7-2014

Board interlock networks and the use of relative performance evaluation

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Published in International Journal of Accounting & Information Management (2014) 22 (3), 237-251. DOI: 10.1108/IJAIM-06-2013-0039

Abstract:

Purpose

The purpose of this paper is to explore how networks of boards of directors affect relative performance evaluation (RPE) in chief executive officer (CEO) compensation.

Design/methodology/approach

In this study, the authors propose that an interlocking network is an important inter-corporate setting, which has a bearing on whether boards decide to use RPE in CEO compensation. They adopt four typical graph measures to depict the centrality/position of each board in the interlock network: degree, betweenness, eigenvector and closeness, and study their impacts on RPE use.

Findings

The authors find that firms that have more connected board members and whose board members are connected to better connected firms are more likely to reward their CEOs contingent on their peers' performance, indicating that information transmission along the board interlock network facilitates the adoption of RPE. This result is robust to alternative measures for board interlock networks and various types of CEO compensation. It highlights the role of interlocking directorates in disseminating information and practice of RPE use along board network.

Originality/value

The authors use social network analysis to measure the relationships and flows between the connected nodes and study the impact on executive compensation design.

Keywords: Board interlock network, CEO compensation, Relative performance evaluation (RPE)

1. Introduction

When a member of one board of directors also sits on other boards of directors, a director interlock is created. This paper investigates the diffusion of relative performance evaluation (RPE) in chief executive officer (CEO) compensation design across firms connected by director interlocks. CEO compensation is usually tied to the firm's performance. However, risk-averse CEOs are loath to take on risky projects which may benefit shareholders, but who themselves hold a diverse portfolio and consequently are risk neutral. To insulate a CEO from risks that are beyond his/her control, the board of directors can introduce RPE and make the CEO's compensation contingent on the peer performance (Lazear and Rosen, 1981; Holmstrom, 1982). Despite its theoretical appeal, prior research has mixed results on the use of RPE (Gibbons and Murphy, 1990; Jensen and Murphy, 1990; Barro and Barro, 1990). This lack of consistent empirical evidence supporting the use of RPE in CEO compensation is intriguing, and therefore "determining why RPE is not more comprehensive represents a productive opportunity for future research" (Gibbons and Murphy, 1990).

In this study, we propose that an interlocking network is an important inter-corporate setting, which has a bearing on whether boards decide to use RPE in CEO compensation. Specifically, the results of the regression suggest that board interlocks with strong focal position are more likely to adopt RPE after controlling for significant factors found in prior studies (Gong *et al.*, 2011; Albuquerque, 2009) and consistent with prior research findings that the social influence and information acquisition cost appear to vary according to the interlock type (Geletkanycz and Hambrick, 1997; Palmer *et al.*, 1995; Dahawy *et al.*, 2012).

This paper contributes to the literature in the following ways. First, it adds to the RPE literature by investigating the impact board interlock networks have on RPE. Specifically, using board interlock networks, this paper contributes to our understanding of which types of boards are more likely to use RPE. Second, we provide substantial evidence consistent with the information flowing via the interlock network, leading to a lower information cost to adopt RPE use in CEO compensation. Although previous research demonstrates the impact of board interlocks on the executive compensation (Hallock, 1997), this is the first study, to our knowledge, that introduces board interlocks to explain the diffusion in the use of RPE in CEO compensation design. We attribute this use of RPE to the more accessible information arising from board interlocks.

The remainder of the paper is organized as follows. Section 2 summarizes the extant relevant literature and develops the main hypothesis. Section 3 describes the sample selection and research design. Section 4 presents the empirical findings, and Section 5 concludes the paper.

2. Literature review and hypothesis development

2.1 Literature on RPE

Agency theory predicts the use of RPE in performance evaluation (Holmstrom, 1982). As individual performance is affected by random factors which are beyond the worker's control, tying the worker's compensation/performance to his or her peers' performance, which is also affected by the common uncertainties, can provide incentives while at the same time insulating employee compensation from shocks outside his or her control (Gibbons and Murphy, 1990).

However, there is a lack of empirical evidence substantiating RPE in CEO compensation contracts and dismissal decisions (Murphy, 1999; Bannister and Newman, 2003; Jenter and Kanaan, 2014). Gibbons and Murphy (1990) and Baker and Gompers (2003) suggest that firms may not adopt RPE due to the inability to identify an appropriate peer group. Albuquerque (2011) finds that the use of RPE in CEO compensation contracts is less likely for high growth firms, because the selection of a peer group to co-opt the common shocks is more difficult for a high growth firm, compared with a value firm. Wu and Zhang (2010) contend that the boards select firms whose accounting information is comparable to theirs in implementation of RPE. Gong *et al.* (2011) argue that firms that hire compensation consultants are more likely to use

RPE, due to the easy access to proprietary information about industry-wide compensation practices and potential competitors. This line of research suggests that the selection of peers is challenging, and information costs are not trivial and may deter the RPE use in CEO compensation.

