Board Networks, Gender Diversity, and CSR Engagement

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Abstract

This study investigates the effect of network centrality of women directors on the corporate social responsibility (CSR) of firms. We use social network analysis (SNA) to construct board interlock networks and compute degree, betweenness, and eigenvector centrality for women directors. Using panel data on NSE-listed manufacturing firms from 2016 to 2023, the results indicate that firms with more well-connected women directors allocate significantly higher resources to CSR. Among centrality measures, eigenvector and betweenness centrality show particularly strong associations. Instrumental variable regressions, which address potential endogeneity in board composition, confirm the robustness of these findings. The evidence suggests that well-networked women directors enhance a firm's commitment to CSR, pointing to how board diversity can generate broader societal benefits.

Keywords: Women directors, Board networks, Corporate social responsibility, Board diversity

JEL Codes: G34, M14, D85, J16

1 Introduction

In recent years, Corporate Social Responsibility (CSR) has become a central feature of corporate governance. CSR reflects a firm's voluntary commitment to contribute to social development, environmental sustainability and ethical conduct while achieving financial performance (Carroll, 1999). The role of boards of directors in shaping CSR has garnered significant attention, as directors form an important part in corporate governance. Among board

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characteristics, gender diversity has emerged as a particularly important dimension, with a broader societal push toward inclusivity and equity.

However, simply counting the number of women on corporate boards provides an incomplete picture of their actual influence on firm outcomes. This is because boardroom dynamics are deeply rooted in broader inter-organizational networks. Moreover, social capital also plays a crucial role in how effective a director is (Burt, 1992; Mizruchi, 1996). In this context, social network analysis offers a powerful tool to examine these director networks. For women directors, who are scarce in number and are historically disadvantaged, network centrality can be an especially critical source of influence.

This study examines how the centrality of women directors in the interlock network influences a firm's CSR compliance and expenditure. Interlocking directorates, where a director sits on multiple corporate boards, create pathways for the diffusion of norms, knowledge, and governance practices. More central directors are better placed to access diverse information, broker resources and influence firm strategy (Bianchi et al., 2022). For women directors, occupying central network positions may balance the traditional scales of power in their favour. This may enable them to advocate more effectively for ethical and socially responsible practices.

1.1 Corporate Social Responsibility – Institutional Background

Indian companies, much like their global counterparts, have long been involved in social initiatives that extend beyond their core financial goals. A formal policy emphasis on CSR in India began with the Ministry of Corporate Affairs releasing the *Corporate Social Responsibility Voluntary Guidelines* in 2009 (MCA, 2009). This development ultimately led to the enactment of Section 135 of the Companies Act, 2013 (MCA, 2013), which mandated both CSR spending and disclosure for certain categories of companies (Sarkar and Sarkar, 2015).

Section 135 of the Companies Act (MCA, 2013) outlines that companies with a net worth of ₹500 crore or more, a turnover of ₹1,000 crore or more, or a net profit of ₹5 crore or more are required to fulfil certain CSR obligations. These include: (i) forming a CSR Committee composed of at least three directors, including at least one independent director, and (ii) ensuring, under the committee's guidance, that the company spends a minimum of 2% of its average net profits from the preceding three financial years on activities specified in its CSR policy during each financial year. According to Sarkar and Sarkar (2015), India distinguished itself as the first nation to legally require CSR activity for large, profitable companies.

1.2 Motivation of the Study

Therefore, the Indian context offers an interesting setting for this study. The Companies Act of 2013 mandated the presence of at least one woman director on the boards of listed firms. While this reduced the representation gap, questions remain about the impact of women directors on firm policies such as CSR. In addition to this, mandating CSR creates a regulatory context and a subsequent unique institutional environment to explore how women's influence on boards translates into CSR outcomes. Additionally, it would be interesting to study the same through the lens of social networks.

While previous studies have linked female board presence to greater CSR engagement (Bear et al., 2010; Rao & Tilt, 2016), relatively few have explored how social network structures mediate this relationship. We use centrality measures such as degree, closeness, betweenness, and eigenvector centrality to capture distinct dimensions of a director's centrality or influence in the network (Freeman, 1979). For instance, a woman director with high betweenness centrality may serve as a bridge between otherwise disconnected firms or someone with high eigenvector centrality may be part of elite circles of highly influential peers (wielding more social capital and influence).

Theoretically, this study draws on social capital and stakeholder theories. The former postulates that individuals derive value and acquire resources and information from their network ties. The latter on the other hand emphasises the firm's responsibility to balance the interests of diverse stakeholder groups. Additionally, institutional theory suggests that well-networked women directors can carry institutional norms, including those related to CSR, thus encouraging isomorphic pressures across firms (DiMaggio & Powell, 1983).

