0.092**	− 2.23	0.026	− 0.079*	− 1.94	0.053	− 0.089**	− 2.16	0.031	− 0.089**	− 2.16	0.031
OCF	− 0.019	− 0.64	0.521	− 0.015	− 0.49	0.624	− 0.031	− 1.06	0.290	− 0.017	− 0.57	0.570	− 0.019	− 0.64	0.524
LOSS	− 0.015	− 1.36	0.173	− 0.016	− 1.42	0.157	− 0.015	− 1.39	0.166	− 0.015	− 1.38	0.168	− 0.015	− 1.39	0.165
ZSCORE	− 0.001	− 1.27	0.206	− 0.001	− 1.16	0.248	− 0.001	− 1.46	0.145	− 0.001	− 1.21	0.227	− 0.001	− 1.28	0.200
MARANK	0.010**	2.73	0.006	0.010***	2.66	0.008	0.010***	2.77	0.006	0.010***	2.72	0.007	0.010***	2.75	0.006
BVOL	− 0.0004	− 0.12	0.904	0.0001	0.02	0.982	− 0.001	− 0.30	0.761	0.0002	0.05	0.960	− 0.001	− 0.15	0.884
CGOV	− 0.001	− 0.66	0.508	− 0.001	− 0.77	0.443	− 0.001	− 0.71	0.475	− 0.001	− 0.65	0.514	− 0.001	− 0.72	0.473
CSR	− 0.001***	− 3.09	0.002	− 0.001***	− 3.26	0.001	− 0.001***	− 3.07	0.002	− 0.001***	− 3.22	0.001	− 0.001***	− 3.13	0.002
AGE	0.001	0.22	0.827	0.0004	0.11	0.914	0.001	0.13	0.897	0.001	0.17	0.868	0.001	0.19	0.852
CEOPOWER	0.011***	3.14	0.002	0.012***	3.23	0.001	0.010***	2.79	0.005	0.011***	3.09	0.002	0.011***	3.09	0.002
BR	− 0.307***	− 23.59	< 0.0001	− 0.307***	− 24.15	< 0.0001	− 0.307***	− 28.15	< 0.0001	− 0.307***	− 23.35	< 0.0001	− 0.307***	− 23.89	< 0.0001

(continued on next page)

Table 4 *(continued)*

Panel B: dependent variable = bond yield

	Clustered Standard Errors OLS Regression; Dependent Variable = YIELD														
Parameter	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|
Industry	Included			Included			Included			Included			Included		
Year	Included			Included			Included			Included			Included		
Observations	1148			1148			1148			1148			1148		
Adj. R^2	0.5928			0.5929			0.5931			0.5928			0.5929		

Panel A reports the results from the ordered probit regression of regressing bond ratings (BR) on CEO network centrality measures (namely DEGREE, EIGENVECTOR, CLOSENESS, BETWEENNESS, and COMPOSITE) and control variables over the period of 2004–2014 based on the following model equation:

$BR = \beta_0 + \beta_1 \times \textit{CEO NETWORK CENTRALITY MEASURES} + \beta_x \times \textit{Control Variables} + \textit{Year \& Industry Dummies} + \varepsilon.$

Panel B reports the results from the clustered standard errors OLS regression of regressing bond yield (YIELD) on CEO network centrality measures (namely DEGREE, EIGENVECTOR, CLOSENESS, BETWEENNESS, and COMPOSITE) and control variables over the period of 2004–2014 based on the following model equation:

$YIELD = \beta_0 + \beta_1 \times \textit{CEO NETWORK CENTRALITY MEASURES} + \beta_x \times \textit{Control Variables} + \textit{Year \& Industry Dummies} + \varepsilon.$

Continuous control variables are winsorized at the 1% and 99% percentiles each year before entering the regression tests. *, **, and *** represent significance at the 10, 5 and 1% (two-tailed) confidence levels, respectively. Refer to Appendix 1 for variable definition.

on CEO network centrality and control variables (including BR) and report results in Panel B of Table 4. As shown in Panel B, each of the five CEO network centrality measures is significantly and negatively related to bond yields (YIELD), suggesting that firms with better connected CEOs experience lower cost of debt.

5. Additional tests

5.1. Changes analysis

Our main analysis uses a level analysis that regresses bond ratings on CEO network centrality and various control variables. To mitigate the concern about omitted correlated variables that may affect both bond ratings and CEO centrality simultaneously, we employ a changes analysis. This test can provide additional evidence that changes in bond ratings can be attributed to changes in CEO centrality. In addition, Jorion and Zhang (2007) argue that bond rating studies should take into account the bond rating in the previous period. For example, a downgrade from BB + to B may contain more information to users than a downgrade from BB + to BB. The findings in Jorion and Zhang (2007) highlight the importance of a changes analysis in our study.

