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**Article**

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## GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

# Understanding the small-world nature of board network in India

Shreya Biswas<sup>1\*</sup>

**Abstract:** The study analyzes the small-world nature of the board interlock network for National Stock Exchange-listed firms in India. The small world is the notion that each firm can reach any other firm in the network through a small number of intermediate firms. We find that since the introduction of corporate governance regulations in India, the small worldliness of the network has increased, indicating the concentration of directorial positions in the hands of few elites in the country. The small-world nature of the network can be attributed to the presence of few linchpins in the network and the majority of the linchpins are business group firms in the country. The linchpin acts as a bridge between otherwise sparsely connected clusters in the network. The firms that act as linchpins have higher profitability on account of access to a larger pool of resources.

**Subjects:** Corporate Finance; Business, Management and Accounting; Corporate Governance

**Keywords:** small world; board of directors; inter-firm network; firm performance

### 1. Introduction

Board interlocks are formed when a director occupies more than one seat, and as a result, the firms also get connected. Theoretically, board interlocks can provide the connected firms' (1) access to a larger pool of resources (resource dependence theory); (2) access to financial resources

### ABOUT THE AUTHOR

Shreya Biswas is an Indian researcher associated with BITS, Pilani, Hyderabad campus working in the area of corporate governance issues faced by Indian firms. Shreya's research interest lies in understanding the importance of board's social capital and diversity and how it affects various firm outcomes in India. She is also working in the area of external governance structure of firm comprising of auditors and its interaction with board composition and ownership structure of Indian firms.

### PUBLIC INTEREST STATEMENT

The board of directors monitors the managers of the firm such that they act in the best interest of the outside shareholders along with providing strategic advice to the managers. In India, the corporate governance regulations were introduced in 2003 which had requirements pertaining to the composition of the board of directors in order to strengthen the monitoring role of the board. This study finds that after introduction of corporate governance regulation, there was an increase in the concentration of directorial positions in the hands of few directors. We find that business group firms are the most well-connected firms in India on account of directorial ties. Further, better-connected firms are more profitable firms as they can access a larger pool of information not otherwise available in the market. The study indicates that firms in India should consider the importance of directorial ties and may appoint directors strategically to reap its positive association with firm outcome.

(financial control theory); and (3) reputation in the marketplace (legitimacy theory; Mizruchi, 1996). Interlocks may also indicate the integration of the elites and upper classes of the society (class hegemony theory). Board interlocks and its effect on firm outcomes like performance (Larcker, So, & Wang, 2013; Zona, Gomez-Mejia, & Withers, 2018) and governance practices (Barnea & Guedj, 2009; Bouwman, 2011) have been a widely researched. However, few papers have studied how the structure of the inter-firm network on account of board interlocks has evolved over time. This study aims to study the small-world nature of board interlock-driven network in India since the introduction of corporate governance regulations in the country in 2003. The study further analyzes the relation between small-world feature of director network and firm performance in the context of an emerging market economy. Small-world feature of the network refers to the notion that each firm is connected to other firms in the network via a few intermediate steps.

We consider India on account of two reasons. Firstly, director interlocks are commonly observed phenomenon since the early twentieth century, given the dearth of managerial talent (Mehta, 1955). Further, in business group firms, often the promoters or their relatives occupy board positions in several group companies for monitoring purposes (Mehta, 1955; Sarkar, 2010). Kali (1999) finds that in economies with weak legal system, the business networks based on informal relationships and norms are likely to dominate. In the absence of fully developed capital markets and weak law enforcement environment in India, director interlocks provide the firms' access to information, capital as well as legitimacy. If directorial positions are occupied by few elites of the society leading to concentration of power, the inter-firm network formed as a result of directorial ties in India is expected to be a small world. Secondly, the corporate governance regulatory environment in India is still evolving and such changes in the regulatory environment are likely to affect the inter-firm networks. Since the corporate sector in India is characterized by concentrated ownership structure, the board has a vital function of ensuring that the majority of shareholders do not expropriate the minority shareholders. In order to protect shareholder's interests, the corporate governance regulations in the form of Clause 49 of the Listing Agreement were introduced in India in 2003 and were later revised in 2006. The regulation requires at least half of the board to comprise non-executive directors. The proportion of independent directors needs to be at least one-third for boards that are headed by a non-executive director and at least 50% in case the board has an executive chairman. The regulations led to a sudden increase in the demand of directors in the directorial labor market. In such a scenario, directors already serving on the boards of firms are likely to be appointed as non-executive or independent directors by other firms for complying with the regulatory requirements. This is likely to further increase the concentration of directorial positions in the hands of the few. Given this background, India appears to be an interesting laboratory to examine the relation between small-world feature of director interlock network and firm profitability.

