Network Analysis of Indian Corporate Interlocks
Patterns, Players and Sectors

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Abstract. Corporate interlock networks have received significant attention, especially in developed economies such as the USA, Japan, Germany, etc. However, their significance in developing Asian countries, where corporate governance regulations are relatively lax, remains crucial. Especially concerning India, its intricate history and diverse heritage contribute to a distinctive and intricate corporate environment. While numerous studies have attempted to address this, they often suffer from limited data scope, typically focusing on a few hundred firms. In this study, we analyze a bipartite network comprising 4601 Indian firms and 25569 directors. Our analysis explores the cohesion among key actors and fragmentation of the market across sectors. We observed that companies with large board sizes tend to form an elite structure, maintaining dense connections among themselves. In contrast, we did not observe such an elite structure among the directors. The study also reveals distinct characteristics of the manufacturing, agriculture, and power sectors within this intricate network.

Keywords: Corporate interlock network · Bipartite network analysis · Interlocking directorates · Centrality · Community detection · Assortativity

1 Introduction

The rich cultural heritage and diversity of India not only impacts its social fabric but also its corporate and economic landscape. India's history, cultural variations, diverse religions, and languages have a profound impact on its business market. In the last decade, India has ascended from the tenth to the fifth-largest economy, boasting a formidable $4.1 trillion GDP [10]. This ascent can be attributed to the distinctive nature of Indian corporate governance as compared to its Western counterparts. Inspired by the "Employee first, customer second" motto, major Indian firms tend to prioritise employee transparency and freedom [2] over strategies, mergers, acquisitions, or deal making. This emphasis results in a less stringent regulatory environment, allowing greater overlapping between

the boards of companies, and creating a complex corporate-interlock network. Corporate interlock refers to the phenomenon where board members serve on multiple boards, creating a network of interconnected companies [12]. The complexity of the network is further compounded by the prevalence of family-owned groups (business groups) whose interests span across multiple sectors. While such networks have received extensive attention in major economies like the USA [5], Japan [3], China [13], and Germany [19], their exploration within the Indian context is rather limited. Although some literature exists, it is constrained in scope [4, 16, 14, 15], often analyzing only a few hundred companies and directors. We examine a comprehensive dataset comprising of BSE[3] listed companies and their directors. Directors participating in multiple boards create covert channels for the flow of information, fostering the dissemination of trust and policymaking strategies. These connections exhibit heightened complexity in developed economies because of less stringent governing regulations. We study the diversity and complexity of these connections, with the major contributions listed below.

1. Analysis of the density and cohesion of Indian corporate network, exploring the structural properties of the bipartite network formed by companies and directors.
2. Identification of the central actors comprising both key firms and key directors. Further, the important sectors within Indian landscape have been delineated from various perspectives.
3. Analysis of cross-sectoral linkages to identify distinctive patterns and diversity across sectoral markets, accessing the degree of market fragmentation

Next, we highlight significant contributions in the literature (Section 2). Subsequently, an overview of the dataset is provided in Section 3. Despite the market's highly fragmented nature, the giant component (smaller in size compared to other countries) maintains the same structural characteristics as the original network. Two projected networks are then constructed on the giant component to elucidate company-company and director-director relations. In Section 4, we delve into analyzing key actors and their connections, followed by examining interconnections across sectors and the fundamental properties of various sector-based markets. Finally, the major findings are presented in Section 5, which subsequently concludes the paper.

2 Related Work

We begin by emphasizing notable research conducted within the Indian context. Helmers et al. [9] examined the corporate interlocking network of India from 2000 to 2007, focusing on the role of boards in shaping firms' innovation strategies and intellectual property management. Chandrashekar et al. [4] investigated changes in the interlock network for 166 companies in India from 1995 to 2007. They

[3] Bombay Stock Exchange (BSE) is one of India's oldest and largest stock exchanges