2.2 Literature on board interlock networks

An important function of boards is the provision of resources, information, legitimacy and access to supports from external organizations (Pfeffer and Salancik, 1978; Karim *et al.*, 2013). The ability of a board to fulfill this function is linked to a board's directorate connections to other entities, that is, the board interlocks (Pfeffer and Salancik, 1978; Shropshire, 2010; Yu, 2011). Sociologists have long viewed each company's board as a node/participate in a large board interlock network along which information, knowledge and experiences flow (Stuart and Kim, 2010). Empirical research documents the imitation of practices and strategies, across interlocked firms, such as anti-takeover activities (Davis, 1991), takeover activities (Haunschild, 1993), diversification activities (Chen *et al.*, 2009), establishment of investor relations departments (Rao and Sivakumar, 1999), CEO compensation (Hallock, 1997), accounting practices and so on. In this paper, we focus on the impacts of board interlock networks on RPE use in CEO compensation.

We hypothesize that the communication that takes place through board connections is one important mechanism that facilitates the selection of peers and the spread of RPE use. While board interlock networks provide access to information, the availability of this access is not equal to all boards in the network. Firms with more connections and whose connections are with more connected firms are privileged in their information acquisition. This more central position in the social network has been documented to exhibit better access to information, resulting in a lower information acquisition and process cost, and therefore more favorable economic consequences (Freeman, 1977; Mizruchi, 1996). Stuart and Kim (2010) find that well-connected firms are more likely to be merger and acquisition targets and to be associated with better performing acquisitions. Larcker *et al.* (2013) find that firms central in the boardroom network experience improved accounting and market performance. In this paper, we specifically apply these ideas to boards and their adoption of RPE in CEO compensation; if central boards have better access to peer information via their networks, then we expect central boards to be advantaged in selecting peers and designing an optimal compensation contract incorporating the information about the exogenous shocks that are common to the entire peer group. Our specific hypothesis is described below.

H: Ceteris paribus, the more central the position of the board in the board interlock network, the more likely it will adopt the use of RPE in CEO compensation.

3. Research design

3.1 Interlock network measures

Social network analysis maps and measures the relationships and flows between the connected nodes (Haythornthwaite, 1996). In our context, each firm is a node in a large board interlock network that arises from directorates sitting on multiple boards. The importance and role of a specific node/firm varies, depending on its position/centrality within the network. Occupying a favored position means that the board will have better access to information and resources than the board in a less favorable position. In this paper, we adopt three typical graph measures to depict the centrality/position of each board in the interlock network and study their impacts on RPE use: *degree*, *betweenness* and *eigenvector*.

Degree of centrality is the most intuitive measure, and is defined as the number of unique outside boards directly linked to a focal firm, and the network links are not weighted. A higher value of *degree* indicates that the firm shares board members with more firms, and thus has better access to resources (Larcker *et al.*, 2013).

The second measure is *betweenness*, which is a measure of the number of times a node/firm occurs on the shortest path between any two other nodes/firms (Freeman, 1977). It measures the potential control over others in the network, as any node that falls "between" other nodes would mediate the flow of resources between those nodes.

Finally, *eigenvector* centrality, proposed by Bonacich (1972), is positively proportional to the sum of adjacent centralities and identifies as more eigencentral a node whose associated principal component is higher than other nodes. This measure represents to some extent a node's "influence" in the network. A node increases its influence by either linking to many other small nodes or connecting to a few very highly influential nodes. Mathematically, let A be the adjacency matrix of the interlock network: $A_{ij} = 1$ if node i and node j are connected, otherwise $A_{ij} = 0$. Let x_i represent the eigenvector centrality of node i, Bonacich (1972) proposes that the eigenvector centrality of node i should be proportional to the sum of the eigenvector centrality of all nodes related to it. Hence, $x_i = 1 / x \sum_{j=1}^{n} A_{ijxj}$, where n is the total number of nodes that link to node i and λ is a constant. Representing the equation in eigenvector notation, we have: $Ax = \lambda x$, in which *x is the vector including the social capital of all nodes. Furthermore, x is exactly the eigenvector of adjacency matrix A*. Proven by Perron–Frobenius Theorem (Berman and Plemmons, 1979; Cvetkovic *et al.*, 1995), within a connected network (i.e. any pair of nodes in the network is reachable from each other), the requirement of positive entries in the vector ensures ***x to be the eigenvector of the largest eigenvalue (principal eigenvector); hence, the corresponding eigenspace is monodimensional.***

As we can see in Figure 1, five nodes/firms A, B, C, D and E are connected. We assume that information flows in both directions as long as two nodes are connected. We choose node C to explain the above three centrality measures. Node C is directly linked to B and D, and therefore has a degree of two. Node C is on the shortest path between A and D, A and E, B and D and B and E, and hence has a betweenness of four. To compute eigenvector centrality, we first write the adjacency matrix A as

$$\begin{pmatrix} 01000 \\ 00100 \\ 00010 \\ 00001 \\ 00000 \end{pmatrix}$$

We get the principal eigenvalue of A and the eigenvector of [0.63, 1.1, 1.3, 1.1, 0.63]. The third entry 1.3 corresponds to node C's eigenvector centrality.