1.3 Outline of the Study

This study is structured as follows. The next section presents a review of relevant literature on gender diversity, board networks, and CSR. The subsequent section outlines the data and methodology, including the construction of director networks. This is followed by the results section. This study, contributes to the understanding of how social structures shape boardroom influence and corporate governance practices. It challenges the notion that representation alone is sufficient for impact, arguing instead that the centrality of women within board networks matters significantly for advancing corporate social responsibility and other desirable corporate governance practices.

2 Literature Review

2.1 Corporate Social Responsibility (CSR) – A Conceptual Background

The concept of corporate social responsibility (CSR) is deeply rooted in business history. The evidence of care for the well-being of society within the commercial circles can be traced across centuries. However, according to Carroll (1999), the initiation of the modern academic discourse on CSR is widely attributed to Howard R. Bowen's seminal 1953 publication, *Social Responsibilities of the Businessman*.

Bowen's work was predicated on the understanding that large corporations wield considerable power and their decisions profoundly affect citizens' lives. Bowen offered an early definition

of business's social responsibilities as the pursuit actions aligned with our society's values. Given his pioneering and foundational contributions, Carrol (1999) considers Bowen as the 'Father of Corporate Social Responsibility'.

While definitions vary, the essence of CSR lies in the firm's responsibility to contribute positively to society beyond mere legal compliance and profit-making. Carroll's (1979) seminal four-part model—economic, legal, ethical, and philanthropic responsibilities—has become a foundational framework in the field (Carroll, 1979; Carroll 1999).

2.2 Empirical Studies on CSR – its Determinants and its Association with Firm Behaviour

Several studies have been carried out over the years on CSR and the various determinants of the same. For instance, it was found that larger and more visible firms spent more on corporate philanthropy (Brammer and Millington, 2005). According to Waddock and Graves (1997) stronger financial performance can enable firms to enhance their corporate social performance (CSP). At the same time, higher levels of CSP may contribute to better financial outcomes, assuming other factors remain constant.

Because CSR activities reveal aspects of a company's identity, investing in social initiatives can help the firm foster positive attitudes and actions from stakeholders, such as purchasing products, applying for jobs, or investing in the company. Over time, this can also contribute to building a strong corporate or brand image, reinforcing relationships with stakeholders, and encouraging supportive behaviours like word-of-mouth promotion, employee commitment, and proactive citizenship within the organization (Du et al., 2010).

Additionally, after reviewing literature on CSR spanning 2000 to 2015, Jain and Jamali (2016), found that board size and board independence generally had a positive influence on CSR outcomes. They also found that powerful or entrenched CEOs tend not to promote CSR.

Moreover, they also suggest that more diverse boards encourage stronger engagement in corporate social responsibility initiatives.

Husted and de Jesus (2006) suggest that firms benefit more by taking a strategic approach to corporate social responsibility (CSR) rather than being forced into it. This is because the strategic route is likely to produce a greater overall social impact than purely altruistic efforts.

2.3 Gender Diversity in the Context of CSR

The composition of the board of directors has been widely studied as a determinant of CSR engagement. Bear et al. (2010) showed that a higher number of women on the board is associated with stronger corporate social responsibility (CSR) ratings. Incorporating diverse perspectives can help effectively address the interests and concerns of a broad group of stakeholders. Women board members provide a broad range of contributions to boards. Bear et al. also suggest that women board members play a role in enhancing corporate reputation by contributing to the firm's CSR.

This relationship was also observed by Rao and Tilt (2016) in a sample of Australian firms. They found that more diverse boards tend to perform better in CSR reporting, especially in areas related to social and environmental issues, compared to boards with less diversity. However, in the study, they also tried to understand the interaction effect of female directors and multiple board appointments. They suggest that the growing demands placed on women directors to serve on several boards may negatively affect CSR outcomes.

Additionally, several other studies have also (Wang and Coffey (1992); Willaims (2003); Post et al. (2011)) suggested a positive association between higher proportion of women directors and socially responsible activities by the firm.

2.4 Empirical Research on Interlocking Directorates and CSR

According to Mizruchi (1996) interlocking directorate arises when an individual associated with the board of one organisation serves on the board of another. Interest in interlocks surged during the 1970s and 1980s and continued to grow alongside the expansion of research on interorganizational relationships in the 1990s. While interlocks are not a universal explanation for all interfirm dynamics, they remain a valuable indicator of network connections between companies. Interlocks also tend to reflect resource dependencies among firms.