In this test, we conduct a bivariate changes analysis by separately regressing the change in bond rating (ΔBR) from year t-1 to year t on the change in each of the five CEO centrality measures (ΔDEGREE, ΔEIGENVECTOR, ΔCLOSENESS, ΔBETWEENNESS, and ΔCOMPOSITE) from year t-1 to year t. Table 5 reports that results of the changes analysis. The coefficient on ΔDEGREE is 0.003 (*t*-stat = 2.61), on ΔEIGENVECTOR is 705.529 (*t*-stat = 1.95), on ΔCLOSENESS is 0.365 (*t*-stat = 2.08), on ΔBETWEENNESS is 98.703 (*t*-stat = 3.30), and on ΔCOMPOSITE is 0.018 (*t*-stat = 3.28), supporting a significant positive relation between the changes in CEO network centrality and the changes in bond ratings. In other words, results in Table 5 suggest that an increase (a decrease) in CEO centrality can lead to an increase (a decrease) in bond ratings, strengthening our primary findings.

5.2. Lagged measures of CEO network centrality

To ensure that our results are not driven by endogeneity issues such as reverse causality, we re-run the regression analysis using lagged values of CEO network centrality and report results in Table 6. Specifically, Table 6 presents that the coefficient on LagDEGREE is 0.012 (*t*-stat = 12.80), on LagEIGENVECTOR is 8466.2 (*t*-stat = 27.06), on LagCLOSENESS is 4.757 (*t*-stat = 34.15), on LagBETWEENNESS is 109.3 (*t*-stat = 5.42), and on LagCOMPOSITE is 0.056 (*t*-stat = 10.20), indicating a significant positive relation between CEO centrality in year t-1 and bond ratings in year t. Taken together, results from using lagged measures of CEO centrality suggest that reverse causality should not be a major concern in our study.

5.3. Firm fixed effects regression

To further mitigate concerns about omitted correlated variables, we perform a firm fixed effects regression analysis. Table 7 presents the results of firm fixed effects regression of estimating Eq. (6). Specifically, Table 7 reports that the coefficient on DEGREE is 0.004 (*t*-stat = 1.82), on EIGENVECTOR is 1711.022 (*t*-stat = 4.15), on CLOSENESS is 1.424 (*t*-stat = 2.97), on BETWEENNESS is 98.127 (*t*-stat = 1.73), and on COMPOSITE is 0.026 (*t*-stat = 2.33), still showing a significant and positive relation between CEO network centrality and bond ratings. In Table 7, industry dummy variables are not included because fixed effects regression exclude time-constant variables. Overall, results from firm fixed effects regression, along with the changes analysis, suggest that omitted correlated variables should not be a major concern in our study.

Table 5
CEO network centrality and bond rating changes analysis.

Parameter	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|
Intercept	− 0.014	− 1.33	0.184	− 0.015	− 1.34	0.180	− 0.014	− 1.28	0.200	− 0.014	− 1.32	0.187	− 0.014	− 1.27	0.205
ΔDEGREE	0.003***	2.61	0.009												
ΔEIGENVECTOR				705.529*	1.95	0.051									
ΔCLOSENESS							0.365**	2.08	0.038						
ΔBETWEENNESS										98.703***	3.30	0.001			
ΔCOMPOSITE													0.018***	3.28	0.001
ΔSIZE	0.511***	5.81	< 0.0001	0.518***	5.88	< 0.0001	0.516***	5.86	< 0.0001	0.513***	5.84	< 0.0001	0.511***	5.81	< 0.0001
ΔLEV	− 0.994***	− 5.25	< 0.0001	− 1.005***	− 5.29	< 0.0001	− 0.999***	− 5.27	< 0.0001	− 0.993***	− 5.25	< 0.0001	− 0.994***	− 5.25	< 0.0001
ΔMTB	0.001	0.15	0.884	0.001	0.16	0.873	0.001	0.16	0.875	0.000	0.12	0.903	0.000	0.13	0.896
ΔROA	0.125	0.39	0.697	0.129	0.40	0.689	0.117	0.37	0.715	0.122	0.38	0.704	0.122	0.38	0.703
ΔOCF	0.029	0.12	0.904	0.026	0.11	0.915	0.029	0.12	0.906	0.034	0.14	0.888	0.034	0.14	0.890
ΔLOSS	− 0.048	− 1.30	0.192	− 0.048	− 1.31	0.191	− 0.049	− 1.33	0.184	− 0.047	− 1.29	0.196	− 0.048	− 1.30	0.192
ΔZSCORE	0.117***	6.26	< 0.0001	0.117***	6.26	< 0.0001	0.117***	6.28	< 0.0001	0.116***	6.23	< 0.0001	0.116***	6.24	< 0.0001
ΔMARANK	0.024**	0.72	0.470	0.024	0.70	0.481	0.023	0.68	0.496	0.025	0.74	0.458	0.025	0.73	0.466
ΔBVOL	0.124**	2.48	0.013	0.124**	2.48	0.013	0.125**	2.50	0.012	0.124**	2.48	0.013	0.124**	2.49	0.013
ΔCGOV	0.035**	2.71	0.007	0.036***	2.74	0.006	0.035***	2.70	0.007	0.036***	2.75	0.006	0.035***	2.72	0.007
ΔCSR	− 0.002	− 0.38	0.701	− 0.002	− 0.37	0.709	− 0.002	− 0.41	0.682	− 0.002	− 0.41	0.680	− 0.002	− 0.41	0.680
ΔAGE	0.363	1.11	0.267	0.404	1.24	0.217	0.352	1.07	0.284	0.370	1.13	0.257	0.352	1.08	0.281
ΔCEOPOWER	− 0.081	− 1.29	0.197	− 0.082	− 1.30	0.194	− 0.082	− 1.30	0.194	− 0.082	− 1.32	0.187	− 0.082	− 1.30	0.192
Industry	Included			Included			Included			Included			Included		
Year	Included			Included			Included			Included			Included		
Observations	5141			5141			5141			5141			5141		
Adj. R^2	0.0655			0.0649			0.0650			0.0664			0.0661		

