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Abstract

This study finds that the inter-firm network in India on account of director interlocks is a small world and the network has become more integrated since the introduction of corporate governance regulations in the country. Using a sample of National Stock Exchange listed firms in India the study finds a negative relation between average path length and probability of acquiring indicating the importance of faster reach of information among the firms within the network. The paper also finds a non-linear relation given by inverted U-shaped curve between firm level clustering and probability of acquiring. Initially, increase in clustering has a positive effect through the informational quality effect; however at higher levels the negative informational redundancy effect dominates leading to a curvilinear relation.

Keywords: Corporate Governance, Small-world, Director Interlocks, Inter-firm Network, Acquisitions

JEL Code: G32, G34, G38, M21, Z130

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Small World of Inter-Firm Network and Firm's Acquisition Behaviour

1. Introduction

The resource dependence theory of board suggests that directors help organisations to manage external uncertainty and provide access to external information and other resources (Pfeffer, 1972). The interlocked director provides the firm access to larger pool of resources on account of his affiliation with numerous firms. These interlocks are one of the mechanisms which facilitate formation of inter-firm network. Studies have found a positive relation between firm's centrality in network on account of director interlocks and its financial performance (Larcket et al., 2013; Balasubramanian et al., 2011). However, the extent of clustering among firms in network also determines the flow of information within the network. The firm level centrality measures given by degree, betweenness and closeness measures (Freeman, 1979) do not account for clustering among neighbouring firms in the network. The small world literature explicitly accounts for effect of clustering in network. Small world is simply the notion that everyone is connected to everyone else in the world (Milgram, 1967). In mathematical terms, small world concept translates into a network characterised by small average path length and high clustering among nodes of the graph (Watts and Strogatz, 1998). The small world effect is favourable for faster diffusion of information among nodes for large networks even if network density is low. These networks have few bridging ties also called the linchpins which enable transfer of information among different clusters. Potentially changes in small world property of a network can directly influence the flow of information. Empirical studies have established the small world nature of the co-authorship network (Newman, 2004; Moody, 2004; Goyal et al. 2006), network of Broadway artists (Uzzi and Spiro, 2005), inter-firm network (Kogut and Walker, 2001; Davis et al., 2003), technology alliance network (Verspagen and Duysters, 2004) and network of

investment banks syndicate (Baum et al., 2003). small world property affects outcomes. Few studies also analyse the effect of small world property of clustering on firm level outcomes like innovation (Ahuja, 2000; Schelling and Phelps, 2007; Fleming et. al. 2007), mergers and acquitisions (Davis et al., 2012) and lower firm value (Mendes-Da-Silva and Verges, 2011). This paper attempts to understand inter-firm network formed on account of director interlocks in India using the small world approach and analyse whether firm level constituents of small world property is related to firm outcome.

Using a sample of NSE listed firms in India we find that the inter-firm network formed on account of sharing of directors is a small world. The small world feature essentially depends upon presence of linchpins in an otherwise sparsely connected network which reduces the path length drastically. The business group firms act as major linchpins in the network which highlights the powerful position of group firms in Indian corporate sector. Further, since the introduction of corporate governance regulations, there appears to be a rise in integration within the network. To analyse whether firm level constituents of small world property affects firm behaviour we choose acquisition as a desirable firm outcome, since it is an important corporate level strategy for the firms to achieve its long run growth targets. Mostly acquisitions are undertaken for the purpose of diversification, vertical integration, market entry and others. Any acquisition proposal by the management of the firm has to be approved by board of directors before its implementation and it entails active involvement of directors. While searching for a target, the firm can obtain factual information about potential target from their financial statements, analysts' reports and various other sources. However, soft information regarding the internal management of the potential target and their organisational culture may not be readily available in the market. The presence of inter-firm ties through interlocks can be an important

source of availability of hard as well as soft information that reduce the search costs and help in identification of potential target. So, acquisition is a vital firm outcome that can determine the growth trajectory of the firm in the long run and interlocks may facilitate this process.

We find that node level average path length is negatively associated with firm's probability of acquisition as it makes the search process for target firms longer. On the other hand there exist an inverted U-shaped relation between node level clustering and logit of probability of acquisition indicating the trade-off between the quality of information and amount of accessible information. The firm level small world measure and the network level small world statistic also have a quadratic relation with the likelihood function. Further, the group firms having more number of direct ties within the group are more affected by increase in distance from other firms in the network. We find that small world properties are also related to the probability of number of bids. The findings emphasise the role of director interlocks in transmission of soft information among the firms in the network.

The contribution of this paper to the existing literature is primarily twofold. Firstly, it adds to the small world literature by analysing small world feature of director interlocks driven inter-firm ties and highlights shrinking nature of network in the context of an emerging economy. Secondly, it contributes to the literature of ego-centric network studies by analysing the relationship of node level properties of clustering and average path length on probability of firm level acquisition tendencies.

The remaining of the paper is structured as follows. Section 2 develops the testable hypotheses and section 3 provides a description of data and the methodology followed. Section 4 presents the small world analysis of the interlock driven network. Section 5 discusses the empirical findings and section 6 gives the summary and conclusions of the study.

2. Development of Hypotheses

In the pre and post-independence era in India, director interlocks were observable phenomenon given the dearth of managerial talent (Mehta, 1955). Further Indian economy has been historically dominated by large business groups (Mehta, 1955; Sarkar, 2010) and often the promoter or his/her relatives occupy board positions of group companies for monitoring purposes. 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. In presence of concentrated ownership structure monitoring role of board becomes vital to ensure that majority shareholders do not expropriate minority shareholders. In order to protect shareholders' interests; the corporate governance regulations in the form of the Clause 49 of the Listing Agreement was introduced in India in 2003 and was later revised in 2006[3]. The regulations led to a sudden increase in demand of directors in the directorial labour market. In such a scenario directors already serving on boards of firms may have been appointed as non-executive or independent directors by other firms for complying with the regulatory mandate. This may have led to further increase in concentration of managerial power in the hands of the few. It suggests that interlock driven network can not only be characterised as a small world, but post introduction of corporate governance regulations, the 'small worldliness' of the network may have increased. We intend to analyse how firm level attributes of small world property may affect firm outcomes.