found that 45% of the companies remained connected over the decade with a stable core network. While our analysis is based on more recent data, we observed similar patterns. Saatiraju et al. [16] conducted a similar examination in 2017, analyzing data from 150 top Indian companies and 1535 directors selected from Fortune India. Prem et al. [15] studied data consisting of 8184 directors affiliated with the boards of 1220 companies listed by National Stock Exchange[4] of India. While our study aligns with the above mentioned literature, our dataset is more recent and comprehensive. Additionally, we provide a detailed analysis of both intra and inter-sectoral corporate linkages. Numerous similar works exist for other developed and developing countries. For instance, a network analysis in 1982 on 1131 large US companies [11] demonstrated the high stability of centrality measures over time, with banks exhibiting more stability than non-bank entities. In the 20th century, the US corporate network was controlled by a small group of individuals forming the inner circle of the interlock network, but a study in 2016 showed that this inner circle had disappeared [5]. Results for Italy [18] indicated that manufacturing and finance were the two major industries, with manufacturing firms being more modular and dominated by three firms, while finance was dominated by a single firm, based on data from approximately 200 firms. Similar results were observed for Germany [1]. We also observe the high prominence of inter-sector connections over intra-sector ones. In essence, our study offers a more comprehensive analysis rooted in network science principles over a much larger dataset. Such extensive data coverage is relatively scarce in existing literature.

3 Dataset

The dataset, sourced from various online platforms [17] encompasses 4601 publicly listed Indian companies and 25569 personnel holding directorships on these firms between 2004 and 2018. We represent the information as a bipartite network, $G = (C, D, E)$. $C = \{c_1, c_2, \ldots, c_n\}$ and $D = \{d_1, d_2, \ldots, d_m\}$ represent the set of companies and the set of directorates respectively. There exists an edge between company c_i and the personnel d_j if d_j is on the board of directors for company c_i. A director d_j is considered to be interlocked iff s/he sits on the board of at least 2 companies in the dataset. Such a set of interlocking directors is represented as D^I. A company c_i is considered to be interlocked iff it has at least one director from D^I. The set of such interlocking companies is represented as C^I. Based on the interlocking directorates and companies, we derive an induced interlocking subgraph $G^I(C^I, D^I, E^I)$ where $E^I = \{(c_i, d_j) : c_i \in C_I, d_j \in D^I, (c_i, d_j) \in E(G)\}$. A visual depiction of the giant component of the interlocking subgraph is shown in Figure 1.

[4] NSE provides a modern, fully automated electronic trading system offering an efficient and transparent market for various securities, including equities, derivatives, and debt instruments.

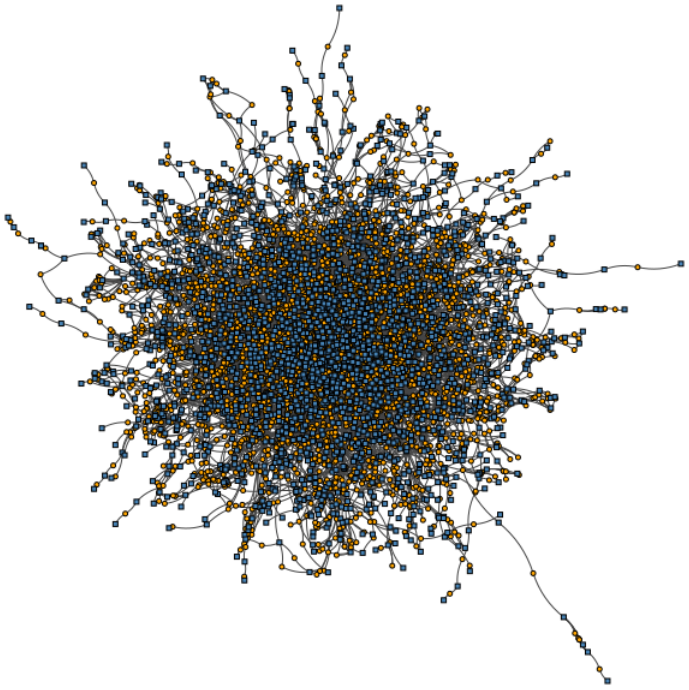


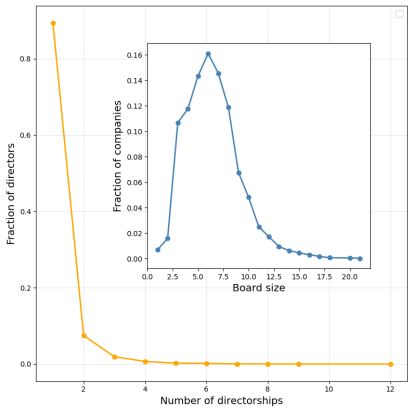
Fig. 1: The giant component of the interlocking network. Director nodes are represented by orange circles. Company nodes are depicted as blue squares.