To summarize, *degree* centrality is the most intuitive measure, but does not take the quality aspect of each link into consideration. *Betweenness* measures the number of shortest paths in the network that pass through a given node. *Eigenvector* centrality seems more sophisticated, as it takes into consideration both the number of links and the

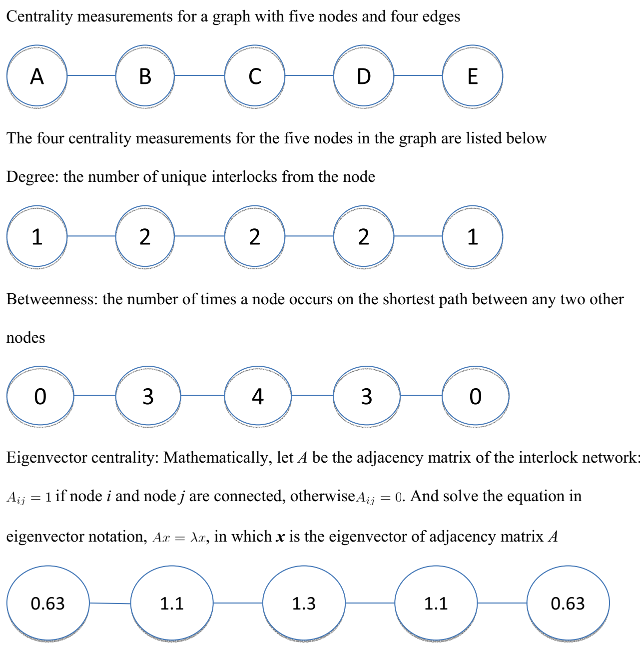

Figure 1.
Centrality measurements for a graph with five nodes and four edges

quality of the related nodes into consideration. Our later empirical analysis will show that these three measures have high correlations. Thus, we will run tests on them alternatively rather than plugging them in together.

3.2 Peer selection and peer performance

Following Albuquerque (2009), we select the peer group from firms within the same 2-digit Standard Industrial Classifications (SIC) and size (market value of equity) quartile. First, we form portfolios annually based on the 2-digit SIC using all the firms in the merged the Center for Research in Security Prices (CRSP)-CompuStat dataset. Second, firms in an industry are sorted by market value at the end of previous fiscal year end to determine size quartiles in each industry portfolio, and firms are then allocated to each industry-size group. We match each firm with an industry-size peer group, which excludes the firm itself, and compute a simple average portfolio return (and return on asset, that is, ROA) using the firm-specific peer group. Peer calculation requires matching fiscal year end and a minimum of two firms per industry-size group. When the number of firms per industry-size group is less than two, the portfolio's return (and ROA) is based on industry average. Each firm's stock return is the natural logarithm of the annual gross real return to shareholders assuming that dividends are reinvested: Ln((1 + retann/100)/CPI)) where "retann" is the annual (compounded) stock return obtained from the CRSP monthly data and "CPI" is the annual rate of Consumer Price Index (CPI) inflation from CPI detail reports.

3.3 Model specification

To analyze the association between board interlock networks and the adoption of RPE in CEO compensation, we estimate the following model:

$$CEOPay_{it} = \beta_o + \beta_i \text{ firmReti,t} + \beta_2\text{PeerReti,t} + \beta_3 \text{ centralityi,t} + \beta_4 \text{ centrality\_PeerRet i,t} + \beta_5 \text{ invint i,t} + \beta_6 \text{ var\_retres i,t} + \beta_7 \text{ ROAi,t} + \beta_8 \text{ PeerROAi,t} + \beta_9 \text{ Interlocki,t} + \beta_{10} \text{ Regulationi,t} + \beta_{11} \text{ NUMMTGSDi,t} + \beta_{12} \text{ TenureYeari,t} + \beta_{13} \text{ CEOChairi,t} + \beta_{14}\text{ownerdummyi,t} + \beta_{15} \text{ industry} + \beta_{16} \text{ year} + \varepsilon\text{i,t.}$$

In this paper, three levels of CEO compensation are examined. CEO total compensation (EXECUCOMP data item TDC1) comprises salary, bonus, other annual compensation, long-term incentive payouts, all other total compensation, total value of restricted stock granted and total Black–Scholes value of stock options granted. CEO cash salary (EXECUCOMP data item TOTAL_CURR) is defined as the dollar value of the base salary and bonus. CEO long-term incentive (Ltcomp) is the summation of other annual compensation, long-term incentive payouts, all other total compensation, total value of restricted stock granted and total Black–Scholes value of stock options granted. All the components of compensation have been adjusted to the constant dollars of January 1992 and have been gone through the natural logarithm transformation.