This table reports the results from the clustered (by year and by firm) standard errors regression of regressing the changes in bond ratings (ΔBR) on the changes in CEO network centrality measures (ΔDEGREE, ΔEIGENVECTOR, ΔCLOSENESS, ΔBETWEENNESS, and ΔCOMPOSITE) and control variables over the period of 2004–2014 based on the following model equation:

$\Delta BR = \beta_0 + \beta_1 \times \Delta CEO\ CENTRALITY\ MEASURES + \beta_x \times \Delta Control\ Variables + Year\ \&\ Industry\ Dummies + \varepsilon$.

Continuous control variables are winsorized at the 1% and 99% percentiles each year before entering the regression tests. *, **, and *** represent significance at the 10, 5 and 1% (two-tailed) confidence levels, respectively. Refer to Appendix 1 for variable definition.

Table 6
CEO network centrality and bond rating using lagged ceo centrality measures.

Parameter	Estimate	Chi-Square	Pr > ChiSq	Estimate	Chi-Square	Pr > ChiSq	Estimate	Chi-Square	Pr > ChiSq	Estimate	Chi-Square	Pr > ChiSq	Estimate	Chi-Square	Pr > ChiSq
lagDEGREE	0.012***	12.80	0.000												
LagEIGENVECTOR				8466.2***	27.06	< 0.0001									
LagCLOSENESS							4.757***	34.15	< 0.0001						
LagBETWEENNESS										109.3**	5.42	0.021			
LagCOMPOSITE													0.056***	10.20	0.001
SIZE	1.379***	1173.17	< 0.0001	1.390***	1201.46	< 0.0001	1.369***	1162.06	< 0.0001	1.392***	1204.36	< 0.0001	1.383***	1184.13	< 0.0001
LEV	− 2.845***	176.65	< 0.0001	− 2.813***	172.75	< 0.0001	− 2.892***	182.48	< 0.0001	− 2.852***	177.48	< 0.0001	− 2.850***	177.26	< 0.0001
MTB	0.023***	11.19	0.001	0.024***	11.68	0.001	0.021***	9.12	0.003	0.024***	11.75	0.001	0.023***	11.34	0.001
ROA	6.098***	70.79	< 0.0001	6.121***	71.32	< 0.0001	5.939***	67.06	< 0.0001	6.096***	70.75	< 0.0001	6.087***	70.54	< 0.0001
OCF	4.299***	64.10	< 0.0001	4.320***	64.73	< 0.0001	4.454***	68.42	< 0.0001	4.269***	63.20	< 0.0001	4.316***	64.54	< 0.0001
LOSS	− 0.564***	28.03	< 0.0001	− 0.552***	26.88	< 0.0001	− 0.582***	29.82	< 0.0001	− 0.562***	27.84	< 0.0001	− 0.566***	28.22	< 0.0001
ZSCORE	0.438***	333.08	< 0.0001	0.437***	331.60	< 0.0001	0.435***	329.36	< 0.0001	0.436***	330.78	< 0.0001	0.437***	331.98	< 0.0001
MARANK	− 0.146*	2.85	0.092	− 0.151*	3.07	0.080	− 0.154*	3.17	0.075	− 0.147*	2.92	0.088	− 0.148*	2.92	0.088
BVOL	− 0.871***	219.67	< 0.0001	− 0.866***	217.41	< 0.0001	− 0.869***	218.99	< 0.0001	− 0.879***	224.16	< 0.0001	− 0.873***	220.69	< 0.0001
CGOV	0.075**	4.50	0.034	0.077**	4.72	0.030	0.079**	5.05	0.025	0.073**	4.30	0.038	0.075**	4.51	0.034
CSR	0.055***	38.55	< 0.0001	0.059***	44.64	< 0.0001	0.056***	39.71	< 0.0001	0.058***	41.84	< 0.0001	0.056***	39.69	< 0.0001
AGE	0.347***	23.21	< 0.0001	0.393***	30.26	< 0.0001	0.349***	23.73	< 0.0001	0.374***	27.38	< 0.0001	0.356***	24.63	< 0.0001
CEOPOWER	− 0.621***	52.99	< 0.0001	− 0.621***	53.10	< 0.0001	− 0.605***	50.31	< 0.0001	− 0.627***	54.11	< 0.0001	− 0.623***	53.39	< 0.0001
Industry	Included			Included			Included			Included			Included		
Year	Included			Included			Included			Included			Included		
Observations	5141			5141			5141			5141			5141		
Adj. R^2	0.6428			0.6437			0.6443			0.6420			0.6426		