The small-world concept translates into a network characterized by small average path length and high clustering among the nodes (firms) of the graph (network). The small-world effect is favorable for faster diffusion of information among the nodes for large networks even if the network density is low. These networks have few bridging ties also called the linchpins which enable the transfer of information among the different clusters. Potentially changes in small-world property of the network can directly influence the flow of information. Using a sample of National Stock Exchange (NSE)-listed firms, we find that the inter-firm network in India formed on account of the sharing of directors is a small world. The small-world feature depends upon the presence of linchpins in an otherwise sparsely connected network which reduces the path length drastically. Further, since the introduction of corporate governance regulations, there appears to be a rise in integration within the network. Regression analysis suggests that linchpins (firms connecting otherwise sparsely connected firms in the network) have higher profitability compared to non-linchpin firms on account of access to a larger pool of information.

The contribution of this paper to the existing literature is primarily twofold. Firstly, it adds to the social and economic network literature by analyzing how the introduction of Corporate Governance regulations in a country can affect network properties. Secondly, it adds to the understanding of the role of

organizational structure in an emerging economy by highlighting how inter-firm network characteristics can be related to firm profitability.

The remaining of the paper is structured as follows. Section 2 reviews the background literature. Section 3 provides a description of data and the methodology followed for the analysis. Section 4 presents the findings and Section 5 provides the summary and conclusions of the study.

## 2. Background literature

### 2.1. Board interlocks

Among the early empirical studies on corporate interlocks, Dooley (1969) finds that board interlocks are higher for larger companies in the United States. The research findings of social scientists in the 1970s and initial 1980s were mostly supportive of class hegemony or social cohesion theory of interlocks. The study by Mintz and Schwartz (1981) was one of the first studies in the literature to suggest that interlocks facilitate economic coordination in decision-making process of companies. The debate whether interlocked directors serve an organizational function or is a class phenomenon gained prominence with the stream of research on “broken” interlocks (Koenig, Gogel, & Sonquist, 1979; Ornstein, 1984; Richardson, 1987; Stearns & Mizruchi, 1986). Other researchers studied the relation between director interlocks and firm-specific strategic outcomes in line with financial control theory (Mizruchi & Stearns, 1988). Resource dependence or financial control theory also implicitly suggests that in presence of alternative sources of information or improvement in the external regulatory environment, the board network should become less important for firms (Haunschild & Beckman, 1998).

In the early 2000s with the advancement in network methodology, there emerged a burgeoning body of literature analyzing the effect of existing social networks on economic outcomes. Hochberg, Ljungqvist, and Lu (2007) in their study show that better-networked venture capital firms exhibit superior performance. Few studies tried to establish a link between a firm’s connectedness on account of the sharing of director and governance practices (Barnea & Guedj, 2009; Bouwman, 2011). Other studies have found a relation between board network and firm performance in the context of United States (Larcker et al., 2013), Italy (Zona et al., 2018), Brazil (Santos, da Silveira, & Barros, 2012), China (Peng, Mutlu, Sauerwald, Au, & Wang, 2015) and India (Balasubramanian, Barua, Bhagavatalu, & George, 2011; Shaw, Cordeiro, & Saravanan, 2016). Studies have also found that board and CEO interlocks are related to higher Initial Public Offering (IPO) valuation (Filatotchev, Chahine, & Bruton, 2018), productivity of firms (Lincoln, Gerlach, & Takahashi, 1992) and survival and sales growth of firms (Zheng, Singh, & Mitchell, 2015). The firms that have higher centrality measure within the network are likely to have superior corporate social performance (Macaulay, Richard, Peng, & Hasenhuttl, 2018). The firms with higher centrality on account of director interlocks pursue growth strategies both domestically and in international markets (Singh & Delios, 2017). Further, Riccaboni, Wang, and Zhu (2019) document that being central within the corporate group is related to higher sales growth and the effect is stronger for smaller corporate group sizes.

### 2.2. Small-world networks

The scientific origin of the small-world phenomenon can be attributed to the work of Watts and Strogatz (1998). Small-world networks can be considered as a set of networks with low average path length and high clustering. The former ensures that two agents within the network can be reached in a relatively small number of steps and high clustering suggests that each agent is locally connected to many of its neighbors. The average path length gives the distance between any two nodes of the network using the shortest path connections between them. Clustering coefficient or alternatively the transitivity of a node tells whether the direct ties of the node are themselves connected.