We add the measures for a board's position in the interlock network, and its interaction with peers' performance into the basic model used in prior research to test the use of RPE (Albuquerque, 2009). We deflate all the network measures by firm size to control for size effect (Smith and Watts, 1992). Our variable of interest is the interaction between peer performance and the board's network position measurement, controlling for the fact that firms with a more focal position might use relatively more RPE due to easy information acquisition.

A set of control variables is included to capture any variation in the level of CEO pay that is not related to firm or peer performance. We provide the rationale for including these control variables below.

Firm performance. CEO compensation is designed to reward good performance, and more ideally, relative good performance compared with peers. We include the firm's and its peers' accounting performance, the firm's stock performance and its peers' stock performance to capture performance effects on the use of RPE.

Executive attributes. The CEO power hypothesis suggests that more entrenched CEOs have more bargaining power and may exploit captured governance mechanisms to set their own pay with little shareholder oversight (Bebchuk *et al.*, 2002, Bertrand and Mullainathan, 2001). We use the natural logarithm of CEO tenure year (*tenureyear*) to proxy for CEOs' power and influence on the boards. Previous literature also shows that the shareholder value added by a CEO is linked to his or her tenure. Alternatively, we use a CEO ownership dummy variable (*ownerdummy*) to capture CEO power. It is a dummy variable that takes the value of 1 if the CEO ownership share is lower than the median for the year across CEOs in the sample, and 0 otherwise. The percentage of CEO ownership is calculated as the number of shares (excluding options) owned by the CEO divided by the number of common shares outstanding at the end of the fiscal year.

Board attributes. A number of research works show that board structure, or, alternatively, corporate governance helps to explain cross-sectional variation in CEO compensation (Yermack, 1996; Bertrand and Mullainathan, 2001; Grinstein and Hribar, 2004; Chhaochharia and Grinstein, 2009). We use the following measures to control for the effect of corporate governance:

- *Interlock* is a dummy variable that takes the value of 1 if the CEO is involved in an interlock relationship requiring disclosure in the proxy statement for that year;

- *NUMMTGS* is a dummy variable that takes the value of 1 if the number of board meetings held during the year is less than the overall sample median of meetings for that year; and
- *CEOChair* is a dummy variable that takes the value of 1 if the CEO is the board chair for that year, and 0 otherwise.

Firm's idiosyncratic risk. The relationship between CEO compensation and a firm's risk can work both ways. Agency theory predicts that a CEO should be compensated for taking risks. However, high compensation may result in CEO conservatism, avoiding risks by all means. We use firm-specific stock return variance (var_retres) to capture operating or informational environment risk (Core *et al.*, 1999; Aggarwal and Samwick, 1999). It is measured as the error variance from regressing the firm's stock returns on the firm's peer group stock returns using the last 60 months of data when available.

Firm's investment intensity (invint). Baber *et al.* (1996) suggest that the firm's past two years' investment intensity reflects its current investment opportunities, and measure it as the sum of acquisitions (EXECUCOMP data item AQC), research and development (EXECUCOMP data item XRD) and capital expenditures (EXECUCOMP data item CAPXV), deflated by depreciation expense (EXECUCOMP data item DP). Mathematically, it can be expressed as

$$\text{invint} = \frac{\sum_{i=t-2}^{i=t}(\text{capital expenditure} + \text{R\&D expenditure} + \text{Acquisitions})}{\sum_{i=t-2}^{i=t}\text{Depreciation}}.$$

Other control variables. In addition to the above controls, we add *Regulation*, which is a dummy variable which is equal to 1 for firms in the gas and electric industries with SIC codes 4900-4939. We also include year dummies to capture year-specific differences in the level of compensation, for example, due to business cycles or trends in pay (Murphy, 1999), and industry dummies to account for unobservable variations in the industry level of pay, for example, due to variation in the demand for managerial talent across industries (Murphy, 1999).

4. Empirical results

We present the main empirical results to test the extent to which use of RPE in CEO compensation contracts varies with a board's influence throughout an interlock network.

4.1 Descriptive data

Table I reports the summary statistics on the variables used in the empirical tests. We do not find high skewness in compensation after we take the natural logarithm of the raw CEO compensation. In stark contrast, there is a wide variation in interlock network measures; for example, the lower quartile of betweenness has a betweenness mean of 32.7, and the mean of the upper quartile is 441.1.