We consider an important firm level strategic decision – probability to acquire another firm - as the desired outcome variable. As discussed above, the process of identifying a potential

[3]The regulation requires that at least half of the board of the listed firms is composed of non-executive directors. The proportion of independent directors needs to at least one-third for boards that are headed by a non-executive director and at least fifty percent in case the board has an executive chairman.

target is largely dependent on availability of both hard and soft information about the target firm. The interlocked director network can provide access to hard as well as soft information to the firm. As financial markets develops, the availability of hard or factual information in form of financial reports, stock prices and analysts' reports increases. However, it is also important to obtain knowledge about other factors like management style, employee diversity and human resource policies of the potential target in order to ensure a seamless and successful merger. Such information can be categorised as soft information. Given the importance of inter-firm network in transmission of soft information among the firms which may not be otherwise available in the market, network level properties can be vital in influencing firm policies like acquisition.

The acquiring firm's search for a potential target largely depends upon availability of timely information about potential target. Assuming that each tie is an information source, then a firm (node) that is farther away from other firms (nodes) is likely to have access to lesser information due to slower reach. This is to say that as the average path length of the firm increases the flow of vital information falls. Thus, we propose:

Hypothesis 1a: The increase in average path length of firm is negatively associated with its probability of acquisition.

On the other hand, clustering has two opposing effects on the flow of information. Clustering can enhance flow of information in two ways. Firstly, clustering can build trust among members of the cluster leading to efficient flow of information (Coleman, 1988). In a cluster as each member is directly connected to other; any deviation from cooperation is observable and can be punished by the cluster members and this can act as a threat to firm's reputation. Secondly, as clustering rises information available to the firm can reach other firms faster due to presence of ties among neighbours and also ensures better quality of information.

On the contrary clustering can be viewed as localisation of information or lack of availability of diverse information. The members of highly clustered group have no or less number of ties outside the cluster which shrinks the pool of available resources and such clustering may not provide significant information benefit to the firm. According to Burt (2004); ties with same set of nodes leads to informational redundancy.

While searching for a potential target, both quality of information as well as availability of diverse information about other firms in the network is important. Thus, there exists a trade-off between quality of information available to the firm and the variety of information that the firm can access. Ex-ante it appears that that there exists a non-linear relation between the extent of clustering in the network and probability of acquisition. Uzzi and Spiro (2005) find a parabolic relation between the level of clustering in the Broadway artist network and the creativity of the members. At lower levels, an increase in clustering can enhance the quality of transmitted information due to trust within the cluster and this is the *information quality effect*. However, after a threshold is reached any further increase in clustering may circulate same information within the network providing no informational advantage to the firms. This is the *information redundancy effect* as highlighted by Burt (2004). So, we hypothesise:

Hypothesis 1b: At lower levels an increase in firm level clustering has a positive effect on the probability of acquisition, however post a threshold level any further increase in clustering is likely to be negatively related to the probability of acquisition.

Given that group firms have different characteristics than standalone firms in emerging markets, the relation between firm level small world characteristics and probability of acquisition may also differ for these sub-samples. The group firms in India have number of directorial ties within the group (Sarkar and Sarkar, 2012) and lesser number of ties with standalone firms.

These group firms may already possess information about other firms in its group through pre-existing channels like equity ownership and transfer of goods. In such a scenario directorial ties with group firms can provide less informational advantage than standalone firms. Having strong ties within the group may not be always beneficial and having weaker ties with members outside the group may provide vital information[4] to group firms (Granovetter, 1973). The less number of ties with standalone firms or firms belonging to other business groups reduce the availability of diverse information and as a result the informational redundancy effect is likely to dominate the effect of superior quality of the information within the cluster at much lower levels. This leads to the next set of hypotheses:

Hypothesis 2a: The negative relation between average path length and probability of acquisition will be stronger for group firms.

Hypothesis 2b: The negative informational redundancy effect of clustering will outweigh the positive informational quality effect at lower levels for group firms.

If firm level small world properties help in dissemination of soft information which may be important in acquisition deals, then the availability of such information is also likely to be related to the probability of the number of acquisition bids initiated by the firm in the following year. This leads to the following hypotheses:

Hypothesis 3a: The increase in average path length of firm is negatively associated with probability of more number of acquisition bids by the firm.

Hypothesis 3b: An increase in firm's clustering has a positive effect on the probability of number of acquisition bids at lower levels, but at higher levels of clustering the probability of number of acquisition bids are likely to fall.

[4]Granovetter's (1973) study finds that weak ties are more important for obtaining job referrals than direct ties.

3. Data and Methodology

Our analysis relies on the data provided by the Prowess database maintained by the Centre for Monitoring Indian Economy (CMIE). Prowess is a database containing detailed information on large and medium Indian firms from their respective annual reports. It contains activity codes of firms, equity ownership pattern, financial data as well as the names of the directors of firms. The sample consists of all firms listed on the National Stock Exchange of India in 2012 for which information on their board of directors was available for 2003, 2007 and 2012. The study considers listed firms in 2012 which is the most recent year for which data is available. Further, the firms are traced back in 2003 and 2007 to focus on firms immediately after the introduction of corporate governance regulations in March 2003, and also in the period post the implementation of the revised Clause 49 of the Listing Agreement in January 2006 respectively. We only consider the firms who are members of giant component of the network for this analysis. 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. Post screening we arrived at a sample of 3130 firm year observations.