With the formalization of the small-world model, an array of empirical studies has established the small-world nature of real-world networks in the field of organizational studies. The corporate board networks in the United States exhibited small-world property (Conyon & Muldoon, 2006; Davis, Yoo, & Baker, 2003). The small-world property of ownership network was established in Germany (Conyon &

Muldoon, 2008; Kogut & Walker, 2001) and India (Mani, 2010; Mani & Moody, 2014). Baum, Shipilov, and Rowley (2003) studied the small-world property of the network of investment banks syndicate in Canada from 1952–1990. The study by Verspagen and Duysters (2004) find that the strategic technology alliance network can be characterized as a small world and it helps in the transfer of knowledge.

Only a handful of studies have focused on the network structure and consequence of inter-firm networks in the context of emerging market economies. The study by Mendes-Da-Silva (2011) provides evidence for small-world phenomenon in the network formed by the board of directors and firms using a sample of 400 Brazilian firms from 1997 to 2007. They find that high clustering leads to a lower firm value indicating that high local alignment in the network may not be beneficial for the firm. Mani and Moody (2014) find that the ownership network position of Indian firms is related to the value of transactions.

The studies on small-world property of organizational networks and its effects on outcomes in the context of emerging economies are still scant. Also, mostly studies have focused on the structure of the network at a given point of time and not on the longitudinal aspect of network structure. This paper tries to fill in this particular gap in the present literature of small worlds and economic networks.

### 3. Data and methodology

The sample consists of firms listed on the NSE of India in 2012 for which information on their board of directors were available for 2003 and 2007. We consider 2003 and 2007 to focus on firms immediately after the introduction of corporate governance regulations in March 2003, and also in the period after the implementation of the revised Clause 49 of the Listing Agreement in January 2006, respectively. This helps us to understand how regulatory changes get reflected in board features like interlocks. We obtain the final sample after excluding firms for which financial information is not available or details on the shareholding pattern is missing or having extreme values. After the screening, we arrive at a final sample consisting of 3,402 firm-year observations.

#### 3.1. Board network

First, we create a simple numerical identification number called the unique director identification number (“UDID”) for each of the directors within the sample. Once the UDIDs are created, we construct an incidence matrix for each of the years under analysis where the firms (cases) are the rows and the directors (affiliations) are the columns of the matrix. If a particular director  $j$  serves on the board of firm  $i$ , then the element  $a_{ij}$  takes the value 1 and 0 otherwise. We arrive at year-wise adjacency matrices from these incidence matrices whose rows and columns are firms in the network and each element in the matrix tells whether there is a connection among the firms on account of director interlocks. From the adjacency matrices, we obtain the year-wise board network.

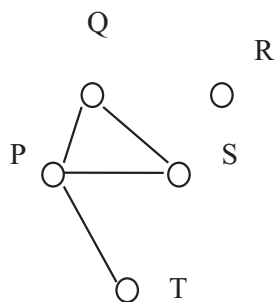
#### An Example

Let us consider five firms P, Q, R, S and T. Now, say firm P shares one common director each with firms Q, S and T; firm Q has interlocks with firms P and S; firm R has no interlocks; firm S has interlocks with P and Q; and firm T shares one director with firm P. Given this information, one can

	P	Q	R	S	T
P	-	1	0	1	1
Q	1	-	0	1	0
R	0	0	-	0	0
S	1	1	0	-	0
T	1	0	0	0	-

construct a simple  $5 \times 5$  adjacency matrix where 1 in each cell depicts the presence of director interlocks and 0 indicates there are no underlying director interlocks between the two firms.

From the adjacency matrix, we plot the following graph showing the connections among the firms:



In this example, it is evident that firm P has the highest betweenness centrality as firms Q and S have to pass through firm P in order to reach firm T and its betweenness measure is two. Firm P also has the closest to all other firms in the network as it can reach three other firms directly in the network. Hence, firm P is likely to have maximum access to resources within the inter-firm network.

For this analysis, we only consider the firms that are members of the giant component of the network. The giant component of a graph is the maximally connected sub-graph such that all its members are connected either directly or indirectly. This ensures that the distance between any two firms in the network is finite. In the above example, it would imply that firm R is not a part of the giant component of the network. After screening, we arrived at a sample of 3,130 firm-year observations which were a part of the giant component of the network.