Table II presents the Pearson correlation among all the variables. We find that three measures for CEO compensation are all highly and positively correlated. Among three proxies for board network, *betweenness*, *eigenvector* and *degree* are positively associated with each other in a significant way. We note that CEO total, cash and long-term

Table I.
Descriptive data

Variable	Observation	Q1	Mean	Median	Q3	SD
Totalcomp	5,698	7.1	7.8	7.7	8.5	1.2
Cashcomp	5,674	6.1	6.6	6.6	7.1	1.0
Ltcomp	5,483	3.2	4.9	5.1	6.71	2.3
Betweenness	5,698	32.7	308.5	191.2	441.1	375.9
Eigenvector	5,698	0.000	0.002	0.001	0.003	0.003
Degree	5,698	0.4	0.9	0.7	1.3	1.3
FirmRet	5,698	−0.09	0.08	0.09	0.24	0.29
PeersRet	5,698	−0.01	0.09	0.10	0.18	0.16
Invint	5,698	1.39	2.96	2.24	3.69	3.03
var_retres	5,698	0.004	0.013	0.008	0.015	0.023
ROA	5,698	0.013	0.033	0.034	0.061	0.059
PeerROA	5,607	0.000	−0.026	0.019	0.038	0.242
INTERLOCK	5,698	0	0.051	0	0	0.221
Regulation	5,698	0	0.091	0	0	0.287
NUMMTGS	5,698	0	0.5	1	1	0.5
Tenureyear	5,698	1.10	1.63	1.61	2.30	0.92
CEOChair	5,698	0	0.70	1	1	0.46
Ownerdummy	5,698	0	0.44	0	1	0.50

Notes: *Totalcomp*: Ln($Salary_t$ + $Bonus_t$ + $Othann_t$ + $Ltip_t$ + $Allothtot_t$ +$Rstkgrnt_t$ + Blk_Valu_t); *Cashcomp*: Ln($Salary_t$ + $Bonus_t$); *Ltcomp*: Ln($Othann_t$ + $Ltip_t$ + $Allothtot_t$ +$Rstkgrnt_t$ + Blk_Valu_t); *Degree*: the number of unique interlocks from a node; and *Betweenness*: the number of times a node occurs on the shortest path between any two other nodes; *Eigenvector*: let A be the adjacency matrix of the interlock network: A_{ij} if node i and node j are connected, otherwise $A_{ij} = 0$; the eigenvector centrality of node i is $x_i = 1 / x \sum_{j=1}^{n} A_{ijxj}$ where n is the total number of nodes that link to node i and λ is a constant; *FirmRet:* the natural logarithm of the annual gross real return to shareholders assuming that dividends are reinvested: Ln((1+retann/100)/CPI)) where "retann" is the annual (compounded) stock return obtained from the CRSP monthly data and "CPI" is the annual rate of CPI inflation from CPI detail reports; *PeerRet:* following Albuquerque (2009), the performance of a firm's peer group is calculated based on matching 2-digit SIC and size (market value of equity): form portfolios annually based on 2-digit SIC using all the firms in the merged CRSP-CompuStat dataset; firms in an industry are sorted by market value at the end of previous fiscal year end to determine size quartiles in each industry portfolio, and firms are allocated to each industry-size group; and matching each firm with an industry-size peer group, which excludes the firm itself, and computing a simple average portfolio return using the firm-specific peer group; Peer calculation requires matching fiscal year end and a minimum of two firms per industry-size group, when the number of firms per industry-size group is less than two, the portfolio's return is based on industry average. *Invint*: the firm's investment opportunity, $\Sigma_{i=t-2}^{i=t}$(capital expenditure + R&D expenditure + Acquisitions) / $\Sigma_{i=t-2}^{i=t}$Depreciation. *Var_retres*: the *Variances of idiosyncratic return*, which is measured as the error variance from regressing firm stock returns on the firms' peer group stock returns using the last 60 months of data when available. *ROA* = earnings/total assets; *PeerROA* = the mean of the peer group's contemporaneous ROA. The peer selection is based on 2-digit SIC and size; *Interlock*: a dummy variable that takes the value of 1 if the CEO is involved in an interlock relationship requiring disclosure in the proxy statement for that year; *Regulation: a* dummy variable which is equal to 1 for firms in the gas and electric industries with SIC codes from 4900-4939. *NUMMTGS*: a dummy variable that takes the value of 1 if the number of board meetings held during the year is less than the overall sample median of meetings for that year; *TenureYear:* the difference between the year and month in which the CEO first started in this position and the year and month of current fiscal year if the CEO is still in the position, and then take natural log; *CEOChair*: a dummy variable that takes the value of 1 if the CEO is the board chair for that year and 0 otherwise; *Ownerdummy:* is a dummy variable that takes the value of 1 if the CEO share ownership is lower than the median for the year across CEOs in the sample