3.1 Small World Statistic

The small world statistic is defined as the ratio of clustering coefficient to average path length of the graph. The clustering coefficient of a node *i* is given by the probability that nodes connected to *i* are themselves connected. In other words it represents the transitivity property of a node and is given as:$CC_i = P(X_{jk} = 1|X_{ij} = X_{ik} = 1)$. Clustering coefficient of firm *i* gives the probability that two firms *j* and *k* are connected given that firm *i* has direct ties with firms *j* and *k*. The average path length is the number of links in geodesic between node *i* and all other nodes and is

given by: $\mathrm{APL_i} = \frac{\sum_{j,i\neq j} l(i,j)}{N}$, where *N* is the number of nodes in the network and *l(i,j)* is number of links between nodes *i* and *j*. The graph level clustering coefficient and average path length is simply the average of node level clustering coefficients and average path lengths respectively.

In order to compare the ratio, general norm is to normalise it with the ratio of clustering coefficient to average path length of a random graph with 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 ($\mathrm{APL_R}$) tends to LogN/Logk and clustering coefficient ($\mathrm{CC_R}$) can be approximated by k/N. Thus, the small world statistic (SW) of graph is given as: $\mathrm{SW} = (\frac{\mathrm{CC}}{\mathrm{CC_R}})/(\frac{\mathrm{APL}}{\mathrm{APL_R}})$.If the SW statistic is greater than one then the graph is said to be a small world. However, most of the studies find that SW statistic much larger than one and the obtained value of the SW statistic increases with the number of nodes in the network.

3.2 Acquisition Behaviour

3.2.1 Dependent Variable

The firm's decision to acquire another firm in a particular year is likely to depend on accounting information, strategy and resources in the previous year. Hence, for predicting acquisitions we collect information on mergers and acquisitions announcements in 2004, 2008 and 2013 of the firms listed with NSE. We consider all bids that were made by firms in these years including failed bids. The aim of the analysis is to study the role of non-market information in predicting probability of making a bid and not necessarily a successful bid. The dependent variable '*acquire'* is a dummy which takes the value one if the firm has initiated any acquisition bid during 2004, 2008 or 2013 and zero otherwise.

It is possible that a firm makes more than one acquisitions announcements during the year, however, multiple announcements are not captured by our 'acquire' variable. In order to focus on the number of bids made by a particular firm during the year we define a variable called *'number of bids'* which takes the value zero if the firm did not initiate any bid, assumes the value one if the firm initiates one deal, and equals two if the firm initiates more than one acquisitions during the year.

3.2.2 Control Variables

In the regression analysis, we control for firm's level of leverage, market to book value ratio, firm size, group affiliation, profitability and cash flow. The more leveraged a firm, lower is its likelihood of acquiring another firm. We define leverage as debt to equity ratio of the firm. Studies suggest that acquiring firms are likely to have high market to book ratio (Andrade et al., 2001; Rhodes-Kropf and Robinson, 2008), hence we control for the market to book value ratio given as the ratio of market value of equity to net worth of firm. The more profitable firms and those with more cash flow are more likely to acquire as they have more resources at their disposal. We use the ratio of profit before depreciation, income tax and amortization (PBDITA) to total sales as a proxy for cash flow of the firm. We consider size of firm as a proxy for its market power. The larger firms are more likely to acquire firms to increase its current market power. The size of firm is given by the logarithm of total assets. Affiliation to a group can also affect acquisition behaviour. The group firms can engage in more acquisition activities in order to diversify into newer industries. Also, firms affiliated to a group can obtain financial resources from other group firms and get access to external funding at lower rates (Gopalan et al., 2007). Thus, group firms can be in a better position to obtain funding required for merger and acquisition. Group affiliation is given by group dummy which takes the value one if firm belongs

to a business group and zero otherwise. In addition to these control suggested by literature, we also control for the centrality of firm in the network on account of director interlocks. The resource dependence view suggests that the firms having director interlocks are in a favourable position to access information which can be vital for strategic behaviour like acquisition. We control for firm's centrality in the network using *eigen measure* of centrality proposed by Bonacich (1972, 1987).The eigen centrality gives importance to quality of ties of each firm i.e. each firm's centrality is measured as the weighted sum of its ties where weights are the scores of qualitative ties of connected firm. Intuitively, say firm *i* is connected to firm *j* which in turn is connected to other well connected firms, as a result *i* will be in a stronger position in the network in terms of access to information and power. Thus, the eigen vector centrality of each node is a proportion of the sum of centrality of the neighbouring nodes. It is given as $\lambda C_i^e(A) = \sum_{j=1}^{n} a_{ij}.C_j^e(A)$, where $C^e(A)$ is an eigen vector of A and λ is its eigen value. As relations in network are assumed to be either positive or neutral, only non-negative eigen values are considered. Bonacich suggested that eigen vector associated with largest eigen value be considered as the centrality of firm. We also incorporate industry and time dummies in order to control for industry and time specific factors respectively.

3.3 Methodology

We use a logit specification for the analysis of hypotheses 1a-2b and the model is given as:

$$P_i = E(Y|X_i) = \frac{1}{1+\exp(-Z_i)} \quad (1)$$

where$Z_i = \beta_0+\beta_1 X_{1,i}+\beta_2 X_{2,i} + \cdots +\beta_k X_{k,i}$

$$L_i = \ln\frac{P_i}{1-P_i} = Z_i \quad (2)$$

$$\frac{\partial P_i}{\partial X_i} = \beta_i P_i (1 - P_i) \quad (3)$$

Equation 2 gives the linear relation between the regressors and the logit (L_i) and equation 3 gives the change in probability of an outcome for an incremental change in the regressors (X) which is a non-linear relation. Specifically for the average path length and clustering coefficient we estimate models given by equations 4-5 respectively.

$$L_i = \ln \frac{P_{i,t+1}}{1 - P_{i,t+1}} = \beta_0 + \beta_1 \text{Average path length}_{i,t} + \sum_j \beta_j \text{ Firm characteristics}_{i,t} + \sum_l \gamma_l \text{ Industrydummies} + \sum_k \delta_k \text{ YearDummies} + \varepsilon_{i,t+1} \quad (4)$$

$$L_i = \ln \frac{P_{i,t+1}}{1 - P_{i,t+1}} = \beta_0 + \beta_1 \text{Clustering coefficient}_{i,t} + \beta_2 \text{Clustering coefficient}_{i,t}^2 + \sum_j \beta_j \text{ Firm characteristics}_{i,t} + \sum_l \gamma_l \text{ Industrydummies} + \sum_k \delta_k \text{ YearDummies} + \varepsilon_{i,t+1} \quad (5)$$

where $P_{i,t+1}$ is the one year ahead probability of an acquisition bid by the firm.