### 3.2. Small-world statistic

The small-world statistic (SW) is defined as the ratio of clustering coefficient to the average path length of the graph. The clustering coefficient of a node  $i$  is given by the probability that the nodes connected to  $i$  are themselves connected. In other words, it represents the transitivity property of the node and is given as  $CC_i = P(X_{jk} = 1 | X_{ij} = X_{ik} = 1)$ . The average path length is the number of links in the geodesic between node  $i$  and all other nodes and is given by:  $APL_i = \frac{\sum_{j \neq i} l(i,j)}{N}$ , where  $N$  is the number of nodes in the network and  $l(i,j)$  is the number of links between nodes  $i$  and  $j$ . The graph level clustering coefficient and average path length is simply the sum of node-level clustering coefficients and average path length, respectively.

In order to compare the ratio, the general norm is to normalize it with the ratio of clustering coefficient to average path length of a random graph with the same number of nodes. Watts and Strogatz (1998) suggested that if ties are formed entirely in a random manner for a graph with  $N$  nodes and average degree  $k$ , then the average path length ( $APL_R$ ) tends to  $\text{Log}N/\text{Log}k$  and clustering coefficient ( $CC_R$ ) can be approximated by  $k/N$ . Thus, the small-world statistic (SW) of the graph is given as  $SW = \left(\frac{CC}{CC_R}\right) / \left(\frac{APL}{APL_R}\right)$ .

If the SW statistic is greater than unity, then the graph is said to be a small world. However, most of the studies have found SW statistic to be much larger than 1 and it has been observed that the obtained value of the SW statistic increases with the number of nodes in the network. This would suggest that small-world feature of individual and organizational network is an expected outcome. In order to make sense of our SW statistic, we compare it to other studies conducted in developed as well as emerging market economies.

The small-world phenomenon in a network prevails due to the presence of few shortcuts in an otherwise sparse graph. Few firms connect distant clusters within the network and they are called the “linchpins” or the “structural holes” (Burt, 2004) within the network. To identify the linchpins in the network, we compute the betweenness centrality of the firms.

The betweenness centrality views a firm as being in a favored position to the extent that the firm falls on the shortest paths between other pair of firms in the network. Betweenness centrality of firm  $i$  is defined as the ratio of the number of shortest paths connecting  $j$  and  $k$  that pass through  $i$  and the overall number of shortest paths that connect  $j$  and  $k$ . Let  $P_i(jk)$  denotes the number of geodesics between  $j$  and  $k$  that  $i$  lies on, and let  $P(jk)$  be the total number of geodesics between  $j$  and  $k$ . The betweenness centrality measure is given by  $\sum_{k \neq j: i \in (j,k)} \frac{P_i(jk)}{P(jk)}$ .

### 3.3. Econometric methodology

To analyze the relation between small-world characteristic of firms and firm profitability, we estimate a firm-level fixed effects model wherein we consider firm profitability as the dependent variable. Firm profitability is measured using Tobin's Q-ratio and return on equity (ROE). Q-ratio is defined as the ratio of the sum of market value of equity and book value of debt to book value of debt and equity. ROE is defined as the ratio of profit after tax to total equity. Our interest variable is a dummy called *linchpin*, which takes the value 1 if the betweenness centrality measure is in the highest decile and 0 otherwise. We also control for factors that are related to firm profitability like firm size (logarithm of total assets), debt–equity ratio, board size (number of board members), R&D (research and development expense as a percentage of total income), promoter's shareholding and marketing expenditure as a percentage of total income.

We checked for multicollinearity using variance inflation factor and all the values are less than 2 (Appendix 1 Table A2) that linear correlation among the explanatory variables does not affect our model inference.

## 4. Empirical analysis

### 4.1. Small-world analysis

Panel A of Table 1 indicates that the giant component of the inter-firm network constitutes 89% of the firms in 2012, vis-à-vis 72% of firms in 2003. This suggests that more firms are becoming part of the connected network over the years. Further, clustering has remained almost stable; however, the average distance among the firms has decreased during the period. The average number of direct connections of the firm on account of sharing of directors given by degree measure increased to 10.59 in 2007 as compared to 7.67 in 2003. However, between 2007 and 2012, the average degree marginally increased from 10.59 to 11.23. The average path length of the empirical graph is closer to that of a random graph in absolute terms, but the inter-firm network appears to be highly clustered, vis-à-vis the corresponding random graph and as a result the small-world statistic is much larger than 1.

Even though the value of 1 has been used as a benchmark; the calculated statistic value increases with the increase in the number of nodes of the graph. We tabulate the small-world statistic values obtained in a few other small-world studies on ownership and director networks in panel B of Table 1. Our small-world statistic ranges from 21.17 to 31.02 and appears to be comparable to the SW statistic of Indian ownership network analyzed by Mani and Moody (2014). Even though our SW statistic is not comparable to the studies in the context of developed nations owing to differences in the legal and institutional framework, we report their findings for the purpose of benchmarking.