Table II.
Pearson correlation

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Totalcomp (1)																	
Cashcomp (2)	0.70																
	< 0.0001																
ltcomp (3)	0.55	0.41															
	< 0.0001	< 0.0001															
Betweenness (4)	0.27	0.22	0.26														
	< 0.0001	< 0.0001	< 0.0001														
Eigenvector (5)	0.30	0.27	0.28	0.61													
	< 0.0001	< 0.0001	< 0.0001	< 0.0001													
Degree (6)	0.13	0.13	0.14	0.47	0.73												
	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001												
FirmRet (7)	0.08	0.14	0.09	−0.01	0.01	0.01											
	< 0.0001	< 0.0001	< 0.0001	0.37	0.32	0.29											
PeerRet (8)	0.02	0.07	0.07	−0.02	0.001	0.001	0.44										
	0.10	< 0.0001	< 0.0001	0.16	0.94	0.92	< 0.0001										
Invint (9)	0.02	−0.06	−0.16	−0.10	−0.08	−0.03	−0.01	−0.02									
	0.23	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.01	0.32	0.09									
var_retres (10)	−0.06	−0.13	−0.16	−0.11	−0.11	−0.06	−0.0	−0.03	0.14								
	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.000	0.02	< 0.0001								
ROA (11)	0.11	0.13	0.05	0.00	−0.02	−0.11	0.22	0.08	−0.08	−0.17							
	< 0.0001	< 0.0001	0.000	0.99	0.09	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001							
PeerROA (12)	0.05	0.07	0.06	0.03	0.04	0.01	0.05	0.10	−0.03	−0.08	0.07						
	0.00	< 0.0001	< 0.0001	0.04	0.002	0.47	0.001	< 0.0001	0.04	< 0.0001	< 0.0001						
INTERLOCK (13)	−0.03	−0.02	0.01	−0.01	0.00	0.01	0.02	−0.003	−0.02	0.04	0.00	0.00					
	0.06	0.12	0.31	0.59	0.98	0.33	0.16	0.84	0.13	0.001	0.98	0.95					
Regulation (14)	−0.16	−0.08	0.06	−0.06	−0.06	−0.04	0.02	0.001	−0.13	−0.13	−0.05	0.06	0.03				
	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.002	0.17	0.96	< 0.0001	< 0.0001	0.000	< 0.0001	0.05				
NUMMTGS (15)	0.09	0.07	0.10	0.09	0.10	0.07	−0.04	−0.01	−0.05	0.001	−0.10	0.03	−0.01	0.16			
	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.002	0.28	0.000	0.95	< 0.0001	0.01	0.71	< 0.0001			
Tenureyear (16)	0.02	0.06	−0.06	−0.09	−0.10	−0.07	0.01	0.01	0.05	0.02	0.03	0.00	0.08	−0.06	−0.13		
	0.10	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.52	0.30	0.000	0.22	0.01	0.10	< 0.0001	< 0.0001	< 0.0001		
CEOChair (17)	0.15	0.18	0.19	0.13	0.16	0.10	−0.01	0.003	−0.07	−0.11	0.02	0.04	−0.01	0.07	0.04	0.23	
	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.53	0.80	< 0.0001	< 0.0001	0.19	0.01	0.54	< 0.0001	0.01	< 0.0001	
Ownerdummy (18)	−0.15	−0.12	−0.12	−0.21	−0.20	−0.13	−0.01	0.01	0.05	0.10	−0.03	−0.05	0.03	−0.19	−0.20	0.41	0.05
	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.54	0.31	< 0.0001	< 0.0001	0.06	< 0.0001	0.03	< 0.0001	< 0.0001	< 0.0001	0.001

compensation are all significantly and positively associated with the firm's stock performance and accounting performance. We also observe that the coefficient between firm's and peers' stock return is 0.44 ($p < 0.0001$), and the coefficient between the firm's and peers' accounting performance is 0.07 ($p < 0.0001$), indicating that their performances are highly correlated, and the univariate analysis may blur the identification of the use of RPE. We find that *betweenness*, *eigenvector* and *degree* are statistically positively associated to CEO payment, indicating that more connected boards tend to pay their CEOs more, providing support to the prior literature documenting the same phenomenon (Hallock, 1997).

4.2 Multivariate analysis

Table III presents the regression results when the dependant variable is total compensation. We include betweenness as well as the interaction between betweenness and peer return. We find that the coefficients of firm stock return (*FirmRet*) and firm accounting performance (*ROA*) are both positive, indicating that total compensation is tied to both the market and accounting performance. Consistent with prior research, we find the coefficient of investment opportunity intensity (*invint*) is positive (coef. = 0.018 and *p*-value [lteq] 0.0001), indicating executives for growth firms should be compensated more for taking more risks. However, the firm-specific stock return variance (*var_retres*) is negatively (coef. = −1.489 and *p*-value = 0.023) associated with CEO total payment, indicating that boards punish volatile stock performance. We interpret *var_retres* as a measure for a firm's smooth performance, but not for the specific risk, because our peer

Table III.
The dependent variable is total compensation, *TotalComp* = Ln(Salary$_t$ + bonus$_t$ + othann$_t$ + ltip$_t$ + allothtot$_t$ +Rstkgrnt$_t$ + Blk_Valu$_t$)