To test hypotheses 3a and 3b we apply an ordered logit model wherein our dependent variable is *number of acquisition bids* unlike acquire dummy in the above specification. We use an ordered logit instead of count data models as number of bids is a categorical variable (number of bids variable takes the value zero when firm do not initiate any bid, one corresponds to single bid and the dependent variable assumes two when there are more than one bid by the firm). This

model is also called proportional odds model since it assumes that all the variables on the right hand side of the equation are related in the same manner across different thresholds. So, for three categories of the ordinal variable the conditional and cumulative probabilities are given as:

$$P(Y_i = j|X_i) = \begin{cases} F(\alpha_0 - \beta X_i), & j = 0 \\ F(\alpha_2 - \beta X_i) - F(\alpha_1 - \beta X_i), & j = 1 \\ 1 - F(\alpha_2 - \beta X_i), & j = 2 \end{cases} \quad (6)$$

$$P(Y_i \leq j|X_i) = \frac{\exp(\alpha_j - \beta X_i)}{1+\exp(\alpha_j - \beta X_i)} \quad (7)$$

We carry out one and 99 percent winsorisation of the data to ensure that results are not affected by presence of extreme values of the variables.

4. Small World Analysis

Panel A of table 1 indicates that the giant component of inter-firm network constitutes 89 percent of firms in 2012 vis-à-vis 72 percent firms in 2003. This suggests that more firms are becoming part of maximally connected network over the years. Further, clustering has remained almost stable, however, average distance among firms have 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 average degree marginally increased from 10.59 to 11.23. The average path length of empirical graph is closer to that of a random graph in absolute terms, but inter-firm network appears to be highly clustered vis-à-vis corresponding random graph and as a result the small world statistic is much larger than one.

Table 1: Small World of Director Interlock Driven Network

Panel A gives the year-wise small world statistic and other topological properties of interlock driven inter-firm network. The small world statistic is given as the ratio of clustering coefficient to the average path length of the after being normalised with respect to a random graph with same number of nodes and average degree. The average path length is the average of distances among all the nodes in the network. The clustering coefficient is the average of node level clustering coefficients of all the nodes which is given by the probability that the neighbours of a node are themselves connected. Average degree is defined the mean of the number of direct connections of all the nodes in the network. Panel B presents a summary of few of the previous small world studies on board and ownership networks.

	Panel A		
	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

Panel B

Authors	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 (2012)	Indian ownership network	1050 firms and 5727 individuals	1.52	2.13E-07	2.69	1.831E-09	201.13

Even though the value of one has been used as a benchmark; calculated statistic value increases with rise in number of nodes of the graph. We tabulate the small world statistic values obtained in 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 value of 22.46 for German board network of 291 nodes (Kogut and Walker, 2001) and higher than the value of 11.84 found for US board network of 600 nodes (Davis et al., 2003). This suggests that director interlocks in India may not be a purely random outcome and inter-firm network driven by director interlocks in India does appear to be a small world.

The small world phenomenon prevails due to presence of few shortcuts in an otherwise sparse network. Few firms connect distant clusters within the network and they are called 'linchpins' or 'structural holes' (Burt, 2004) within the network. To identify linchpins in the network, we compute betweenness centrality (Freeman, 1979) of firms. 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*. If this ratio is close to 1, then *i* lies on most of the shortest paths connecting *k* to *j*, while if it is close to 0, then *i* is less critical to *k* and *j*. Let $P_i(kj)$ denote the number of geodesics between *j* and *k* that *i* lies on, and let $P(kj)$ be the total number of geodesics between *j* and *k* . Then betweenness centrality is given by: $\sum_{k \neq j : i \notin (k,j)} \frac{P_i(kj)}{P(kj)}$. The top ten firms along with their group affiliation and rankings based on their betweenness scores in each years of analysis are given in panel A of table 2. In all years mostly business group firms constitutes major linchpins in the network. Panel B of table 2 lists firms which act as linchpins in more than one year of analysis. Ceat Ltd belonging to RPG Enterprises Group and HDFC of HDFC Group were consistently among the top ten firms based on betweenness centrality in last decade. Also, in 2003 and 2007 three common firms occupied

the top ten positions and four most central firms in 2007 also remained central in 2012. This suggests that among business group firms few have consistently acted as linchpins in the network contributing towards small worldliness of the network.

Table 2: Top Ten Linchpins in the Network

Panel A gives the top ten firms which acted as linchpins in the network for each year under analysis based on their betweenness centrality scores. The betweenness centrality is computed as the ratio of number of shortest path connecting two nodes 'j' and 'k' that passes through node 'i' to total number of shortest paths connecting nodes 'j' and 'k'. It also provides group affiliation as given by CMIE Prowess and year-wise rankings of top ten firms. Panel B gives firms which featured among the top ten central firms in more than one year along with their year-wise rankings.