The top 10 firms along with their group affiliation and rankings based on their betweenness scores in each of the years of analysis are given in panel A of Table 2. In all the years, mostly business group firms constitute the major linchpins in the network. This is in line with previous



**Table 1. Small world of board interlock-driven network**

		Panel A				Panel B						
		2003	2007	2012								
Vertices		897	1381	1539								
Edges		2501	6162	7698								
Vertices in giant component		644	1159	1366								
Edges in largest component		2127	5322	6594								
Average degree		7.67	10.59	11.23								
Average path length		4.27	3.98	3.96								
Clustering coefficient		0.34	0.35	0.34								
Average path length (random)		3.17	2.99	2.98								
Clustering coefficient (random)		0.01	0.01	0.01								
Small-world statistic		21.17	28.98	31.02								
		Network	Nodes in giant component	APL	CC	APL (random)	CC (random)	SW statistic				
Kogut and Walker (2001)	German firm network		291	5.64	0.84	3.01	0.022	22.46				
	German ownership network		429	6.09	0.83	5.16	0.008	100.48				
Davis et al. (2003)	US board network		600	4.27	0.88	2.93	0.016	11.84				
	US director network		5311	4.33	0.87	3.06	0.003	183.03				
Mani (2010)	Indian ownership network		1050 firms and 5727 individuals	1.52	2.13E-07	2.69	1.83E-09	201.13				
Mani and Moody (2014)	Indian ownership network		665 firms (2001)	-	-	-	-	23.91 (2001)				
			722 firms (2005)					27.77 (2005)				

**Table 2. Top 10 linchpins in the network**

Rank	Panel A									
	2003			2007			2012			Group
	Firm	Group	Firm	Group	Firm	Group	Firm	Group		
1	I C I C I Bank Ltd.	ICICI Group	Ceat Ltd.	RPG Enterprises Group	Housing Development Finance Corpn. Ltd.	HDFC Group	Housing Development Finance Corpn. Ltd.	HDFC Group	Central Government	
2	Tata Steel Ltd.	Tata Group	Housing Development Finance Corpn. Ltd.	Jaypee Group	JaypeeInfratech Ltd.	Jaypee Group	Jaypee Group	Jaypee Group	Jaypee Group	
3	Housing Development Finance Corpn. Ltd.	HDFC Group	Jayprakash Associates Ltd.	Hindustan Motors Ltd.	Birla C.K. Group	Jayprakash Associates Ltd.	Jayprakash Associates Ltd.	Jaypee Group	Jaypee Group	
4	Ceat Ltd.	RPG Enterprises Group	Hindustan Motors Ltd.	Birla C.K. Group	Jayprakash Associates Ltd.	Jaypee Group	Jaypee Group	Jaypee Group	Jaypee Group	
5	Piramal Enterprises Ltd.	Piramal Ajay Group	Aditya Birla Nuvo Ltd.	Birla Aditya Group	Tata Power Co. Ltd.	Tata Group	Tata Group	Tata Group	Tata Group	
6	Larsen & Toubro Ltd.	Larsen & Toubro Group	Tube Investments Of India Ltd.	MurugappaChettiar Group	Lakshmi Precision Screws Ltd.	Standalone	Lakshmi Precision Screws Ltd.	Standalone	Standalone	
7	Mahindra & Mahindra Ltd.	Mahindra & Mahindra Group	Ambuja Cements Ltd.	Holcim (F) Group	Ceat Ltd.	RPG Enterprises Group	Ceat Ltd.	RPG Enterprises Group	RPG Enterprises Group	
8	Grasim Industries Ltd.	Birla Aditya Group	Shipping Corpn. Of India Ltd.	Central Government	Ashok Leyland Ltd.	Hinduja (Ashok Leyland) Group	Ashok Leyland Ltd.	Hinduja (Ashok Leyland) Group	Hinduja (Ashok Leyland) Group	
9	Atul Ltd.	Lalabhai Group	Tata Steel Ltd.	Tata Group	Jindal Steel & Power Ltd.	Om Prakash Jindal Group	Jindal Steel & Power Ltd.	Om Prakash Jindal Group	Om Prakash Jindal Group	
10	Southern Petrochemical Inds. Corpn. Ltd.	Chidambaram M.A. Group	A C C Ltd.	Holcim (F) Group	Taj G V K Hotels & Resorts Ltd.	GVK Reddy (Novopan) Group	Taj G V K Hotels & Resorts Ltd.	GVK Reddy (Novopan) Group	GVK Reddy (Novopan) Group	
		<b>Panel B</b>								
	<b>Rank in 2003</b>	<b>Rank in 2007</b>	<b>Rank in 2012</b>							
Ceat Ltd.	4	1	7							
Tata Steel Ltd.	2	9	-							
Housing Development Finance Corpn. Ltd.	3	2	1							
Jayprakash Associates Ltd.	-	3	4							
Shipping Corpn. Of India Ltd.	-	8	2							