3.1 Basic Overview

The basic metrics of the network are shown in Figure 2b. The average board size of a company is 6.4. A director is appointed on 1.2 boards on average. Only 10.6% of directors engage in corporate interlocks, with the remaining 89.4% serving on the board of a single company (refer Figure 2a). In contrast, 56.9% of companies exhibit interlocking ties. Additionally, highly represented directors (serving on 4 or more boards), constituting only 1.1% of the director population, are associated with 29% of listed companies.

3.2 Data preprocessing

The bipartite network consists of 2043 components, with only 51.5% of the company nodes forming a giant connected component (GC). There is a significant prevalence of small components of size less than 100. The distribution of the component sizes is shown in Figure 3a. In the context of the Indian corporate network, the existence of several large and small disconnected components can be



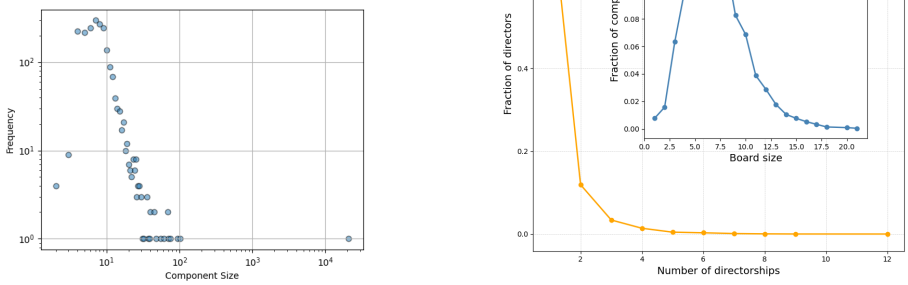
(a)

	Total (G)	Interlocking (G^I)	Highly boarded
Number of companies	4601	2622	535
Number of directors	25569	2706	300
Number of edges	29589	10992	413
Profit (in Cr.)	343505	350956.7	302545
Income (in Cr.)	5128252	4938784	3813778

(b)

Fig. 2: (a) Degree distribution of company and director nodes in the bipartite network $G(C, D, E)$. and (b) Basic properties of the interlocking network G^I

attributed to a significant number of family-owned businesses[5], regulatory barriers, fragmented markets, infrastructure challenges, and intense competition.



(a) (b)

Fig. 3: (a) Distribution of the component sizes in the bipartite network, $G(C, D, E)$ (log log scale) and (b) Degree Distribution of the giant component, GC

[5] According to a report by Credit Suisse, family-owned businesses account for over 60% of listed companies in India. India ranks third in the list of countries with family-owned companies, following China and USA

While smaller in size as compared to a few other countries [8], GC remains a good representative of the original network, exhibiting similar degree distribution (Figure 3b) and sector composition (Figure 4). Moreover, the most highly boarded companies and most highly engaged directors[6], listed in Table 2, belong to the the giant component. The prevalence of large board sizes (more than 15) can be attributed to the 14 year timeframe during which the data was collected, capturing board resignations and new appointments. Interlocking directors continue to act as conduits between companies even after their tenure. While further exploration through longitudinal analysis is conceivable, it is presently beyond the scope of our study.

Abbr:	**Full Form**	**Abbr:**	**Full Form**
MMP:	Manufacturing (Metals & Chemicals)	T:	Trading
F:	Finance	MT:	Manufacturing (Wood Products)
B:	Business Services	C:	Community, Personal & Social Services
MME:	Manufacturing (Machinery & Equipments)	O:	Others
CPS:	Construction	MF	Manufacturing (Food Stuffs)
MP:	Manufacturing (Paper Products, Publishing, Printing, Reproduction of Recorded Media)	AG:	Agriculture and Allied Activities
E:	Electricity, Gas & Water Companies	TSC:	Transport, Storage and Communications
R:	Real Estate and Renting	MQ:	Manufacturing (Textiles)
MO:	Manufacturing (Others)	MLP:	Manufacturing (Leather & Products Thereof)
MW:	Mining & Quarrying	I:	Insurance

Table 1: Sector Abbreviations and Full Forms

In order to gain deeper insights into the structural properties and relational dynamics within the corporate network, we create two projected networks G_c and G_d from the giant component $GC(C, D, E)$. The projected network of companies is represented as $G_c(C, E_c, W_c)$. The weight $w_{i,j}$ for an edge (c_i, c_j) is determined by the dice coefficient of the sets of directors shared between c_i and c_j, i.e.,

$$w_{i,j} = 2\frac{|N(c_i) \cap N(c_j)|}{|N(c_i)| + |N(c_j)|} \tag{1}$$

[6] The director names have been anonymized in all tables and figures to ensure confidentiality, uphold ethical standards, and prevent potential biases in the research analysis.