Panel A

Rank	2003		2007		2012	
	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
2	Ceat Ltd.	RPG Enterprises Group	Housing Development Finance Corpn. Ltd.	HDFC Group	Shipping Corpn. Of India Ltd.	Central Government
3	Tata Steel Ltd.	Tata Group	Jaiprakash Associates Ltd.	Jaypee Group	Tata Power Co. Ltd.	Tata Group
4	Housing Development Finance Corpn. Ltd.	HDFC Group	Hindustan Motors Ltd.	Birla C.K. Group	Jaypee Infratech Ltd.	Jaypee Group
5	Piramal Enterprises Ltd.	Piramal Ajay Group	Tube Investments Of India Ltd.	Murugappa Chettiar Group	Lakshmi Precision Screws Ltd.	Private (Indian)
6	Larsen & Toubro Ltd.	Larsen & Toubro Group	Aditya Birla Nuvo Ltd.	Birla Aditya Group	Ceat Ltd.	RPG Enterprises Group
7	Atul Ltd.	Lalbhai Group	Ambuja Cements Ltd.	Holcim (F) Group	Jaiprakash Associates Ltd.	Jaypee Group
8	Mahindra & Mahindra Ltd.	Mahindra & Mahindra Group	Shipping Corpn. Of India Ltd.	Central Government	Ashok Leyland Ltd.	Hinduja (Ashok Leyland) Group
9	Grasim Industries Ltd.	Birla Aditya Group	Tata Steel Ltd.	Tata Group	Taj G V K Hotels & Resorts Ltd.	GVK Reddy (Novopan) Group
10	Southern Petrochemical Inds. Corpn. Ltd.	Chidambaram M.A. Group	A C C Ltd.	Holcim (F) Group	Jindal Steel & Power Ltd.	Om Prakash Jindal Group

Panel B

	Rank in 2003	Rank in 2007	Rank in 2012
Ceat Ltd.	2	1	6
Tata Steel Ltd.	3	9	-
Housing Development Finance Corpn. Ltd.	4	2	1
Jaiprakash Associates Ltd.	-	3	7
Shipping Corpn. Of India Ltd.	-	8	2

It is evident from table 1 that number of firms forming the giant component has consistently increased and magnitude of average distance among firms has 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 size of giant component along with the decrease in distance among its member can be considered as an indication that the network is becoming more integrated (Goyal et al., 2006) or in other words 'small worldliness' of the network is rising. In addition, absolute value of small world statistic has also consistently increased during this period. Thus, inter-firm network in India can be characterised as a small world and it appears that small worldliness of the network has risen in last decade. The increasing small worldliness of the network suggests that managerial power in India is getting more and more concentrated in the hands of few elites of the society.

Table 3: Summary of Network Properties

The table gives the significance of mean and variance of average path length, clustering coefficient and average degree for each pair of years under analysis based on two tailed difference of mean t-tests. The average path length is the average of distance among all the nodes in the network. The clustering coefficient is the average of node level clustering coefficients of all the nodes which is given by the probability that the neighbours of a node are themselves connected. Average degree is defined the mean of the number of direct connections of all the nodes in the network.

	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***

Significance at 1 percent is denoted by ****.

5. Acquisition Analysis

5.1 Descriptive Statistics

Table 4 gives year-wise distribution of firm outcome variable i.e. number of firms that offered an acquisition bid in the following year. Out of the total 456 acquisition bids, 251 are by group firms and remaining 205 bids are by standalone firms. The number of acquisition bids in 2008 was 234 which is maximum among the three years under consideration.

Table 4: Year-wise Acquisition Bids by Firms

The table gives the year-wise number of firms who made an acquisition bid and its distribution by the type of firm. Group affiliations of firms are based on the business group classification data provided by CMIE Prowess. All firms which are not classified as group firms are categorised as standalone firms.

Number of a firms	2004	2008	2013	Total
Group	53	124	74	251
Standalone	33	110	62	205
All firms	86	234	136	456

Table 5 presents the descriptive statistics for full sample of firms and also for group and standalone firms separately. The firms within the network can be on average reached through other four intermediate firms. The mean clustering coefficient is 0.34 suggesting that around 34 percent of a firm's neighbours are themselves connected in the network. The results of simple two sided mean t-test indicates that group firms are on average larger, connected to more connected firms in the network given by higher average and median eigen measure of centrality and have smaller path lengths compared to their standalone counterparts. However, the performance of group firms and standalone firms given by return on assets and market-to-book value on average do not appear to vary significantly. The Wilcoxon signed rank test does suggest that median performance of group firms is better than that of standalone firms.

Table 5: Descriptive Statistic

The table presents summary statistics for full sample of firms as well as for business group firms and standalone firms. Firm size is defined as logarithm of total assets during the year. Leverage ratio gives the debt equity ratio. Cash flow is defined as ratio of PBDITA to total sales of firm. Market to book value is given by ratio of market value of equity to net value of firm and return on assets is ratio of profit before interest and taxes to total assets. The average path length is the average of distances among all the nodes in network. The clustering coefficient is average of node level clustering coefficients of all nodes which is given by the probability that neighbours of a node are themselves connected. Small world measure is the normalised ratio of clustering coefficient and average path length. Eigen is a measure of how well connected are the direct connections of the firm. The significance of mean is based on two tailed difference of mean t-test. The significance in median is based on results of Wilcoxon signed rank test for difference of medians.

	All firms		Standalone firms		Group firms	
	Mean	Median	Mean	Median	Mean	Median
Firm size	8.72	8.54	8.65**	8.42***	8.80	8.67
Leverage	1.22	0.68	1.21	0.67	1.23	0.68
Cash flow	0.23	0.16	0.26	0.16	0.23	0.16
Market-to-book value	0.22	0.11	0.23	0.12***	0.21	0.10
Return on assets	0.13	0.12	0.13	0.12*	0.13	0.12
Average path length	4.03	3.87	4.13	3.98	3.93***	3.78***
Clustering coefficient	0.34	0.29	0.34	0.29**	0.35	0.29
Small-world measure	29.59	26.35	29.05	25.90**	30.11	26.71
Eigen	0.03	0.00	0.02***	0.00***	0.03	0.00

Significance at 1 percent, 5 percent and 10 percent levels are denoted by ****, **, * respectively.

5.2 Regression Results

The result of analysing equation 4 is given in column 1 of table 6. It indicates that after controlling for other factors as firm level average path length increases the likelihood of acquisition falls. Thus, farther away a firm is from others in the network; information takes longer to reach the firm which in turn increases search time for a target. As search process becomes longer the probability of acquisition decreases. This provides support for our hypothesis 1a that time required for flow of information among firms can potentially be related to probability of acquisition.