Parameter	Coef.	*p*-value	Coef.	*p*-value	Coef.	*p*-value
Intercept	−51.030	0.004	−44.490	0.012	−51.140	0.005
FirmRet	0.271	< 0.0001	0.246	< .0001	0.240	< 0.0001
PeerRet	−0.034	0.795	0.054	0.655	0.536	0.001
Betweenness	0.001	< 0.0001				
PeerRet*Betweenness	−0.0001	0.552				
Eigenvector			103.030	< 0.0001		
PeerRet*Eigenvector			−77.624	0.027		
Degree					0.185	< 0.0001
PeersRet*Degree					−0.712	< 0.0001
Invint	0.018	0.000	0.017	0.001	0.014	0.008
var_retres	−1.489	0.023	−1.426	0.029	−1.837	0.006
ROA	1.964	< 0.0001	2.120	< 0.0001	2.175	< 0.0001
PeerROA	0.205	0.001	0.181	0.003	0.201	0.001
INTERLOCK	0.001	0.993	−0.022	0.737	−0.001	0.987
Regulation	−0.235	0.198	−0.268	0.139	−0.348	0.060
NUMMTGS	0.195	< .0001	0.185	< 0.0001	0.208	< 0.0001
Tenureyear	0.083	< 0.0001	0.090	< 0.0001	0.081	< 0.0001
CEOChair	0.325	< 0.0001	0.298	< 0.0001	0.359	< 0.0001
Ownerdummy	−0.376	< 0.0001	−0.375	< 0.0001	−0.439	< 0.0001
Industry	Yes		Yes		Yes	
Year	Yes		Yes		Yes	
R square	0.2255		0.2324		0.2032	
Obs	5,607		5,607		5,607	

selection is matched on industry and size, and the firm's risk should be substantially captured by the peers' risk. In addition, the other variables have the expected sign. For example, the longer the CEO is in office, the higher his/her pay is, as the coefficient of *tenureyear* is 0.083 ($p < 0.0001$). Alternatively, he/she can receive more remuneration if he/she also is the chair of the board, because the coefficient for CEO dual position dummy (*CEOChair*) is 0.325 ($p < 0.0001$). Firms with a less-than-median number of board meetings are also likely to compensate their CEOs more, indicating the CEOs can take advantage of weak corporate governance to extract rents (coef. = 0.195, $p < 0.0001$). Furthermore, a CEO who has lower stakes as an owner of the firm will receive lower payment, as the coefficient for *ownerdummy* is −0.376 and significant at a conventional level.

We do not find a significant negative association between CEO total pay and the peer performance (*PeerRet*), suggesting no evidence for the use of RPE in general. However, we find that RPE varies across a board's interlock network centrality. In two of three models where we use different measures for board interlock network to test RPE, the coefficients of the interaction term between board interlock network and peer stock return are statistically significant in the expected directions. For example, the coefficients of *PeerRet_Eigenvector* and *PeerRet_Degree* are −77.624 and −0.712, respectively, and all are significant at <5 per cent. The coefficient of *PeerRet_Betweenness* is −0.0001, although it is insignificant. Our results indicate that firms that have a better connection are more likely to reward their CEOs contingent on their peers' performance.

Tables IV and V present the regression results when the dependant variable is cash compensation and long-term compensation, respectively. In the basic model, all the control variables carry the same sign as reported in Table IV when the dependent variable is total compensation, except for *intinv*, *INTERLOCK* and *Tenureyear*. It appears that firms with interlock relationships disclosed in the proxy statement tend to pay their CEOs more long-term incentives and marginally decrease cash compensation. In contrast, CEOs with longer tenure are more likely to receive higher cash compensation and lower equity compensation.

In Tables IV and V, again, the variables of interest are the interaction terms between peer stock return (*PeerRet*) and the board interlock network measure. In Table IV, we find that the use of RPE in CEO cash compensation increases when the board is more influential, measured by *degree* centrality (coef. = −0.389, $p = 0.0008$) in the network. In Table V, the results are qualitatively similar, as the coefficient of *PeerRet_Degree* is −0.741 ($p = 0.004$). Overall, our results suggest that firms that are better connected and whose connections are with better connected firms are more likely to make their CEO pay total compensation, cash compensation and long-term compensation, contingent on their competitors' performance.

We also find that the coefficients of the board interlock network measures are usually positive Table III-V, supporting the idea that when board members sit on multiple boards that are more accustomed to high salaries, they are more inclined to approve an increase in CEO pay (Hallock, 1997).