As governance mechanisms, interlocks are believed to offer firms both insight into and potential influence over the operations of the companies with which they are connected. Even when all other conditions are constant, the existence of an interlock can influence a firm's behaviour (Mizruchi, 1996).

Beyond board composition, recent research in the area emphasises the importance of social networks in corporate governance. Social network analysis allows researchers to examine the positional power of directors using metrics such as degree centrality, closeness, betweenness, and eigenvector centrality (Freeman, 1979).

For instance, Westphal and Milton (2000), suggest individuals from demographic minority groups can overcome biases that typically limit their influence by leveraging prior board experience or connections within director networks. This would enable them to appear more similar to the majority group members.

Additionally, it was found that the director's social capital and resources acquired through networks had a positive impact on a company's environmental performance (Glass et al., 2015; Kassinis & Vafeas, 2002; Walls & Hoffman, 2013). However, we can see that little to no studies have explicitly linked network centrality to CSR.

2.5 Identified Research Gap

In India, however, research on the role of women director networks in shaping CSR outcomes is still sparse. Given the regulatory push for both CSR and gender diversity, examining this intersection offers a timely and underexplored research avenue.

The literature shows that CSR is a multifaceted construct shaped by firm characteristics, institutional environments, and governance structures. Gender diversity and social networks on boards are emerging as important determinants of CSR performance. The existing studies have established links between women directors and CSR, and between networks and governance. But, the effect of gendered network centrality on CSR expenditure remains underexplored, especially in the Indian context. This study aims to bridge that gap by examining how the social network of women directors influences CSR practices among Indian firms.

3 Data, Variable and Methodology

3.1 Data

The dataset for this study is compiled from three main sources: CMIE Prowess, the Indian Boards Database and the Ministry of Corporate Affairs (MCA) website. Prowess is maintained by the Centre for Monitoring Indian Economy (CMIE). It provides standardized and reliable financial data sourced from company annual reports. In this study, we use Prowess to collect information on variables related firm characteristics, performance, social responsibility and corporate governance.

The Indian Boards Database (IBD) is maintained by NSE Primeinfobase. It offers detailed data on the demographic and socio-economic profiles of directors serving on the boards of NSE-listed companies. The director level data demographic data is acquired from IBD and the information from the database is used to construct networks in this study. Both ProwessIQ and IBD are widely used in corporate governance research.

We use data on all NSE listed non-financial companies in Prowess. All data (including director level data) is aggregate at the firm level for the analysis. Additionally, we have excluded firms with boards with less than 4 directors. Moreover, we exclude companies for which the CSR expenditure was missing. (out of 10,717 observations, 3,259 observations were thus excluded). The final sample of the study, therefore, comprises an unbalanced panel of 1,365 companies across eight years making it a total of 7,458 firm-year observations. Table 2 denotes the number of companies in the sample over the years.

3.2 Variables

The dependent variable for the study is CSR Expenditure. This is measured as the natural logarithm of the total CSR spending incurred by the firm during a given year. To explore the influence of director networks, the study includes a set of network centrality measures calculated using Gephi. The main variables of interest in the study include degree, eigenvector and betweenness centralities.

Degree_Women measures the average degree centrality of women directors of the firm for an year. The degree centrality refers to the number of direct ties an individual holds in the director network. Eigenvector_Women represents the average eigenvector centrality of women directors of a firm. This captures whether women directors are connected to the influential directors in the network. Betweenness_Women measures the average betweenness centrality of women directors, indicating their role as brokers or bridges connecting otherwise unconnected groups. Higher centrality is expected to reflect greater access to information and influence.

In our study in addition to these variables, we also control for board-level characteristics that may potentially influence the firm's CSR expenditure. We include Board Size (the total number of directors who serve on the board of a given company); Proportion of Women, (the share of

women directors relative to board size); and Board Independence (the share of independent directors on the board). The variable Proportion of Women Directors from Elite Institutions captures the proportion of women directors who are the alumnae of elite Indian institutions (defined as the Indian Institutes of Technology and Indian Institutes of Management). This is used as an instrument for network centrality in the two stage least squares and generalized method of moments regressions.

Besides CSR expenditure, other variables that account for the firm's various corporate social responsibility engagements are also used in the study. The variable d_CSR_cmt indicates whether the firm has a CSR committee. d_f_CSR_cmt takes the value 1 if at least one woman director is a part of the CSR committee. d_Compliance1 on the other hand captures whether the firm complies with Section 135 of the Companies Act, 2013, which requires eligible firms to spend at least 2% of the average net profits from the preceding three financial years on CSR activities.