Column 2 of table 6 gives regression result of effect of clustering on probability of acquisition given by equation 5. The parameter estimates of linear and quadratic terms of clustering coefficient indicate that there exists a non-linear inverted U-shaped relation between

firm's local clustering and logit function corresponding to the probability of acquisition. Initially an increase in clustering among firms in the network can be beneficial as high quality information is shared among members of the cluster due to trust factor. This is the informational quality effect in network. Also, given large number of direct connections among members of the cluster information spreads rapidly. However, there are diminishing returns to additional information in network and once a threshold level is reached, any further increase in clustering negatively affects the firm. A firm belonging to a highly clustered local network has very few ties with firms outside the cluster. This reduces variety of information available to the firm and same information circulates within the cluster and gives rise to information redundancy effect. Very high clustering makes search for the target difficult and in turn negatively affects probability of acquisition.

The negative informational redundancy effect of clustering outweighs the positive informational quality effect when clustering in network exceeds 0.41 which is just above mean level of clustering (0.34) in the network. Around 30 percent of firm year observations have a clustering greater than 0.41 and for remaining 70 percent of firms in India clustering can be helpful in providing vital information about potential target. This indicates that only excessive clustering may not provide any informational advantage to firms and can actually be detrimental. In agreement to hypothesis 1b, we find that above a threshold level of clustering; the informational redundancy effect within network dominates the informational quality effect leading to inverted U-shaped relation between node level clustering and underlying logit function.

Now, we consider the ratio of firm level clustering coefficient and average path length which we call the *firm-level small world measure* and re-estimate the relation. The results in

column 3 of table 6 gives that firm level small world measure initially increases probability of acquisition and similar to clustering coefficient has a negative relation at higher levels. The threshold level of firm level small world measure post which there exist a negative association is 36.57 which is higher than both mean and median firm level small world measure.

Table 6: Small World Characteristic and Probability of Acquisition

The table reports parameter estimates obtained from logit regression of node level network properties of average path length, clustering coefficient, firm level small world measure on probability of acquisition bids. The dependent variable is given by *acquire* dummy which takes the value one if firm has made an acquisition bid in the following year and zero otherwise. The average path length is average of distance of a particular node *i* from all other nodes in network. The clustering coefficient gives the probability that neighbours of a node are themselves connected. Small world statistic gives normalised ratio of clustering to average path length. The values in parenthesis are standard errors clustered at individual firm level. The independent variables are a set of firm characteristic variables, group dummy, industry dummies and year dummies.

Variables	Column1	Column2	Column3
Average path length	-0.428***		
	(0.115)		
Clustering coefficient		1.416**	
		(0.612)	
Clustering coefficient* Clustering coefficient		-1.737***	
		(0.621)	
Firm level small world			0.015**
			(0.007)
Firm level small world * Firm level small world			-0.000**
			(0.000)
Leverage	-0.086*	-0.087*	-0.086*
	(0.044)	(0.045)	(0.045)
Group dummy	0.018	0.041	0.041
	(0.116)	(0.116)	(0.116)
Return on assets	1.249**	1.516***	1.555***
	(0.590)	(0.585)	(0.585)
Market to book ratio	0.052	0.043	0.043
	(0.104)	(0.106)	(0.106)
Firm size	0.264***	0.297***	0.300***
	(0.037)	(0.036)	(0.036)
Cash flow	-0.357	-0.408	-0.409
	(0.263)	(0.266)	(0.266)
Eigen measure	0.988*	1.578***	1.671***
	(0.568)	(0.550)	(0.549)
Industry dummies	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Constant	-15.210***	-17.307***	-18.415***
	(0.892)	(0.642)	(0.429)
Observations	3,130	3,130	3,130
Pseudo R-squared	0.090	0.086	0.084

Significance at 1 percent, 5 percent and 10 percent levels are denoted by ****, **, * respectively against the parameter estimate values. The Pseudo R-squared corresponds to McFadden's R-squared values.

With respect to control variables we observe that the firms which are more profitable given by return on assets are more likely to acquire. Also, larger firms are expected to engage more in acquisitions to increase their market power. The coefficient of leverage is negative indicating that firms that have higher debts are less likely to acquire. The coefficient of eigen is positive and significant highlighting that strength of direct connections can be an important source of information and resources for the firm. However, group affiliation, cash flow and firm's market to book value ratio are not related to firm's probability of acquisition.

Now, to analyse the effect of group affiliation on probability of firm outcome relation, we split the sample into of group and standalone firms and re-estimate the results. The firms belonging to a business group have more number of ties within the group and lesser number of ties with standalone firms which in turn shrink its pool of available information. Thus, ex-ante group affiliation can directly have a negative effect on availability of information about potential targets. Table 7 presents the results for sub-sample of group firms and standalone firms. Column1 gives coefficient of the interest variables for group firms. We find that average path length which is negative and significant at one percent level of significance for group firms. For the group firms, similar to the full-sample result the clustering and firm level small world measures have a non-linear relation with the logit function. The inflection points for clustering coefficient and firm level small world measure is at 0.42 and 35.38 respectively for group firms is also close to the levels observed for the full sample. Column 2 of table 7 gives the results for standalone firms. The average path length has a negative and significant coefficient. The magnitude of parameter estimate of average path length variable for group firms is higher than standalone firms. It indicates that negative relation between average path length and probability of acquisition is stronger for group firms. The results suggest that negative effect of increasing

average path length is stronger for group firms in accordance to hypothesis 2a. The clustering coefficient and firm level small world statistic is not significant for standalone firms. It appears that the full sample results are essentially driven by group firms in the sample.