, where $N(u)$ represents the neighbors of node u in GC. The edge will be absent if $|N(c_i) \cap N(c_j)| = 0$. The projected network of directors, $G_d = (D, E_d, W_d)$, is created similarly.

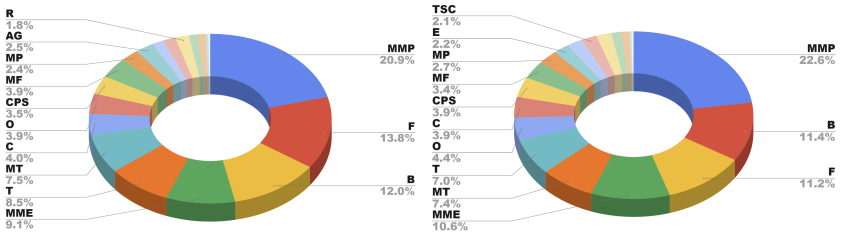


Fig. 4: Sector-wise distribution of nodes in the original network G (top) and the giant component GC (bottom)

Director Name	Degree	Company Name	Degree
P828	13	Tata	240
P973	11	Bajaj	148
P1534	10	Mahindra	98
P2090	10	TVS	93
P3665	9	Murugappa	83
P4298	9	Hinduja	80
P5530	9	Kirloskar	75
P5594	8	Kalyani	70
P6161	8	Essel	70
P49225	8	RPG	64

Table 2: Top 10 highest degree nodes. A higher board size in our dataset indicates a larger number of individuals associated with a company across multiple years.

4 Analysis

The basic properties of the projected networks are shown in Table 3. The number of directors have dropped down significantly in GC, and hence in G_d. A high local clustering and small average path length indicate both the networks to be small-world. Next, we present a centrality measures based analysis on both the projected networks.

4.1 Projected Networks

We find the top 10 companies using a range of centrality metrics, beginning with degree and strength (refer to Table 4). It is observed that certain com-

Property	G_c	G_d
Number of nodes	2138	2706
Number of edges	14516	7320
Density	0.6%	0.2%
Average clustering coefficient	0.42	0.7
Average path length	4.8	4.7

Table 3: Basic properties of the projected network

panies despite their smaller board sizes, possess a more extensive network of corporate ties. This observation aligns with several studies in the literature [7, 6] suggesting that larger board sizes are not always advantageous, particularly for smaller firms. Degree quantifies the number of director-interlocked connections in

Highest Degree Nodes	**Highest Strength Nodes**
∗Tata (T)	Eveready Industries India Ltd (MME)
∗RPG (B)	Atul Limited (O)
Murugappa (MMP)	Neptune Exports Limited (T)
∗Mahindra (MMP)	Williamson Magor & Co. Ltd. (AG)
∗Bajaj (B)	Tea Time Limited (B)
∗Hinduja (TSC)	Rswm Limited (MT)
∗Adani (MP)	Mcleod Russel India Limited (T)
∗Wadia (B)	Housing Development Finance Corp. Ltd. (R)
L & T Ltd. (C)	∗Aditya Birla Nuvo Limited (MT)
JK (CPS)	Ultratech Cement Limited (MMP)

Table 4: Top companies by degree and strength. The companies marked with asterisks (*) are believed to be family-owned based on available information.

a company. On the other hand, strength (sum of weights of incident edges), aka weighted degree, measures the intensity of these relationships. The top 10 degree companies represent India's influential conglomerates across diverse sectors such as manufacturing, business, trading, transport, social services, and construction. Besides manufacturing, numerous trading, agriculture, and real estate companies are observed for strength centrality, indicating robust cohesion among them.

A significant correlation is observed between degree and betweenness centrality (Refer to Table 5). In most of the complex networks, hubs are responsible for connecting disparate parts of the network, thereby increasing their betweenness. Closeness, on the other hand, indicates the proximity of nodes to others in the network, enabling swift information exchange through interlocking directorates. Notably, finance companies are also prominent alongside manufacturing, business, and agriculture sectors in this category. The distribution of sectors among the top 10 central companies, based on centrality measures, is depicted in Figure 5.