In addition to this, the study also incorporates several firm-level control variables to account for differences in financial characteristics and performance. Since prior studies suggest that bigger firms spend more on corporate social responsibility, we control for firm size in the present study. Here, Firm Size is captured as the logarithm of total assets. The Q ratio, used as a proxy for Tobin's Q, is defined as the sum of market capitalization, debt, and paid-up preference capital relative to total assets. Profitability is also measured using Return on Assets (ROA), which is the ratio of profit after tax to total assets. Leverage is defined as total borrowings (including long-term liabilities and short-term debt)

Additionally, we also control for Tangibility Ratio and Liquidity. This is calculated as the share of tangible assets in total assets. Liquidity is expressed as the ratio of current assets to current liabilities. Moreover, to control for a powerful CEO, we include the variable CEO Duality. It

is a binary indicator that takes the value 1 when the CEO simultaneously holds the position of board chair.

Volatility is proxied by the rolling standard deviation of monthly stock returns over a 24-month window. Firm Age_yrs denotes the number of years since the firm was incorporated Firm Age is measured as the natural logarithm of Firm Age_yrs, Sales Growth reflects the year-over-year change in revenue from non-financial operations. scaled by total assets. Finally, two additional measures—Dividend/Assets and Cash/Assets—are included to capture dividend payouts and cash holdings as a proportion of total assets. Table A1 presents the complete list of variables and their definitions.

3.3 Methodology

Network centrality is a useful concept for understanding an individual's influence or strategic position within a social or organisational network. In the context of corporate boards, centrality can reflect a director's access to information. In this study, we compute four commonly used centrality measures—degree, betweenness, and eigenvector centrality—for each director. These measures allow us to capture different dimensions of a director's influence with regard to their potential impact on CSR-related decision-making.

Degree centrality represents the number of direct ties a director has with others in the network. It simply counts how many connections a given node (in this case, a director) has. Consequently, betweenness centrality captures the extent to which a director lies on the shortest path between other pairs of directors. It quantifies the frequency with which a director serves as a bridge or intermediary in the network. Eigenvector centrality, on the other hand, goes beyond the number of direct ties and considers the quality of those connections. A director with high eigenvector centrality is not only well-connected but also connected to other influential

or well-connected directors (Bianchi et al., 2020). Board interlock network for the years 2016 and 2023 are provided in the appendix (Figure 1).

In this study, we use Social Network Analysis in general and measures of centrality in particular to assess the impact of female director networks on social responsibility of the firm. We average the network centrality of women directors at the firm level to understand the impact on the same on the CSR decisions of the firm.

4 Results

*.4.1 Descriptive Statistics

The descriptive statistics for the final regression sample are reported in Table 1. The sample consists of 7,458 firm-year observations from 2016 to 2023, restricted to NSE listed non-financial firms that disclose information on CSR expenditure.

From the table 2 we can observe that the raw CSR spending (CSR Expenditure_ Rs Crs) is in crore rupees. A firm spends an average of 10.79 crore INR (with a standard deviation of 51.8 crore INR) on activities related to corporate social responsibility. The distribution of CSR Expenditure_ Rs Crs, is highly skewed and we can observe that a few firms have extremely large CSR outlays (with the maximum being 1671.72 crore INR). Therefore, the CSR Expenditure_ Rs Crs is winsorised at the 1^{st} and 99^{th} percentile, and the logarithmic transformation of the same is used as the dependent variable in the study (henceforth referred to as CSR Expenditure). CSR Expenditure has a mean of 0.319 with a standard deviation of 1.838, with moderate positive skewness and kurtosis around three.

When it comes to the main variables of interest, women directors have on average, 15.7 connections (degree centrality). While eigenvector centrality of women directors has a mean of 0.07 and betweenness centrality averages 0.001. The measures of centrality are positively skewed suggesting the existence of a few directors who are highly central. This feature is

consistent with most real world networks. Additionally, it is important to note that we used board interlocks to construct the network. And as we have excluded boards under 4 members, 3 would be the minimum value the average degree centrality of the firm can take in the sample.[3]

We can also observe from the table 2 that, the average Return on Assets (ROA) is 6.6 percent, while the mean Q ratio is 2.28. Both measures are positively skewed, which suggests the existence of a small subset of firms that report a very high profitability and market valuation. We see that most firms operate at moderate debt levels with an average leverage of 0.24. While liquidity averages 2.58, albeit with a long right tail driven by a few highly liquid firms. Firm Size, measured as the log of total assets, has a mean of 7.33.