Table 7: Small World Characteristic and Probability of Acquisition-Group and Standalone Firms

The table reports parameter estimates obtained from logit regression of node level network properties of average path length, clustering coefficient, firm level small world measure on probability of acquisition bids for the sub-sample of group and standalone firms. The dependent variable is given by *acquire* dummy which takes the value one if the firm has made an acquisition bid in the following year and zero otherwise. The average path length is the average of distance of a particular node *i* from all other nodes in the network. The clustering coefficient gives the probability that the neighbours of a node are themselves connected. Small world statistic gives the normalised ratio of clustering to average path length. The values in parenthesis are standard errors clustered at individual firm level. For brevity sake we have reported only the coefficients of interest variables.

Variables	Column1 Group firms	Column2 Standalone firms
Average path length	-0.518***	-0.344**
	(0.169)	(0.163)
Clustering coefficient	2.510***	0.608
	(0.942)	(0.825)
Clustering coefficient* Clustering coefficient	-2.976***	-0.812
	2.510***	(0.840)
Firm level small world	0.029**	0.005
	(0.012)	(0.010)
Firm level small world* Firm level small world	-0.000***	-0.000
	(0.000)	(0.000)
Industry dummies	Yes	Yes
Year dummies	Yes	Yes
Other controls	Yes	Yes
Observations	1,584	1,516

Significance at 1 percent and 5 percent levels are denoted by ****, ** respectively against the parameter estimate values. The Pseudo R-squared corresponds to McFadden's R-squared values.

Table 8 presents the result obtained from ordered logistic regression. The dependent variable has three categories i.e. whether the firm is a non-acquirer, initiates single bid or initiates more than one bid. It is evident that the nature of relation between small world characteristics and the number of acquisitions mimics the logistic regression results. For example, column 1 suggests that a unit increase in log odds of average path length decreases the chances of being in the two higher categories by 0.44. The cut 1 and cut 2 are the ancillary

parameters which differentiates the three categories. Cut 1 gives that the observations whose latent variable values are less than 3.79 are classified as non-acquirers when all the explanatory variables are assumed to be zero. Similarly, all the observations above 6.08 will be classified as multiple bidders and the values between 3.79 and 6.08 corresponds to firms with single bids. The assumption of parallel regression was not rejected by the Brant's test (not reported). The findings reiterate that small world characteristics are not only important in predicting probability of acquisition, but can also be related to the likelihood of number of acquisition bids as suggested by hypotheses 3a and 3b.

5.3 Robustness Analyses

To check the persistence of results, we carry out several robustness tests. First we consider alternate specification of firm size and profitability variables. The alternate firm size and profitability indicators are given by logarithm of total income and return on equity (ROE) respectively. ROE is defined as the ratio of post-tax profit to net worth of firm. Column 1 of table 9 indicates that the relation between firm level small world measure and probability of acquisition are qualitatively similar under alternate definition of control variables. Further, it is possible that firm which has higher growth potential is more likely to acquire other firms in order to grow faster. We include R&D, advertising and marketing expenses to total income as a proxy for growth opportunities in the model for predicting acquisition as an additional control. The results obtained from the re-estimation with additional control variable along with set of alternate control variables and are given in column 2 of table 9. We find that the relation between probability of acquisition and firm level small world measure is robust to the inclusion of additional control variable of growth opportunity and alternate definition of firm size and firm performance variables.

Table 8: Small World Characteristic and Number of Acquisitions

The table reports parameter estimates obtained from ordered logit regression of node level network properties of average path length, clustering coefficient, firm level small world measure on number of bids. The dependent variable is given by *number of bids* which takes the value zero if there are no acquisition bids, equals one if the firm has makes one acquisition bid and assumes the value two if there are more than one acquisition bids. The average path length is the average of distance of a particular node *i* from all other nodes in the network. The clustering coefficient gives the probability that the neighbours of a node are themselves connected. Small world statistic gives the normalised ratio of clustering to average path length. The values in parenthesis are standard errors clustered at individual firm level. The independent variables are a set of firm characteristic variables, group dummy, industry dummies and year dummies.

Variables	Column1	Column2	Column3
Average path length	-0.439***		
	(0.116)		
Clustering coefficient		1.349**	
		(0.608)	
Clustering coefficient* Clustering coefficient		-1.688***	
		(0.617)	
Firm level small world			0.014*
			(0.007)
Firm level small world* Firm level small world			-0.000**
			(0.000)
Leverage	-0.089**	-0.090**	-0.089**
	(0.043)	(0.044)	(0.044)
Group dummy	0.025	0.050	0.051
	(0.117)	(0.117)	(0.117)
Return of assets	1.222**	1.502***	1.543***
	(0.584)	(0.578)	(0.577)
Market to book ratio	0.062	0.052	0.051
	(0.105)	(0.106)	(0.106)
Firm size	0.266***	0.301***	0.304***
	(0.036)	(0.035)	(0.035)
Cash flow	-0.360	-0.415	-0.416
	(0.256)	(0.258)	(0.258)
Eigen measure	1.026*	1.619***	1.709***
	(0.576)	(0.566)	(0.564)
Industry dummies	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Constant (cut1)	3.791***	6.100***	6.162***
	(1.153)	(1.031)	(1.022)
Constant (cut2)	6.079***	8.382***	8.443***
	(1.160)	(1.035)	(1.026)
Observations	3,130	3,130	3,130
Pseudo R-squared	0.081	0.077	0.076

Significance at 1 percent, 5 percent and 10 percent levels are denoted by ****, **, * respectively against the parameter estimate values. The Pseudo R-squared corresponds to McFadden's R-squared values.

Table 9: Robustness Checks

The table reports the various robustness results for the relation between small world property and probability of acquisition for the sample of firms. The dependent variable is probability of acquisition given by acquire dummy which takes the value one if the firm has made an acquisition bid in the following year and zero otherwise. Columns1-2 gives the effect of average path length on probability of firm specific outcome with alternate set of controls. Column3 gives the effect of distance from randomness on probability of firm specific outcome. The distance from randomness is given by the absolute difference between node level clustering coefficient and density of the graph. Column4 gives the relation between spline specification of small world measure and probability of acquisition. Column5 gives the coefficients obtained by employing Firth's penalised maximum likelihood. The values in parenthesis give the standard errors clustered at individual firm level. The independent variables are a set of firm characteristic variables, group dummy, industry dummies and year dummies. For brevity we present the result for firm level small world measure only.