This table reports the results from the clustered (by year and by firm) standard errors regression of regressing bond ratings (BR) on lagged CEO network centrality measures (namely LagDEGREE, LagEIGENVECTOR, LagCLOSENESS, LagBETWEENNESS, and LagCOMPOSITE) and control variables over the period of 2004–2014 based on the following model equation:

$BR_t = \beta_0 + \beta_1 \times \textit{CEO NETWORK CENTRALITY MEASURES}_{t-1} + \beta_x \times \textit{Control Variables} + \textit{Year \& Industry Dummies} + \varepsilon.$

Continuous control variables are winsorized at the 1% and 99% percentiles each year before entering the regression tests. *, **, and *** represent significance at the 10, 5 and 1% (two-tailed) confidence levels, respectively. Refer to Appendix 1 for variable definition.

Table 7
CEO network centrality and bond rating firm fixed effects regression.

Parameter	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|
DEGREE	0.004*	1.82	0.069												
EIGENVECTOR				1711.022***	4.15	< 0.0001									
CLOSENESS							1.424***	2.97	0.003						
BETWEENNESS										98.127*	1.73	0.084			
COMPOSITE													0.026**	2.33	0.020
SIZE	1.086***	20.85	< 0.0001	1.092***	21.00	< 0.0001	1.086***	20.86	< 0.0001	1.089***	20.91	< 0.0001	1.086***	20.85	< 0.0001
LEV	− 2.252***	− 11.86	< 0.0001	− 2.268***	− 11.96	< 0.0001	− 2.260***	− 11.91	< 0.0001	− 2.253***	− 11.87	< 0.0001	− 2.253***	− 11.87	< 0.0001
MTB	− 0.001	− 0.25	0.806	− 0.001	− 0.27	0.789	− 0.001	− 0.38	0.705	− 0.001	− 0.24	0.810	− 0.001	− 0.24	0.811
ROA	0.346	1.06	0.287	0.352	1.09	0.278	0.326	1.00	0.316	0.340	1.05	0.296	0.346	1.06	0.288
OCF	1.611***	4.72	< 0.0001	1.640***	4.81	< 0.0001	1.645***	4.82	< 0.0001	1.614***	4.73	< 0.0001	1.619***	4.74	< 0.0001
LOSS	− 0.185***	− 3.57	0.000	− 0.186***	− 3.60	0.000	− 0.187***	− 3.61	0.000	− 0.185***	− 3.58	0.000	− 0.184***	− 3.56	0.000
ZSCORE	0.252***	12.61	< 0.0001	0.250***	12.55	< 0.0001	0.251***	12.57	< 0.0001	0.252***	12.62	< 0.0001	0.251***	12.59	< 0.0001
MARANK	0.201***	3.83	0.000	0.203***	3.88	0.000	0.199***	3.81	0.000	0.201***	3.83	0.000	0.200***	3.81	0.000
BVOL	− 0.195***	− 4.65	< 0.0001	− 0.192***	− 4.58	< 0.0001	− 0.191***	− 4.55	< 0.0001	− 0.195***	− 4.65	< 0.0001	− 0.194***	− 4.62	< 0.0001
CGOV	0.024	1.30	0.195	0.027	1.46	0.145	0.022	1.20	0.231	0.025	1.33	0.183	0.024	1.31	0.191
CSR	− 0.004	− 0.59	0.557	− 0.004	− 0.57	0.565	− 0.004	− 0.59	0.557	− 0.004	− 0.59	0.554	− 0.004	− 0.60	0.550
AGE	− 0.714***	− 6.41	< 0.0001	− 0.657***	− 5.86	< 0.0001	− 0.698***	− 6.26	< 0.0001	− 0.709***	− 6.35	< 0.0001	− 0.706***	− 6.33	< 0.0001
CEOPOWER	− 0.117*	− 1.89	0.058	− 0.109*	− 1.77	0.077	− 0.116*	− 1.89	0.059	− 0.117*	− 1.90	0.057	− 0.118*	− 1.91	0.056
Industry	No			No			No			No			No		
Year	Included			Included			Included			Included			Included		
Observations	5857			5857			5857			5857			5857		
Adj. R^2	0.9337			0.9338			0.9338			0.9337			0.9337		

This panel reports the results from the firm fixed effects regression of regressing bond ratings (BR) on CEO network centrality measures (namely DEGREE, EIGENVECTOR, CLOSENESS, BETWEENNESS, and COMPOSITE) and control variables over the period of 2002–2014 based on the following model equation:

$BR = \beta_1 \times$ *CEO CENTRALITY MEASURES* $+ \beta_x \times$ *Control Variables* + *Year & Industry Dummies* $+ \varepsilon$.