Additionally, the average board size 9.45 members, out of which women directors constitute only 16.8% (on average). Since we have only included boards of four members and above for the study, the minimum board size is given as four. Independent directors account for 51.8% of boards, suggesting relatively high board independence across firms. CEO duality occurs in only 6.5% of cases.

Regarding CSR, around 67% of firms comply with Section 135 of the Companies Act of 2013. 96.7% of firms maintain a CSR committee, and nearly half (49.2%) include at least a woman CSR committee member.

Additionally, Table 4 presents the pairwise correlations among the variables in the study. We can observe that the three network centrality measures—degree, eigenvector, and betweenness—are highly correlated with each other. This is because these centrality measures capture related dimensions of the director's position and influence in the interlock network.

[3] Degree counts the direct connections an individual has. The degree of a director with no external connections, in a board with a strength of four would be board size minus one (excluding the present director), that is, three. Moreover, if none of the directors in the board have outside connections, the average degree of the board would also be three.

Moreover, Table 4 also reports that CSR expenditure is positively correlated with firm size (0.32) and profitability (0.28). This suggests that larger and more profitable firms are more likely to spend a higher amount of money on CSR. This has been observed in other studies as well. Additionally, we can also observe that leverage is negatively correlated with both CSR and firm performance measures. Governance-related variables such as the proportion of women on the board and board independence show relatively weak correlations with CSR expenditure and centrality.

4.2 Network Characteristics

Table 3 (Panel A) reports the top ten most central firms in terms of the average betweenness and eigenvector centralities of women directors for the years 2016 and 2023 (the first and last year of our sample). Panel A highlights the firms with the highest centrality scores in each year. The table tries to showcase how influence within the director network is distributed across firms. In 2016, companies such as NCC Ltd., Uno Minda Ltd. and Schaeffler India Ltd. where the 'linchpins' in the network in terms of betweenness. In the same year, Wipro Ltd., Indian Hotels Co. Ltd., and Larsen & Toubro Ltd. were the most central in terms of eigenvector. By 2023, however, the central positions were occupied by firms such as Computer Age Management Services Ltd., Whirlpool of India Ltd., and KFin Technologies Ltd. for betweenness, and Tata Consumer Products Ltd., Deepak Nitrite Ltd., and Ambuja Cements Ltd. for eigenvector centrality.

Panel B presents the subset of firms that exhibit persistent influence across both periods. Bosch Ltd. and ABB India Ltd. consistently appear among the top firms based on both betweenness and eigenvector measures. Ambuja Cements Ltd. and Computer Age Management Services Ltd., on the other hand, maintain strong eigenvector and betweenness rankings, respectively.

The ‘persistence’ of these firms emphasizes their role in sustaining the influence of women directors within interlocking board networks.

Table 3 (Panel B) reports the average firm-level centrality of women directors from 2016 to 2023. The average women director degree for firms remain relatively stable across the time period of the study, fluctuating between 13 and 15 (Fig. 1). This suggests that, on average, women directors are connected to a consistent number of other directors through board interlocks. Betweenness centrality values for directors remain low throughout the sample, which is expected in large corporate networks. The slight decline over time (this can be observed in Fig 1) may indicate a reduction in their brokerage influence relative to earlier years. This might be because, as more directors enter the network, the network becomes denser over time. In denser networks, there are more alternative paths connecting directors, which reduces the relative importance of any single director as a broker.

The eigenvector centrality of women directors shows substantial variation over the study period. Between 2016 and 2020, the average values remain relatively stable, fluctuating around 0.06–0.07. Eigen vector for women directors for some firms reach very high scores (up to 0.97 in 2018). This indicates that a few firms had women directors positioned in highly influential parts of the network. However, after 2020, the averages show greater fluctuation. From figure 2 we can see a definite dip in 2021 and another drop in 2023. Eigenvector falls to 0.052 in 2021, recovers to 0.061 in 2022, and then decreases to 0.033 in 2023 (Table 3). These patterns suggest that while women directors continue to occupy influential positions in some years, we can see year-to-year variations in how well-connected they are to other powerful directors.

4.3 Main Evidence for Women Director Network Centrality and a Firm’s CSR

To examine the relationship between the network centrality of women directors and corporate social responsibility (CSR) expenditure, the following baseline econometric model is estimated with different measures of centrality

$$Y_{it} = \alpha + \beta X_{it-1} + \gamma Z_{it-1} + \mu_t + \nu_i + \varepsilon_{it}$$

where Y_{it} denotes firm i's CSR expenditure in log terms at time t. X_{it}represents the key explanatory variable, the different measures of network centrality of the director (Degree, Betweenness and Eigenvector). $Z_{it}$is a vector of the control variables used in the study (Z_{it} include, leverage, firm age, firm size, Tobin's Q, CEO duality, cash-to-assets ratio, dividend-to-assets ratio, return on assets (ROA), sales growth, liquidity, tangibility ratio, board size, proportion of women directors on the board and board independence). μ_t are year fixed effects, ν_i are the industry fixed effects and $\varepsilon_{it}$is the error term.