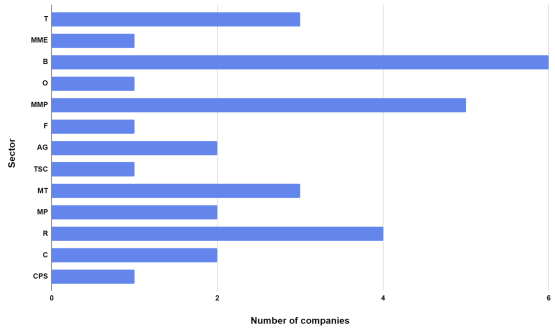


Fig. 5: Distribution of Sectors Among Top 10 Central Companies Based on Centrality Measures

High Closeness Centrality	**High Betweenness Centrality**
*Tata (T)	*Tata (T)
Kalyani (MT)	*Bajaj (B)
Murugappa (MMP)	*Kalyani (MT)
RPG (B)	*Murugappa (MMP)
Ambuja Cements Limited (MMP)	*RPG (B)
Colgate-Palmolive (India) Limited (MMP)	*Adani (MP)
JM Financial Asset Reconstruction (F)	*Mahindra (MMP)
United Spirits Limited (AG)	*Hinduja (TSC)
Balrampur Chini Mills Ltd (MF)	Reliance (R)
Escorts Limited (B)	RIL (R)

Table 5: Top companies by closeness and betweenness. The companies marked with asterisks (*) are believed to be family-owned based on available information.

In Figure 6, we observe the induced subgraph comprising the highest degree nodes within the network. The substantial interconnections among these nodes depict a rich-club like structure showing some of the most elite companies in the network. Companies from diverse sectors exhibit prominence across various centrality measures. However, the absence of Electricity, Gas & Water (EGW) companies from top centrality rankings might stem from their distinct operational characteristics, including regulatory constraints and industry standards. These factors could impact their involvement in interlocking directorates.

We visualize the connections between the most central firms and directors (refer Figure 7b). The network is sparse, indicating that highly central directors may not necessarily serve on the boards of highly central firms. As demonstrated in the Figure 6, while central firms exhibit strong connections among themselves, this is not solely attributed to highly central directors.

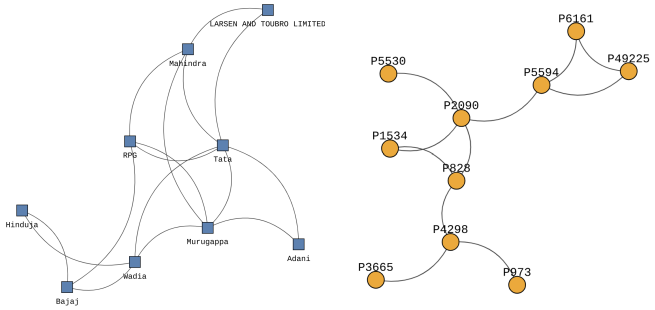
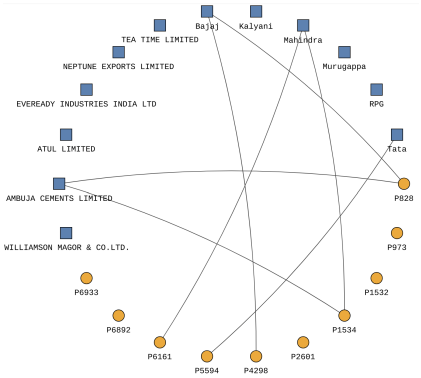


Fig. 6: Induced subgraphs highlighting the highest degree nodes within the projected network of companies and directors

#	Dg	St	Bw	Cl
1	P973	P4298	P973	P181
2	P1534	P6161	P1532	P562
3	P6161	P6892	P7902	P1041
4	P828	P1534	P2601	P1117
5	P5594	P828	P1534	P1120
6	P49225	P2089	P28478	P1165
7	P2090	P40945	P4298	P1454
8	P3665	P49225	P3610	P6891
9	P4298	P25994	P2017	P6914
10	P5530	P38657	P6161	P7207

(a)



(b)

Fig. 7: Left: Top 10 Directors by Centrality Measure; #: Rank, Dg: Degree, St: Strength, Bw: Betweenness, Cl: Closeness, Right: Induced bipartite subgraph on most central actors

4.2 Sector based analysis

In this section, we analyse the complex web of interlocks within and across sectors, providing insights into the Indian corporate landscape. Within sectors, connections are sparse, comprising only 15% edges of the total network. The remaining 85% ties crisscross various sectors, forming the backbone of connectivity. It is shown that the extent of interlocking exceeds 50% for all sectors, prompting a deeper analysis of the cross-sector ties. The network lacks sector-based homophily, leading to fragmentation when focusing solely on one sector's companies. We present sector-specific network characteristics and identify core companies within each sector, unveiling trends that traverse diverse industries. Additionally, we offer insights into the largest communities within the network.