5. Conclusion

The lack of evidence for the use of RPE in CEO compensation has been puzzling and has stimulated researchers to investigate this puzzle. This paper contributes to the literature

Parameter	Coef.	*p*-value	Coef.	*p*-value	Coef.	*p*-value
Intercept	−55.54	0.0004	−50.81	0.001	−55.86	0.0004
FirmRet	0.378	<.0001	0.359	<.0001	0.357	<.0001
PeerRet	−0.110	0.336	−0.006	0.952	0.271	0.052
Betweenness	0.000	<.0001				
PeerRet*Betweenness	0.000	0.481				
Eigenvector			74.950	<.0001		
PeerRet*Eigenvector			−32.315	0.295		
Degree					0.118	<.0001
PeersRet*Degree					−0.389	0.001
Invint	−0.006	0.180	−0.006	0.169	−0.009	0.055
var_retres	−2.567	<.0001	−2.465	<.0001	−2.788	<.0001
ROA	1.373	<.0001	1.513	<.0001	1.546	<.0001
PeerROA	0.137	0.011	0.118	0.026	0.134	0.013
INTERLOCK	−0.091	0.116	−0.108	0.060	−0.092	0.114
Regulation	−0.217	0.200	−0.209	0.213	−0.254	0.136
NUMMTGS	0.116	<.0001	0.105	<.0001	0.123	<.0001
Tenureyear	0.099	<.0001	0.105	<.0001	0.098	<.0001
CEOChair	0.295	<.0001	0.269	<.0001	0.317	<.0001
Ownerdummy	−0.274	<.0001	−0.264	<.0001	−0.314	<.0001
Industry	Yes		Yes		Yes	
Year	Yes		Yes		Yes	
R square	0.2052		0.2165		0.1932	
Obs	5,583		5,583		5,583	

Table IV.
The dependent variable is cash compensation, *CashComp* = Ln(Salary$_t$ + bonus$_t$)

by showing that the RPE puzzle can partially be attributed to the failure to identify the influence of board interlock networks. We present strong empirical evidence that firms that have more connected board members and whose board members are connected to better connected firms are more likely to adopt RPE in CEO compensation, regardless of total payment, cash payment or long-term payment. This paper contributes to an emerging body of research using the social network of the boardroom to explain the variation in the boards' strategies. In particular, we employ methods from social network analysis to construct network measures of firms' directors and examine how, beyond standard controls and governance measures, this network affects the RPE used in CEO compensation design. Our results are robust to alternative types of CEO compensation and for various measures of the board interlock network. These results highlight the importance of understanding the intricate ways in which a board of directors makes decisions and suggest that information transmission along the board interlock network can facilitate the use of RPE.

In this paper, we use implicit approach, but not explicit approach, to test the existence of RPE. Although the disadvantages of implicit analysis are pointed by Gong *et al.* (2011) and Albuquerque (2009), we adopt this approach for two reasons. First, direct RPE use information is only available since 2006, and needs to be hand-collected from proxy statements, which makes it difficult to have a large sample. Gong *et al.* (2011), for example, have only 1,419 firm observation from a single year of 2006. Second, Gong *et al.* (2011) demonstrate that implicit test (i.e. ignores the board's actual peer selection and aggregates the peers' performance) in fact generates measurement errors that

Parameter	Coef.	*p*-value	Coef.	*p*-value	Coef.	*p*-value
Intercept	−73.88	0.036	−60.54	0.084	−73.98	0.038
FirmRet	0.515	< 0.0001	0.471	< 0.0001	0.458	< 0.0001
PeerRet	−0.095	0.711	0.035	0.886	0.735	0.020
Betweenness	0.001	< 0.0001				
PeerRet*Betweenness	0.001	0.169				
Eigenvector			170.57	< 0.0001		
PeerRet*Eigenvector			37.18	0.588		
Degree					0.281	< 0.0001
PeersRet*Degree					−0.741	0.004
Invint	−0.064	< 0.0001	−0.066	< 0.0001	−0.073	< 0.0001
var_retres	−7.893	< 0.0001	−7.783	< 0.0001	−8.558	< 0.0001
ROA	1.301	0.013	1.694	0.001	1.823	0.001
PeerROA	0.106	0.370	0.065	0.580	0.101	0.399
INTERLOCK	0.508	0.000	0.471	0.000	0.508	0.000
Regulation	0.785	0.028	0.714	0.044	0.562	0.120
NUMMTGS	0.333	< 0.0001	0.315	< 0.0001	0.359	< 0.0001
Tenureyear	−0.133	0.000	−0.122	0.000	−0.137	< 0.0001
CEOChair	0.816	< 0.0001	0.772	< 0.0001	0.884	< 0.0001
Ownerdummy	−0.154	0.019	−0.151	0.020	−0.273	< 0.0001
Industry	Yes		Yes		Yes	
Year	Yes		Yes		Yes	
R square	0.237		0.241		0.215	
Obs	5,394		5,394		5,394	

Table V.
The dependent variable is long term compensation, LtComp = Ln($Othann_t$ + $ltip_t$ + $allothtot_t$ + $Rstkgrnt_t$ + Blk_Valu_t)

significantly bias against finding evidence for the RPE use (i.e. inducing a Type-II error). Thus, our results provide a low bound support for the RPE use among firms that are more centrally positioned in the board interlock network.

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