Additionally, it is important to note that all independent variables are lagged by one year to allay potential reverse causality concerns. Moreover, all continuous variables are winsorized at the first and ninety-ninth percentile to mitigate the effect of outliers.

The estimation results are presented in Tables 6 to 8. Table 6 presents the results for Degree Centrality as the main variable of interest. Tables 7 and 8 report the results for Betweenness and Eigenvector Centrality respectively. All three measures of centrality cannot be included in the same model, as they are highly correlated (see Table 4 for correlations). Model (1) reports pooled OLS estimates without fixed effects. Model (2) includes year fixed effects and model (3) adds industry fixed effects. Model (4) incorporates both firm and industry fixed effects. Across Models (2) to Model (4), standard errors are clustered at the firm level to account for within-firm correlation over time.

We can see that the regression results across Tables 6 to 8 examine the relationship between women directors' centrality in board interlock networks and firms' CSR expenditure. Regardless of whether centrality is measured through degree, betweenness, or eigenvector, the results consistently indicate a positive and statistically significant association.

Starting with degree centrality, the estimates show that firms with women directors holding more board connections spend more on CSR. This reflects the idea that a larger number of ties facilitates information flow and exposure to CSR practices adopted by other firms. Betweenness centrality yields a similar pattern, with coefficients remaining strongly positive across specifications. This suggests that women directors occupying brokerage positions—linking otherwise unconnected boards—are effective in diffusing CSR norms and transmitting external practices. Eigenvector centrality, which reflects the influence of being connected to other well-connected directors, also displays a positive effect. This shows that firms with women directors who are connected to influential individuals can leverage these connections to promote CSR activities within their firms.

If we focus on the fully specified models with time and industry fixed effects (Model 4, in Tables 6-8), the coefficients on women directors' centrality measures are positive and statistically significant. The estimated coefficient for degree indicates the percentage change in CSR expenditure associated with each additional board connection held by a woman director. Since the dependent variable is in log form, a coefficient of 0.01 (in Model 4, Table 6), implies that every extra direct tie is associated with roughly a 1% higher CSR expenditure.

Similarly, betweenness centrality of women directors in the firm also has a positive and significant effect on the CSR expenditure incurred by the firm. However, from the summary statistics table (Table 2) , we can see that even after winsorizing, betweenness centrality ranges between 0 and 0.006804. It has a mean of 0.000527 and has a median of zero, suggesting that most directors do not serve as bridges in the network. Therefore, interpreting the coefficient for betweenness becomes difficult. At the 99th percentile betweenness is 0.003261, so we can see that an increment in CSR by say 0.003261 would increase CSR by 12.5% in Model 4 reported in Table 7.

The coefficient on eigenvector centrality in model 4 indicates that a 0.01 increase in the average eigenvector centrality of women directors is associated with a 0.78% increase in CSR expenditure, holding all other factors constant. Given the distribution of eigenvector centrality in the sample (median 0.018, maximum 0.461), this implies that more central women directors on the board are economically associated with higher CSR investments by firms

The control variables provide further support for the validity of the models. Firm profitability, size, and tangibility are consistently positively related to CSR expenditure, while leverage shows a negative effect, implying that firms with a higher debt to equity ratio allocate fewer resources to discretionary CSR spending. Sales growth is negatively associated with CSR. This might be because high-growth firms prioritize reinvestment (Richardson and Lanis , 2007). That said, dividend payouts, liquidity, and larger boards generally strengthen CSR commitment.

There, the findings demonstrate that not only the number of connections (degree centrality), but also the structural position (betweenness) and the quality of connections (eigenvector) of women directors matter for shaping CSR strategies.

4.4 Addressing Potential Endogeneity Concerns Using Instrument Variable Regressions

While examining the effect of network centrality of women directors on CSR expenditure, endogeneity can become a key concern. Endogeneity violates the Gauss-Markov assumptions, making the ordinary least squares (OLS) estimator inconsistent.

There are two main sources of potential endogeneity in this context – reverse causality and omitted variable bias. Firms that are more socially responsible may be more likely to attract or appoint well-networked women directors. This may create a reverse causality where CSR spending and network centrality influence each other simultaneously.