Continuous control variables are winsorized at the 1% and 99% percentiles each year before entering the regression tests. *, **, and *** represent significance at the 10, 5 and 1% (two-tailed) confidence levels, respectively. Refer to Appendix 1 for variable definition.

Table 8
CEO network centrality and bond rating two-stage OLS regression analysis (2SLS).

	Dep. Var. = DEGREE_Instrumened			Dep. Var. = EIGENVECTOR_Instrumened			Dep. Var. = CLOSENESS_Instrumened
Parameter	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate
Panel A: first stage of 2SLS							
Intercept	− 12.556***	− 7.62	< 0.0001	0.000	− 0.72	0.474	− 0.038***
DEGREE_Mean	0.871***	19.54	< 0.0001				
EIGENVECTOR_Mean				1.010***	8.94	< 0.0001	
CLOSENESS_Mean							0.923***
BETWEENNESS_Mean							
COMPOSITE_Mean							
SIZE	1.207***	8.79	< 0.0001	0.000**	2.28	0.023	0.004***
LEV	− 2.668***	− 3.43	0.001	0.000	− 1.19	0.234	0.004
MTB	0.008	0.47	0.639	0.000	− 0.40	0.686	0.000**
ROA	0.024	0.01	0.992	0.000	− 0.42	0.675	0.008
OCF	− 5.516***	− 2.83	0.005	0.000	− 0.08	0.937	− 0.043***
LOSS	− 0.719*	− 1.86	0.063	0.000	0.08	0.939	0.000
ZSCORE	− 0.122	− 1.47	0.142	0.000	0.97	0.334	0.001***
MARANK	− 0.485	− 1.47	0.143	0.000	− 0.55	0.584	0.002
BVOL	− 1.068***	− 5.00	< 0.0001	0.000***	− 2.71	0.007	− 0.004***
CGOV	− 0.322**	− 2.49	0.013	0.000***	− 2.92	0.004	− 0.001
CSR	0.156***	4.58	< 0.0001	0.000	0.03	0.978	0.000
AGE	2.024***	7.71	< 0.0001	0.000*	− 1.88	0.061	0.003***
CEOPOWER	0.017	0.05	0.959	0.000*	− 1.91	0.056	− 0.001
Industry	Included			Included			Included
Year	Included			Included			Included
Observations	5857			5857			5857
Adj. R^2	0.1588			0.0160			0.1454
Panel B: second stage of 2SLS							
Intercept	− 1.256***	− 3.14	0.002	− 1.282***	− 3.21	0.001	− 1.696***
COMPOSITE_Instrumented	0.016***	4.93	< 0.0001				
DEGREE_Instrumented				1719.821***	3.89	0.000	
EIGENVECTOR_Instrumented							5.999***
CLOSENESS_Instrumented							
BETWEENNESS_Instrumented							
SIZE	1.378***	38.89	< 0.0001	1.395***	39.62	< 0.0001	1.371***
LEV	− 2.677***	− 13.41	< 0.0001	− 2.709***	− 13.57	< 0.0001	− 2.732***
MTB	0.006	1.41	0.159	0.007	1.51	0.132	0.005
ROA	3.447***	5.81	< 0.0001	3.492***	5.88	< 0.0001	3.320***
OCF	4.639***	9.28	< 0.0001	4.539***	9.08	< 0.0001	4.824***
LOSS	− 0.754***	− 7.61	< 0.0001	− 0.763***	− 7.69	< 0.0001	− 0.773***
ZSCORE	0.449***	21.11	< 0.0001	0.446***	20.93	< 0.0001	0.443***
MARANK	− 0.117	− 1.38	0.169	− 0.121	− 1.42	0.155	− 0.135
BVOL	− 0.930***	− 16.97	< 0.0001	− 0.943***	− 17.22	< 0.0001	− 0.922***
CGOV	0.018	0.55	0.584	0.018	0.55	0.580	0.022
CSR	0.052***	5.91	< 0.0001	0.055***	6.27	< 0.0001	0.051***
AGE	0.333***	4.93	< 0.0001	0.377***	5.61	< 0.0001	0.350***
CEOPOWER	− 0.570***	− 6.80	< 0.0001	− 0.565***	− 6.73	< 0.0001	− 0.566***
Industry	Included			Included			Included
Year	Included			Included			Included