Extent of interlocking Assuming each company node c_i in the network is labeled with its sector name, denoted as $s(c_i)$, we find the proportion of companies in a given sector x

$$\phi_x = \frac{|\{c_i : s(c_i) = x, c_i \in C(G)\}|}{|C(G)|} \tag{2}$$

, and the fraction of interlocking companies

$$\phi_x^I = \frac{|\{c_i : s(c_i) = x, c_i \in C_I(G^I)\}|}{|C(G)|} \tag{3}$$

We also define the degree of interlocking (in the range of $[0, 1]$) for each sector as

$$\mu_x^I = \frac{|\{c_i : s(c_i) = x, c_i \in C(G)\}|}{|\{c_i : s(c_i) = x, c_i \in C^I(G^I)\}|} \tag{4}$$

The values corresponding to ϕ_x and ϕ_x^I for various sectors are depicted in Figure 8. For most sectors, the degrees of interlocking range from 56% to 72%.

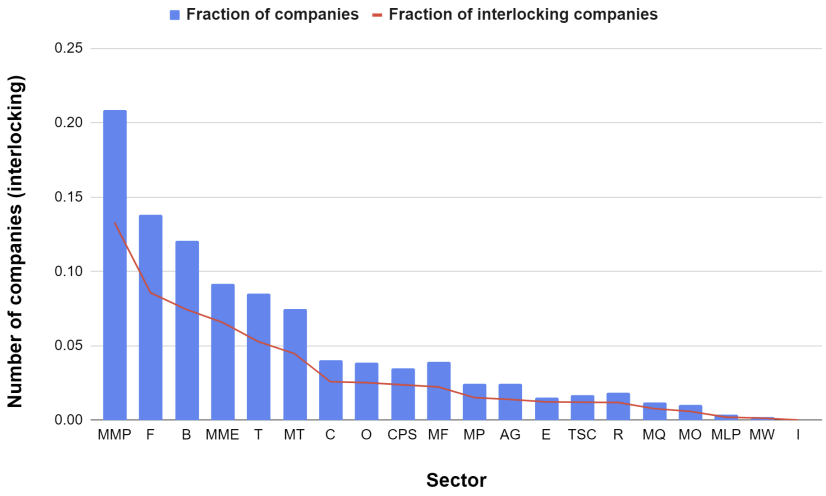


Fig. 8: The bars represent ϕ_x and the line represents ϕ_x^I for various sectors

Manufacturing (food-stuff, leather products) and agriculture sectors show the lowest values ($\tilde{5}6\%$), whereas electricity, gas, and water companies reach values as high as 81%. This difference might be due to the family-owned nature of manufacturing and agriculture enterprises, potentially emphasizing autonomous decision-making, substantial infrastructure demands, and the fragmented nature of the supply chain. In contrast, electricity, gas, and water utilities often operate within governmental regulations that foster collaboration among companies, ensuring service provision, infrastructure development, or energy security.

Intra-Sector vs. Inter-Sector Interlocks Figure 9 depicts the distribution of cross-sector connections among the major sectors. An entry (s, t) in the heatmap indicates the proportion of connections originating from sector s that terminate in sector t.

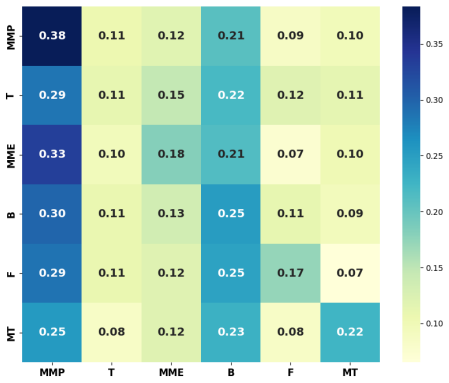


Fig. 9: Fraction of Cross-Sector Connections Among Major Sectors

The dense columns for MMP (Manufacturing metals and chemicals) and business firms show that companies from other sectors tend to have interlocking directorates with them. Although finance and manufacturing equipment & machineries are also the major sectors, they tend to have more interlocks within the sectors. Overall, the proportion of intra-sector connections (in major sectors) is only 22%. However, this disparity does not necessarily indicate sector-based heterophily within the network. To accurately determine whether the network exhibits sector-based homophily, we calculated assortativity,

$$R(G_c) = \frac{1}{2|E_c|}\sum_{u,v}(A_{u,v} \times \delta_{u,v}) - \frac{1}{4|E_c|^2}\sum_{u,v}(\delta_{u,v} \times d_u d_v)$$

Here, $A_{u,v}$ represents the adjacency matrix of G_c. $\delta_{u,v}$ is the Kronecker delta, equaling 1 if companies u and v belong to the same sector, and 0 otherwise. d_w denotes the degree of node w. $R(G_c)$ is observed to be 0.04, indicating the connections to be sector-neutral[7].