Additionally, omitted variable bias is also a concern. There may be unobserved confounding factors such as commitment to sustainability or pressure from stakeholders affect both board composition and connections as well as the firm's corporate social responsibility. Therefore, in order to control for this potential endogeneity, we use instrument variable regressions.

For a variable to act as a suitable instrument, it should satisfy two conditions – instrument relevance and instrument exogeneity (Wooldridge, 2013). The first condition suggests that the instrument should be sufficiently correlated with the endogenous regressor. On the other hand, instrument exogeneity recommends that the instrument should be uncorrelated with the dependent variable or the unobserved factors in the error terms.

In this study, we use the proportion of women directors who have attended elite institutions in India as the instrument for network centrality. This instrument is similar to the one used by Amin et al. (2020) (they have used the fraction of MBA graduates from elite institutions as an instrument for board networks). The instrument used in the study is likely to influence a director's network centrality as elite institutional background can provide privileged access to influential social networks through alma mater and alumni ties. At the same time, the women directors' alma mater affiliation would be exogenous to firm-level CSR decisions. Thus, the instrument would satisfy both the relevance and exclusion criteria required for a valid instrument.

For the instrument variable regression, we first adopt a two-stage least squares (2SLS) regression using the instrument variable discussed previously. 2SLS would break down the endogenous independent variable into endogenous and exogenous components. Here, through 2SLS we would be able to isolate the exogenous variation in the average centrality of women directors that arises from their elite educational background. The predicted values of network centrality from the first stage estimation would be plugged into the regression of CSR

expenditure on the independent variables. This would allow us to obtain unbiased and consistent estimates for the impact of network centrality on CSR.

While two-stage least squares (2SLS) is effective in addressing endogeneity, this approach can have limitations. This is because conventional instrumental variable estimations such as two-stage least squares (2SLS) rely on the assumption of homoskedastic errors. However, this may not hold in our context, given the variation in firm characteristics and CSR behaviour across firms and over time. To ensure robust and efficient estimation in the presence of heteroskedasticity, we also adopt the Generalised Method of Moments (GMM). GMM provides consistent estimates even when the error terms are heteroskedastic and allows us to use additional moment conditions, improving efficiency.

Tables 9 and 10 (see Appendix) report the second-stage results from the two-stage least squares (2SLS) and generalized method of moments (GMM) estimations, respectively. The dependent variable in all four regressions is the logarithmic transformation of CSR expenditure. Columns (1) through (4) in the tables report the results for three alternative centrality measures—degree, betweenness and eigenvector. Additionally, all models include industry and time fixed effects to control for unobserved heterogeneity.

Across all specifications, the instrument performs strongly, as indicated by the Anderson LR test for under identification and the Cragg–Donald F-statistics for weak identification. The Anderson–Rubin test also rejects the null of no effect, providing further confidence in the relevance and validity of the instrument. Since each specification is exactly identified, the Sargan test yields a value of zero.

Turning to the main results (Table 9 and 10), we find consistent and robust evidence that women directors' network centrality significantly increases firm-level CSR expenditure. In column (1), a one-unit increase in degree centrality is associated with approximately a 3.9%

increase in CSR spending, after accounting for fixed effects and other firm-level controls. In column (2), eigenvector centrality is also positive and highly significant. As eigenvector ranges between 0.001933 and 0.461009 units (with a mean of 0569572) a 0.01 unit increase in the centrality measure causes CSR expenditure to increase by 4.44%. This confirms that firms with women directors connected to other influential directors allocate substantially more resources toward CSR.

Finally, column (3) shows that betweenness centrality has an particularly large economic effect. This reflects the pivotal role of brokerage positions in facilitating CSR engagement. While the magnitudes differ across measures, the positive and significant coefficients across all three centrality metrics, suggest that, even after controlling for endogeneity, women directors' position in board networks can have an impact on the firm's CSR.

The control variables behave as expected and in line with the literature. The R-squared is around 70% across all specifications. The GMM estimates (Table 10) largely mirror the 2SLS results, suggesting that the findings are robust to heteroskedasticity. Therefore, we see that even after controlling for endogeneity through 2SLS and GMM, the network centrality of women directors plays a significant role in shaping a firm's CSR outcomes.

4 Conclusion

This study shows that women directors' positions in board interlock networks significantly influence firms' CSR expenditure. Using NSE-listed non-financial firms from 2016–2023, we find that degree, eigenvector, and betweenness centrality of women directors are positively associated with CSR. Instrumental variable estimations, confirm the impact of centrality, particularly when women directors occupy influential or brokerage positions in the network. Our findings suggest that women directors' network positions extend their influence beyond boardroom representation, shaping the firm's social and ethical orientation.