Table 8 *(continued)*

	Dep. Var. = DEGREE_Instrumened			Dep. Var. = EIGENVECTOR_Instrumened			Dep. Var. = CLOSENESS_Instrumened
Parameter	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate
Observations	5857			5857			5857
Adj. R^2	0.6270			0.6264			0.6289

	Dep. Var. = CLOSENESS_Instrumened		Dep. Var. = BETWEENNESS_Instrumened			Dep. Var. = COMPOSITE_Instrumened		
Parameter	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|
Panel A: first stage of 2SLS								
Intercept	− 5.07	< 0.0001	0.000	− 1.48	0.139	− 1.792***	− 6.04	< 0.0001
DEGREE_Mean								
EIGENVECTOR_Mean								
CLOSENESS_Mean	23.97	< 0.0001						
BETWEENNESS_Mean			0.975***	18.78	< 0.0001			
COMPOSITE_Mean						0.907***	20.20	< 0.0001
SIZE	8.26	< 0.0001	0.000**	2.37	0.018	0.174***	6.70	< 0.0001
LEV	1.28	0.201	0.000***	− 3.21	0.001	− 0.435***	− 2.95	0.003
MTB	2.20	0.028	0.000	− 1.32	0.189	0.000	− 0.07	0.945
ROA	0.87	0.386	0.000	− 0.09	0.927	0.044	0.10	0.921
OCF	− 5.54	< 0.0001	0.000***	− 2.92	0.004	− 1.376***	− 3.73	0.000
LOSS	0.21	0.835	0.000*	− 1.76	0.079	− 0.125*	− 1.71	0.087
ZSCORE	3.11	0.002	0.000**	− 2.04	0.041	− 0.018	− 1.15	0.251
MARANK	1.43	0.153	0.000	− 1.37	0.172	− 0.063	− 1.00	0.316
BVOL	− 4.84	< 0.0001	0.000***	− 3.65	0.000	− 0.202***	− 4.99	< 0.0001
CGOV	− 1.30	0.194	0.000***	− 3.15	0.002	− 0.072***	− 2.95	0.003
CSR	1.37	0.172	0.000**	2.44	0.015	0.023***	3.50	0.001
AGE	2.75	0.006	0.000***	2.90	0.004	0.268***	5.39	< 0.0001
CEOPOWER	− 0.77	0.442	0.000*	1.71	0.088	0.043	0.69	0.488
Industry			Included			Included		
Year			Included			Included		
Observations			5857			5857		
Adj. R^2			0.0827			0.1317		
Panel B: second stage of 2SLS								
Intercept	− 4.22	< 0.0001	− 1.300***	− 3.25	0.001	− 1.190***	− 2.98	0.003
COMPOSITE_Instrumented								
DEGREE_Instrumented								
EIGENVECTOR_Instrumented	7.41	< 0.0001						
CLOSENESS_Instrumented			220.209***	2.61	0.009			
BETWEENNESS_Instrumented						0.082***	4.80	< 0.0001
SIZE	38.88	< 0.0001	1.396***	39.63	< 0.0001	1.383***	39.19	< 0.0001
LEV	− 13.73	< 0.0001	− 2.692***	− 13.46	< 0.0001	− 2.678***	− 13.42	< 0.0001
MTB	1.15	0.250	0.007	1.52	0.129	0.007	1.44	0.149
ROA	5.61	< 0.0001	3.478***	5.85	< 0.0001	3.446***	5.81	< 0.0001
OCF	9.65	< 0.0001	4.581***	9.15	< 0.0001	4.661***	9.32	< 0.0001
LOSS	− 7.82	< 0.0001	− 0.758***	− 7.64	< 0.0001	− 0.756***	− 7.62	< 0.0001
ZSCORE	20.87	< 0.0001	0.448***	21.03	< 0.0001	0.449***	21.08	< 0.0001
MARANK	− 1.60	0.111	− 0.121	− 1.43	0.154	− 0.120	− 1.41	0.157

Table 8 *(continued)*

Parameter	Dep. Var. = CLOSENESS_Instrumened		Dep. Var. = BETWEENNESS_Instrumened			Dep. Var. = COMPOSITE_Instrumened		
	t Value	Pr > |t|	Estimate	t Value	Pr > |t|	Estimate	t Value	Pr > |t|
BVOL	− 16.87	< 0.0001	− 0.943***	− 17.20	< 0.0001	− 0.931***	− 16.98	< 0.0001
CGOV	0.65	0.515	0.017	0.50	0.617	0.019	0.59	0.559
CSR	5.91	< 0.0001	0.054***	6.19	< 0.0001	0.052***	6.00	< 0.0001
AGE	5.22	< 0.0001	0.362***	5.38	< 0.0001	0.344***	5.10	< 0.0001
CEOPOWER	− 6.76	< 0.0001	− 0.578***	− 6.88	< 0.0001	− 0.575***	− 6.86	< 0.0001
Industry			Included			Included		
Year			Included			Included		
Observations			5857			5857		
Adj. R^2			0.6258			0.6269		