Despite the absence of sector or region-based homophily, a strong community structure is seen (Louvain community detection algorithm reports the highest modularity: 57%). However, the underlying cause of community formation remains hidden due to inadequate data. The communities are highly diverse and

[7] We also calculated assortativity based on the registration states of the companies. The resulting value was 0.2, which is also considered insignificant.

span multiple sectors. Such intersectoral communities (refer Figure 10 for a specimen) may arise from shared business interests, opportunities for innovation, regulatory requirements, or closely knit colglomerates.

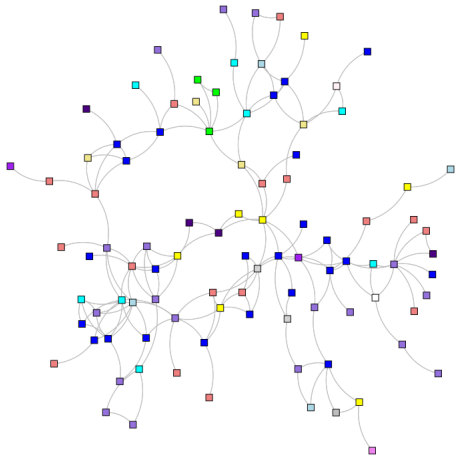


Fig. 10: Visualisation of one of the significant communities. Sectors are visually distinguished by colors: AG (red), R (green), MMP (blue), MT (yellow), MO (gray), F (cyan), E (white), MLP (black), TSC (violet), MF (indigo), MQ (pink), C (purple), I (orange), MME (lightcoral), B (mediumpurple), O (rosybrown), MW (lavenderblush), MP (lightgray), T (khaki), and CPS (lightblue).

The composition of the biggest community is shown in the Figure 11. One

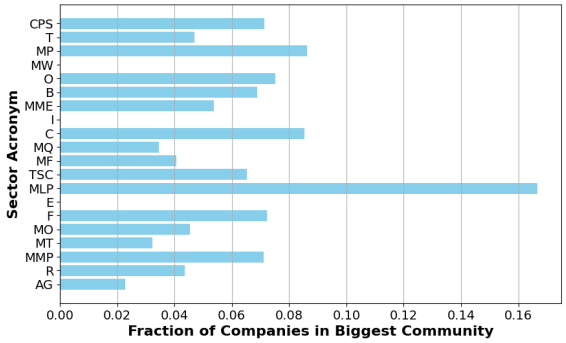


Fig. 11: Composition of the biggest community (comprising 130 companies)

notable observation is the absence of the electricity, water, and gas sector from the largest community. We observed that these companies are evenly distributed across multiple communities and often occupy peripheral positions.

A broad comparison of sectors Considering any single sector in isolation reveals a highly fragmented market landscape. To facilitate comparison across sectors, we extracted induced subgraphs corresponding to each sector and analyzed their individual properties. G_c^s denotes the induced subgraph from G_c, comprising nodes exclusively from sector s. In Table 6, we present the density (D), average clustering coefficient (CC), modularity (M), diameter (Dia), and average path length (P) for each graph G_c^s. Except for select manufacturing, business, and finance sectors, most sectors exhibit an extremely fragmented market, with the giant component comprising fewer than 10 nodes. Figure 12 visually illustrates the fragmented market for the trading sector and compares it to the manufacturing chemicals sector. The giant components of most sectors are no-