findings that in India the operations of group firms differ from standalone firms. Panel B of Table 2 lists the firms that act as linchpins in more than 1 year of analysis. Ceat Ltd belonging to RPG Enterprises Group and HDFC of HDFC Group were consistently among the top 10 firms based on betweenness centrality in the last decade. This suggests that among the business group firms, few have consistently acted as the linchpins in the network contributing towards the small worldliness of the network. It is evident from Table 2 that the number of firms forming the giant component has consistently increased and the absolute average distance among the firms has significantly decreased from 2003 to 2012. The results in Table 3 suggest that the fall in average path length from 2003 to 2007 and between 2003 and 2012 is significant. The simultaneous increase in the size of the giant component along with the decrease in the distance among its members can be considered as an indication that the network is becoming more integrated (Goyal, van der Leij, & Moraga-Gonzalez, 2006) or in other words the *small worldliness* of the network is rising. In addition, the absolute value of the small-world statistic has also consistently increased during the period. Thus, the inter-firm network in India is a small world like many other real-world networks, and the small worldliness of the network has increased since the introduction of corporate governance regulations in the country. The increasing small worldliness of the network suggests that the directorial positions in India are getting more and more concentrated in the hands of a few elites of the society.

#### 4.2. Regression analysis

For our regression analysis, we now focus on major linchpins and its relation with firm performance measures. We define deciles of betweenness score of each firm and a firm is considered as a *linchpin* if its corresponding betweenness score is in the 10<sup>th</sup> decile otherwise not. Based on this classification, 381 firm-year observations in the sample are considered as linchpins in the network out of which 227 belong to group firms and 154 are standalone firm observations. Table 4 presents the summary statistics of firm characteristics like Q-ratio, ROE, firm size, board size, leverage and promoter’s shareholding<sup>1</sup> for the full sample and also for the sub-samples which are linchpins in the network and the firms that are not the linchpins in the network. We observe that average Q-ratio for Indian firms is less than unity when we consider all the firms; however, the profitability of firms that are linchpins in the network is higher than that of non-linchpin firms at 5% level of significance. The promoter’s shareholding is more than 50% for full sample as well as the sub-samples in India reinforcing that firms in India have a concentrated ownership structure. The linchpin firms are also significantly larger than non-linchpin firms, so whether higher profitability is a function of network characteristic or capturing the effect of size is difficult to tease out using univariate analysis. Descriptive statistics indicate that network characteristic like being a linchpin can be associated with firm profitability, and to evaluate further, we consider a multivariate regression framework. Column 1 of Table 5 presents the result of our fixed effects estimation using Q-ratio as the dependent variable. We find that being a linchpin in the network is associated with higher market-based profitability measure like Q-ratio. The results obtained from regressing ROE on linchpin and other controls also indicate a positive association at a 10% level of significance. The positive association between both accounting and market measure of performance and the being an important bridging tie in the network indicates the importance of access to non-market strategic information like human resource policies, technological practices and corporate social responsibility (CSR) policy and followed by other firms. Additionally, well-

**Table 3. Summary of network properties**

	2003		2007		2012	
	Mean	Variance	Mean	Variance	Mean	Variance
Average path length	4.26	0.79	3.98***	0.46***	3.96***	0.47***
Clustering coefficient	0.34	0.10	0.35	0.08***	0.34	0.08***
Average degree	7.67	53.13	10.59***	98.77***	11.23	99.07***

\*, \*\* and \*\*\* indicate 10%, 5% and 1% levels of significance, respectively.

**Table 4. Descriptive statistics**

Variables	All firms	Linchpin	Not a linchpin
Q-ratio	0.90	1.18***	0.87
ROE	0.14	0.17	0.14
Firm size	8.45	10.11***	8.26
Board size	8.81	9.12*	8.87
Leverage	0.20	0.22*	0.20
Promoter's share	52.95	51.21	53.16**

\*, \*\* and \*\*\* indicate 10%, 5% and 1% levels of significance, respectively.