Variables	Column1 Alternate definition of controls	Column2 Additional control	Column3 Alternate definition of clustering	Column4 Spline specification	Column5 Firth's method
Firm level small world	0.016**	0.019**			0.015**
	(0.007)	(0.008)			(0.007)
Firm level small world* Firm level small world	-0.000**	-0.000**			-0.000**
	(0.000)	(0.000)			(0.000)
Distance from randomness			1.427**		
			(0.627)		
Distance from randomness* Distance from randomness			-1.761***		
			(0.639)		
Spline1				0.010*	
				(0.005)	
Spline2				-0.255**	
				(0.119)	
Controls	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes
Observations	3,130	2,862	3,130	3,130	3,130
Pseudo R-squared	0.0758	0.0826	0.0852	0.0841	-

Significance at 1 percent, 5 percent and 10 percent levels are denoted by ****, **, * respectively against the parameter estimate values. The Pseudo R-squared corresponds to McFadden's R-squared values.

We know that for any network, clustering is the conditional probability of a tie between nodes *j* and *k* when there already exists a tie between *i* and *j* and *i* and *k* respectively and the density of a graph is given by the probability that there exists a tie among any two nodes *j* and *k*. So, for a random network the clustering coefficient of a node *i* is equal to density of the graph and can be written as:

$$E(CC_i) = P\left(X_{jk} = 1 \middle| X_{ij} = X_{jk} = 1\right) = P\left(X_{jk} = 1\right) = \text{Density} \quad (8)$$

With the help of the above definition, we create a variable called distance from randomness similar to Davis et al. (2012) which is simply the difference between node level clustering coefficient from year-wise density of graph.

$$\text{Distance from randomness} = |\text{CC}_i - \text{Density}| \quad (9)$$

This distance from randomness variable gives a proxy measure of the wedge between clustering in empirical graph to that of a hypothetical random graph. We re-estimate equation 5 using the alternate measure of firm level clustering given by the distance from randomness variable along with the alternate set of control variables discussed above. Column3 of table 9 gives that linear term of distance from randomness is positive and significant at five percent level of significance and the coefficient of the quadratic term is negative and significant at one percent level of significance. The point of inflection of the curve is also 0.41 which similar to the full sample results discussed earlier. Thus, the results are robust to the alternate specification of the interest variable clustering coefficient along with the inclusion of alternate set of controls.

Given that there is a quadratic relation between small-world measure and logit of probability of acquisition, it is also possible to present the above relation using a spline specification. A linear spline is a continuous function which joins pieces of linear segments and is also referred to as piece-wise regression. The points of intersection of the linear segments are known as the knots of the function. A linear spline with one knot joins two linear segments and the coefficient value remains constant in each of the two segments. We define a spline of degree two having a single knot for firm level small world measure. We specify the knot at 36 which is the inflection point for the firm level small world measure. Column4 gives that coefficient of spline1is positive and significant and that of spline2 is negative and significant. The spline

specification also indicates the quadratic nature of relation between small world measure and logit of probability of acquisition.

Finally, the number of events in our sample is 456 out of 3130 which appears to be adequate for logistic estimation. However, we also re-estimate the specification using Firth's bias correction method which corrects for bias in samples having less number of events. Column 5 suggests that the sign and significance of the coefficients remain same under Firth logistic regression technique.

6. Summary and Conclusions

The study finds that inter-firm network formed on account of director interlocks since the introduction of corporate governance regulations in India can be characterised as a small world. The network is highly clustered and the average distance among the firms has decreased between 2003 and 2012. The numbers of firms that are either directly or indirectly connected to each other have also increased in this period. A simultaneous decrease in average path length and an expanding size of the giant component of the network suggests that small worldliness of inter-firm network has increased during the period. This may be attributed to regulatory requirements pertaining to non-executive and independent directors in India. The introduction of corporate governance regulations could have led to a sudden increase in demand of directors in the directorial labour market. However, in presence of sticky supply curve for expert directors; the individuals already serving on boards were appointed as non-executive or independent directors by other firms for complying with regulatory mandate.

Further, the paper finds that directorial ties can be effective channels of transfer of hard as well as soft information among connected firms. The firms can access hard information through various channels; however director interlocks can be vital for assimilation of soft

information which may not be otherwise readily available in the market. The node level average path length appears to be negatively associated with probability of firm's acquisition tendencies. As average path length increases, it takes longer for information to reach the firm making search process longer. There exists an inverted U-shaped relation between firm level clustering and the likelihood of acquisition. Initially clustering has positive effect due to trust in sharing of information and faster transmission of information within members of the cluster. This is the informational quality effect in the network. However, at higher levels the lack of diverse information within cluster tends to have a negative effect. The results are similar to Uzzi and Spiro's (2005) findings in their study of small world of Broadway artist network and its effect on their creativity. The threshold level post which the negative effect sets in is much higher than mean and median level of clustering for firms, suggesting that majority of the Indian firms benefit from clustering within the network.

The paper highlights the importance of directorial ties in transmission of soft information among the firms which in turn can affect firm level strategic decisions like acquisitions. So, firms intending to expand through the acquisition route can potentially value interlocks as means of obtaining soft information. The firm level analysis emphasises the importance of faster reach of information within network in form of shorter path length. However, clustering in the network leads to a trade-off between the availability of superior quality of information and lack of availability of diverse information. Hence, within the network, firms would prefer to be close to all other firms, but would desire moderate level of clustering. Further research using small world framework can test whether the presence of clustering among Indian firms have other benefits like promoting innovation or sharing and adopting good corporate governance practices which can enhance the productivity of the firms and make them more competitive.

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