Metric	E	R	MP	MMP	T	O	MF	AG	MME	B	F	TSC	C	MT	CPS	MO
$\|V(G_c^s)\|$	45	46	58	478	149	93	74	44	223	261	235	46	82	155	84	22
$\|E(G_c^s)\|$	10	10	7	503	38	18	16	8	117	149	90	8	18	82	17	4
$10 \times D(G_c^s)$	0.1	0.1	0.04	0.04	0.03	0.04	0.06	0.1	0.05	0.04	0.03	0	0.08	0.06	0.07	0.05
$CC(G_c^s)$	0.28	0.6	1	0.37	0.54	0.36	0.75	0.78	0.31	0.32	0.37	0.75	0.59	0.48	0.67	0
$M(G_c^s)$	0.54	0.78	0.74	0.74	0.89	0.86	0.87	0.69	0.87	0.78	0.86	0.75	0.8	0.89	0.87	0.38
$\|V(GC_c^s)\|$	8	4	3	238	9	5	4	4	56	88	44	3	5	19	4	4
$\|E(GC_c^s)\|$	8	3	3	422	9	5	3	4	68	117	51	3	6	25	3	3
$D(GC_c^s)$	0.29	0.5	1	0.01	0.25	0.5	0.5	0.67	0.04	0.03	0.05	1	0.6	0.15	0.5	0.5
$CC(GC_c^s)$	0.28	0	1	0.34	0.51	0.72	0	0.78	0.19	0.35	0.34	1	0.75	0.56	0	0
$M(GC_c^s)$	0.37	0.17	0	0.68	0.22	0.08	0.17	0	0.72	0.69	0.69	0	0	0.49	0.17	0
$Dia(GC_c^s)$	6	3	1	16	3	2	3	2	14	14	15	1	2	5	3	2
$P(GC_c^s)$	2.6	1.67	1	5.18	1.92	1.5	1.67	1.33	6.2	5.12	5.49	1	1.4	2.91	1.67	1.5

Table 6: Network Characteristics by Sector

tably small, rendering them relatively insignificant for analysis. However, sectors like manufacturing, business, and finance stand out with a substantial number of nodes in their giant components. Despite this, these sectors also exhibit a low clustering coefficient and a highly modular structure within their networks.

5 Major Findings and Concluding Remarks

Our examination of India's corporate interlock network unveils a landscape characterized by diversity and cross-sector collaboration. Leveraging a comprehensive dataset, we uncovered distinctive patterns within the Indian context. Some of the major findings are listed below.

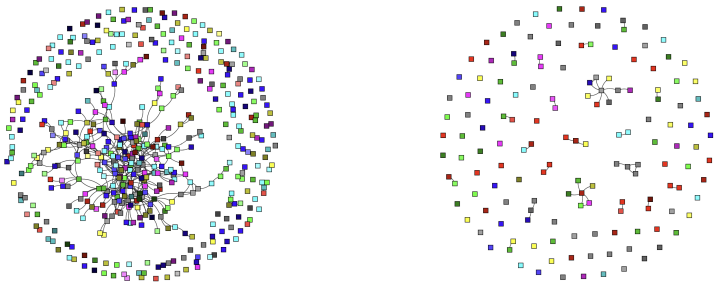


Fig. 12: Induced subgraph of the companies in left: manufacturing (metal and chemicals), and right: trading sectors

1. The giant component encompasses less than 55% of the companies and less than 15% of the directors. Despite its small size, it preserves a diverse sector composition, mirroring that of the original network. Notably, all key players are found within this component.
2. Highly boarded companies exhibit strong connections to other firms through their interlocking directorates. However, highly boarding directors show weaker connections to other directors. This observation aligns with the findings of Chu and Davis [5], indicating that extensively connected directors were less favored on large boards. In contrast to their study, our analysis reveals that the corporate network did not experience a reduction in connectivity. Unlike central directors, central firms demonstrate dense connections, resembling a rich club structure.
3. Business firms closely followed by Manufacturing metal & chemical companies emerged as the most prominent across all centrality measures, indicative of their significant influence. Despite having fewer connections, agriculture and real estate firms exhibited robust ties, indicated by a higher number of shared directors between companies. Only two finance companies ranked among the most central entities. Despite generating substantial revenue, power, gas, and electricity firms are notably absent from the list of highly central companies.
4. Inter-sector connections play a prominent role in the network. Most of the intra-sector subgraphs lack a significant giant component, except for manufacturing firms, finance, and business companies.
5. The graph as a whole, along with the sector-based subgraphs, demonstrates significant modularity, underscoring the influence of business conglomerates. Within the network's largest community, companies from diverse sectors are prevalent, except for those in power, gas, and electricity. Power-related firms are distributed evenly across smaller communities.

Overall, the unique Indian corporate landscape demonstrates diverse interconnections, highlighting resilience and adaptability despite sectoral variations. The scope of the future work includes longitudinal analysis and predictive modeling.

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