**Table 5. Firm performance and being linchpin in the network: fixed and random effects estimators**

Variables	Fixed effects		Random effects	
	Column 1	Column 2	Column 3	Column 4
	Q-ratio	ROE	Q-Ratio	ROE
Linchpin	0.20*** (0.06)	0.06* (0.04)	0.17*** (0.05)	0.01 (0.03)
Firm size	0.07* (0.04)	-0.01 (0.02)	0.03** (0.01)	0.03*** (0.01)
Leverage	0.97*** (0.18)	-0.22* (0.13)	0.52*** (0.08)	-0.12*** (0.04)
Board size	0.00 (0.00)	0.00 (0.00)	-0.00 (0.00)	0.00 (0.00)
Promoter share	0.00 (0.00)	0.00 (0.00)	0.00*** (0.00)	0.00* (0.00)
Constant	-0.27 (0.31)	0.14 (0.18)	0.06 (0.11)	-0.13** (0.06)
Firm fixed effects	Yes	Yes	-	-
Year effects	Yes	Yes	Yes	Yes
Observations	3,370	3,402	3,370	3,402
R <sup>2</sup>	0.15	0.03	0.07	0.02

The table reports the parameter estimates obtained from the regression of firm performance given by Q-ratio and ROE on being a linchpin the network and other firm characteristics variables using firm fixed and random effects.

Significance at 1%, 5% and 10% levels are denoted by \*\*\*, \*\*, \*, respectively, against the parameter estimate values. All standard errors are heteroscedasticity and autocorrelation consistent.

connected directors are likely to bring in prestige and legitimacy to the firm. These factors together may explain higher average Q-ratio and ROE for linchpins in the network compared to non-linchpin firms. Overall, it seems that the higher profitability of linchpins can be attributed to access to a larger pool of information as suggested by resource-dependence theory (Pfeffer & Salancik, 1978). These results are in line with earlier studies like Balasubramanian et al. (2011), Larcker et al. (2013), Peng et al. (2015) and Shaw et al. (2016) where they find a positive relation between firm centrality and profitability in accordance to the resource-dependence hypothesis. Further, as mentioned earlier, the majority of the firms that act as linchpins are business group firms, indicating that network connections can be viewed as one of the reasons why group firms in India exhibit superior profitability compared to standalone firms in India. The result highlights the importance of occupying a central position in the network and access to resources in emerging markets, especially in the absence of fully developed capital markets. It reinforces that the

**Table 6. Hausman test for fixed effects versus random effects**

Variable	Q-ratio regression		ROE regression	
	Difference (FE-RE)	Standard error	Difference (FE-RE)	Standard error
Linchpin	0.026	0.037	0.044	0.026
Firm size	0.046	0.026	-0.036	0.016
Leverage	0.453	0.094	-0.106	0.062
Board size	0.005	0.003	0.002	0.002
Promoter's share	-0.003	0.001	0.000	0.001
Year 2007	-0.052	0.020	0.023	0.013
Year 2012	-0.091	0.038	0.042	0.023
Chi-square (df = 7)	44.94***		15.19**	

The table reports the test result of Hausman test where rejecting the null implies that random effects estimator is inconsistent.

Significance at 1% and 5% levels are denoted by \*\*\* and \*, respectively.

marginal return to additional information is positive for firms in the presence of information asymmetry and incomplete markets.

Firm size is positively related to Q-ratio, suggesting that shareholders may perceive that the larger firms given their reputation in the market are likely to have superior profitability and there exists economies of scale. Having a high debt-equity ratio is negatively associated with ROE as bankruptcy costs of the firms will be higher in accordance to the trade-off theory of capital structure. On the other hand, leverage is positively associated with a market measure of performance like Q-ratio. The firms issuing debt generate a costly signal to the investor about its ability to generate higher future cash flow. It appears that the relation between capital structure and performance is not unambiguous.

Columns 3 and 4 present the random effects estimator obtained from the regressions of Q-ratio and ROE, respectively. The Hausman test indicates that the random effects estimator is inconsistent and hence rejected (Table 6).

Further, we also analyze the relation between profitability and being linchpin for different industries. The results presented in Table A3 of Appendix 1 indicate that occupying an important position within the network is important for firms involved in manufacturing and trading activities. The access to non-market information related to improving productivity and efficiency of manufacturing processes along with the sharing of intellectual capital can be related to profitability. This can have important implications for a country like India where improving profitability and global competitiveness of manufacturing firms in the country is a major policy challenge.<sup>2</sup>