This table reports the results from the two-stage OLS regression (2SLS) of regressing bond ratings (BR) on CEO network centrality measures (namely DEGREE, EIGENVECTOR, CLOSENESS, BETWEENNESS, and COMPOSITE) and control variables over the period of 2004–2014. Panel A shows the results of the first stage of 2SLS of regressing instrumented values of CEO centrality measures on the industry mean of these centrality measures. Panel B presents the results of the second stage of 2SLS of regressing the bond ratings (BR) on the instrumented CEO network centrality measures (from the first stage), namely DEGREE_Instrumented, EIGENVECTOR_Instrumented, CLOSENESS_Instrumented, BETWEENNESS_Instrumented, and COMPOSITE_Instrumented. Continuous control variables are winsorized at the 1% and 99% percentiles each year before entering the regression tests. *, **, and *** represent significance at the 10, 5 and 1% (two-tailed) confidence levels, respectively. Refer to Appendix 1 for variable definition.

5.4. Two-stage OLS regression analysis (2SLS)

To further mitigate the reverse causality concern, we employ a two-stage OLS regression analysis (2SLS) following prior research (e.g., Jiraporn, Jiraporn, Boeprasert, & Chang, 2014). We use the average value of CEO network centrality measures in the same industry (based on the first two digits of the SIC code) as the instrumental variable in the 2SLS. In the first stage of 2SLS, we use the mean value of each of the five CEO centrality measures (i.e., DEGREE_Mean, EIGENVECTOR_Mean, CLOSENESS_Mean, BETWEENNESS_Mean, and COMPOSITE_Mean) to estimate the instrumented value of CEO centrality measures (i.e., DEGREE_Instrumented, EIGENVECTOR_Instrumented, CLOSENESS_Instrumented, BETWEENNESS_Instrumented, and COMPOSITE_Instrumented). In the second stage of 2SLS, we use the instrumented variables as the primary independent variable of interest. In both stages, we use the same control variables and industry/year dummy variables. The results of 2SLS are reported in Table 8.

Panel A of Table 8 presents results of the first stage of 2SLS, where the dependent variables are the instrumented variables, the coefficient on DEGREE_Mean is 0.871 (*t*-stat = 19.54), on EIGENVECTOR_Mean is 1.010 (*t*-stat = 8.94), on CLOSENESS_Mean is 0.923 (*t*-stat = 23.97), on BETWEENNESS is 0.975 (*t*-stat = 18.78), and on COMPOSITE is 0.907 (*t*-stat = 20.20). The significant and positive coefficients suggest that our selection of the instrumental variables is appropriate.

Panel B of Table 8 reports results of the second stage of 2SLS where the dependent variable is bond ratings (BR). In Panel B, the coefficient on DEGREE_Instrumented is 0.016 (*t*-stat = 4.93), on EIGENVECTOR_Instrumented is 1719.821 (*t*-stat = 3.89), on CLOSENESS_Instrumented is 5.999 (*t*-stat = 7.41), on BETWEENNESS_Instumented is 220.209 (*t*-stat = 2.61), and on COMPOSITE_Instrumented is 0.082 (*t*-stat = 4.80), showing a significant positive relation between the instrumented values of CEO centrality and bond ratings. Therefore, results of 2SLS still support our primary findings.

5.5. Other tests

We perform three additional tests to check the robustness of our primary findings. In the first test, we use percentile ranks of the five CEO centrality measures. Using ranks rather than continuous measures allows us to remove potential impact of outliers on our primary findings. In untabulated results, we find that the coefficients on DEGREE_RANK, EIGENVECTOR_RANK, CLOSENESS_RANK, BETWEENNESS_RANK, and COMPOSITE_RANK are all significantly positive, indicating a significant positive relation between the percentile ranks of CEO centrality measures and bond ratings. Therefore, this test provides consistent results and mitigates concerns about any outliers that can influence the primary findings.

In the second test, we use an alternative bond rating measure (IB), which equals one if a firm's bond rating is above investment grade (BBB-) and zero otherwise. Investment grade bonds are generally regarded as good (safe) bonds. Using IB as an alternative dependent variable, we re-run the regression analysis of Eq. (6). Because IB is a dummy variable that takes a value of one or zero, we use Logistic regression in this test. Untabulated results show that the coefficients on all five CEO centrality measures are positive and statistically significant at the 1% level. Thus, results of this additional test still support our main findings.

In the third test, we use different samples. Kisgen (2006) suggests that a large debt offering or a large equity offering can affect a firm's bond credit ratings.[6] Specifically, he argues that a large debt offering (a large equity offering) may lead to a decrease (an increase) in bond ratings. Hence, Kisgen (2006) suggests that future research on bond ratings should exclude firms with large debt or/and equity offerings. Following Kisgen (2006), we exclude observations with large debt or equity offerings and re-run the regression analysis. Using the reduced sample, untabulated results still support a significant positive relation between CEO network centrality and bond ratings.