## 5. Summary and conclusions

The study finds that the small worldliness given by the small-world statistic of the network has increased since the introduction of corporate governance regulation in 2003 from 21.17 to 31.02 in 2012. The finding is similar to that of Mani and Moody (2014) who found that the small-world statistic associated with the Indian ownership network has increased between 2001 and 2005. The numbers of firms that are directly connected to each other through interlocks have also increased from 8 firms in 2012 to almost 11 firms in 2012. This may be attributed to the regulatory requirements pertaining to the non-executive and independent directors in India. The introduction of corporate governance regulations led to a sudden increase in the demand of directors in the directorial labor market. However, in the presence of sticky supply curve for expert directors, the individuals already serving on the boards were appointed as non-executive or independent directors by other firms for complying with the regulatory mandate. It indicates that regulatory changes may have inadvertently led to the concentration of directorial positions and create an inner circle of directors in India. The small worldliness of the network can be attributed to the

presence of few linchpins in the network that are predominantly business group firms in the Indian context. To the best of our knowledge, no study has documented the shrinking nature of the directorial network in the context of India as a consequence of the introduction of corporate governance regulations in the country. This finding indicates that policy intending to safeguard minority shareholder's interests may also indirectly have a negative effect of creating a small world of powerful directors and such concentration of power is undesirable from society's long-run equity perspective. The study also contributes to the understanding of public policy dilemma in the context of emerging market economies, especially the trade-off between short-run efficiency versus long-run equity concern.

Our fixed effects estimators indicate that being a linchpin in the network is associated with, on average, 6% higher ROE and 20% higher Q-ratio for listed firms in India. It provides evidence in favor of resource-dependence theory that suggests that the director network increases access to the pool of information which may not be otherwise available to the firm like CSR policy, R&D and human resource policies, etc. In emerging market economies, the marginal return to information is positive in the absence of fully developed capital markets. The findings are similar to those of Peng et al. (2015), Shaw et al. (2016) and Balasubramanian et al. (2011) where they document the positive relation between social capital of board and performance of the firms in the context of emerging market economies like China and India, respectively.

Separate industry-wise analysis highlights that interlocks can be important for the profitability of manufacturing firms where the knowledge of non-market information like improvement in production technology, means of saving energy and other best practices could be crucial in ensuring competitive advantage. It is noteworthy that the change in corporate governance regulations which was primarily to reduce information asymmetry among the insider and the outsider of a firm seems to have put a sub-set of firms in a more advantageous position than others. The majority of the sub-set of these well-positioned firms in India are the business group firms. The group firms that already had greater access to capital and other resources in the country appear to benefit more from changes in corporate governance regulations as well. The managers of Indian firms especially standalone firms may start realizing the importance of the director network and its linkages with various firm outcomes including profitability and strategically appoint directors.

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#### Note

1. The National Manufacturing Policy (2011) of India intends to increase the share of the manufacturing industry in GDP to 25%.

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## Appendix 1

Table A1. The table defines the variables used in the current analysis	
Variable	Description
<b>Small-world measures</b>	
Average path length	Average number of links in geodesic between node <i>i</i> and all other nodes.
Clustering coefficient	Probability that two firms <i>j</i> and <i>k</i> are connected given that firm <i>i</i> has direct ties with firms <i>j</i> and <i>k</i>
Small-world statistic	Ratio of clustering coefficient and average path length
Betweenness	Ratio of number of shortest paths connecting <i>j</i> and <i>k</i> that pass through <i>i</i> and overall number of shortest paths that connect <i>j</i> and <i>k</i>
<b>Regression analysis</b>	
Tobin's Q-ratio	Sum of market value of equity and book value of debt divided by book value of assets
ROE	Ratio of profit after tax to total equity
Firm size	Logarithm of total assets
Board size	Logarithm of number of board of directors during the year of analysis
Promoter's share	Percent of shares held by the firm's promoters
Leverage	Debt-to-equity ratio of the firm
Linchpin	Dummy variable which takes the value one if betweenness score is in the 10 <sup>th</sup> decile and zero otherwise.

Table A2. Variance inflation factor for all the variables in the model		
	VIF	1/VIF
Linchpin	1.17	0.85
Firm size	1.18	0.85
Leverage	1.01	0.99
Board size	1.00	1.00
Promoter's share	1.02	0.98
Mean VIF	1.08	



**Table A3. Industrywise regression output for Q-ratio**

Industry	Agriculture and poultry	Mining	Manufacturing	Construction	Trading	IT/ITES	Financial services	Transportation	Diversified
Linchpin	-0.53	-0.34	0.10**	0.05	0.34**	0.22	-0.07	0.02	-0.17
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs	28	0.41	1977	169	163	183	336	405	64
R <sup>2</sup>	0.50	45	0.08	0.12	0.20	0.09	0.15	0.09	0.09
F-stat	2.91**	3.80***	24.49***	3.06***	5.64***	2.64**	8.32***	6.64***	1.89*



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