6. Conclusion

In this paper, we examine the impact of CEO network centrality on bond credit ratings at the firm level. Relying on five network centrality measures that have been used extensively in accounting and finance literature, we find a significant positive relation between CEO network centrality and bond ratings, suggesting that firms with better connected CEOs receive higher bond ratings. We also find that firms with better connected CEOs experience lower cost of debt, measured as bond yields. Our findings are consistent with the notion in social science that well-connected CEOs may lead to positive outcomes and bring benefits to their firms.

This study joins the debate on whether having well-connected CEOs is beneficial or detrimental to an organization. Our findings have meaningful implications to different stakeholder groups including shareholders, managers, and academic researchers. For example, our results may encourage managers to become more socially connected in their networks. Additionally, consistent with prior research, we assume that positions in any social network are unequal, creating a hierarchical network or order in social relationships among individuals.

Data availability

Data are available from sources identified in this paper.

Appendix 1. Variable definition

Variable		Description
BR	=	Numerical values of S&P's bond rating;
IB	=	Indicator variable that equals one if a bond rating is greater than investment grade (BBB-), and otherwise zero;
DEGREE	=	Raw scores of degree centrality;
DRGREE_RANK	=	Percentile ranks of raw scores of degree centrality;
EIGENVECTOR	=	Raw scores of eigenvector centrality;
EIGENVECTOR_RANK	=	Percentile ranks of raw scores of eigenvector centrality;
CLOSENESS	=	Raw scores of closeness centrality;
CLOSENESS_RANK	=	Percentile ranks of raw scores of closeness centrality;
BETWEENNESS	=	Raw scores of betweenness centrality;
BETWEENNESS_RANK	=	Percentile ranks of raw scores of betweenness centrality;
COMPOSITE	=	Raw scores of composite centrality;
COMPOSITE_RANK	=	Percentile ranks of raw scores of composite centrality;
SIZE	=	Natural log of total assets (AT);
LEV	=	Long-term liabilities (DLTT) divided by total assets (AT);
MTB	=	Market value of common shares [Outstanding common shares (CSHO) × price at fiscal year-end (PRCC_F)] divided by total book value of common shares (CEQ);
ROA	=	Income before extraordinary items (IB) scaled by total assets (AT);
OCF	=	Cash flows from operating activities (OANCF) scaled by total assets (AT);
LOSS	=	Indicator variable that equals one if a firm report a negative net income (NI) and otherwise zero;
ZSCORE	=	Altman's *Z*-Score, calculated as 3.3 × [Net Income (NI)/Assets (AT)] + Sales (SALE)/Assets (AT) + 0.6 × {market value of common shares [(CSHO) × (PRCC_F)]/Total Liabilities (LT)} + 1.2 × Working Capital [Current Assets (ACT) – Current Liabilities (LCT)]/Assets (AT) + 1.4 × Retained Earnings (RE)/Assets (AT);
MARANK	=	Decile rankings of managerial ability score in Demerjian, Lev, and McVay (2012);
BVOL	=	Business volatility (uncertainty), calculated as the coefficient of variance of sales (SALE) over the prior rolling 5-year period;
CGOV	=	Corporate governance ratings from *Msc*I's ESG database;
CSR	=	Net corporate social responsivity scores (excluding corporate governance) from *Msc*I's ESG database;
AGE	=	Natural log of the number of years of a firm in Compustat database;
CEOPOWER	=	Indicator variable that equals one if a CEO is also the chairman of the board and otherwise zero;
YIELD	=	The difference between the bond's (at-issue) yield and a U.S. Treasury bond with similar maturity;
LagDEGREE	=	Raw scores of degree centrality in year t-1;
LagEIGENVECTOR	=	Raw scores of eigenvector centrality in year t-1;
LagCLOSENESS	=	Raw scores of closeness centrality in year t-1;
LagBETWEENNESS	=	Raw scores of betweenness centrality in year t-1;
LagCOMPOSITE	=	Raw scores of composite centrality in year t-1.

[6] A debt offering is defined as long-term debt issuance (DLTIS, #111) scaled by total assets (AT, #6), and an equity offering is defined as the sale of common and preferred stock (SSTK, #106) scaled by total assets (AT, #6). An offering > 10% is regarded as a large (debt or equity) offering.

Appendix 2. Bond conversion process

Rating category	Bond rating	Value
Highest grade	AAA	22
	AA +	21
High grade	AA	20
	AA −	19
	A +	18
Upper medium grade	A	17
	A −	16
	BBB +	15
Medium grade	BBB	14
	BBB −	13
	BB +	12
Lower medium grade	BB	11
	BB −	10
	B +	9
Speculative grade	B	8
	B −	7
	CCC +	6
Poor standing grade	CCC	5
	CCC −	4
Highly speculative grade	CC	3
Lowest quality grade	C	2
In default	D	1

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