These results align with resource dependence theory, which emphasizes directors' ability to provide access to external resources, and institutional theory, which stresses the diffusion of CSR norms through board interlocks. The diffusion of norms, knowledge, and legitimacy through corporate networks may encourage greater CSR commitment by firms. We can see that not only presence but also the position of women in corporate networks matters for socially responsible outcomes.

Policy implications arise for regulators and stakeholders advocating for board diversity and social responsibility of firms. Beyond numerical representation, fostering opportunities for women to occupy central and influential network positions may yield meaningful improvements in corporate social responsibility. Future research could extend this analysis by examining heterogeneity across industries or exploring the interaction between network centrality and institutional ownership.

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Appendix

A1

Variable definitions

Variables	Definitions
Board Level Variables	
Degree_Women	Average degree centrality of the women directors on the board of a firm. Degree refers to the number of direct connections a node has. Computed using Gephi
Eigenvector_Women	Average eigenvector centrality of the women directors on the board of a firm. Eigenvector centrality captures the number of influential nodes a certain node is connected to. Computed using Gephi
Betweenness_Women	Average betweenness centrality of the women directors on the board of a firm. Betweenness centrality refers to the bridging ability of a node (the ability to connect disconnected clusters). Computed using Gephi
Board Size	The number of directors on a firm's board
Proportion. of Women	The proportion of women directors on the firm's board. Computed as the number of women directors divided by the board size
Board Independence	Proportion of independent directors on a firm's board. Computed as the number of independent directors divided by the board size
Proportion of Women Directors from Elite Institutions	Proportion of women directors on the firm's board who have attended elite institutions in India. In the present study, any Indian Institute of Technology (IIT) or Indian Institute of Management (IIM) is considered an elite institution
CSR Related Variables	
CSR Expenditure	Log of the total amount spent on corporate social responsibility by the firm during the year
d_CSR_cmt	Indicates whether the firm has a CSR committee
d_f_CSR_cmt	Indicates whether the firm has a woman CSR committee member
d_Compliance1	Indicates whether the firm complies with Section 135 of the Companies Act, 2013, which mandates that eligible firms spend at least 2% of the average net profits from the preceding three financial years on CSR activities

Firm Level Variables	
Tangibility Ratio	Tangibility is computed as the difference between net fixed assets and net intangible assets. Tangibility is divided by total assets to arrive at the tangibility ratio
Liquidity	Computed by dividing current assets by current liabilities.
Volatility	A rolling 24-month standard deviation of returns
CEO duality	An indicator for a firm with the CEO also serving as the chair of the board
Firm Age_yrs	Captures the number of years since the incorporation of the firm
Firm Age	Logarithmic transformation of Firm Age_yrs
Firm Size	Computed as the logarithmic transformation of the total assets of a firm
Sales Growth	Increase or decrease in the income from non-financial operations from the previous year
Q ratio	Proxy for Tobin's Q, computed as the ratio of the sum of market capitalization, debt and paid-up preference capital of the firm to its total assets
Return on Assets	Return on assets (ROA) is computed as the ratio of a firm's Profit after tax (PAT) to its total assets.
Leverage	Leverage of a firm is computed as the sum of non-current liabilities and short-term borrowings of the firm divided by its total assets
Dividend/Assets	Dividends divided by total assets
Cash/Assets	Cash balance divided by total assets

Table 1

Summary Statistics

The table presents the descriptive statistics for the final sample for the study. We report the descriptive statistics only for firms where information on CSR expenditure is available. Therefore, the final sample contains 7458 observations over the period of 2016-2023. Table A1 defines the variables used in the study.

	N	Mean	SD	Min	Median	Max	Skewness	Kurtosis
CSR Expenditure	7458	.319	1.838	-3.912	.239	5.347	.277	3.018
CSR Expenditure_RsCr.	7458	10.795	51.780	.01	1.27	1671.72	12.68	243.67
Degree_Women	7429	15.711	12.237	3	11	57	1.581	4.897
Eigenvector_Women	7429	.07	0.100	.002	.027	.461	2.232	7.728
Betweeness_Women	7429	.001	0.001	0	0	.007	2.711	10.503
ROA	7458	.066	0.071	-.414	.059	.29	-.381	8.989
Q ratio	7458	2.283	2.382	.213	1.412	14.041	2.553	10.63
Div/Assets	7458	.017	0.030	0	.007	.174	3.351	15.498
Leverage	6493	.238	0.161	.012	.218	1.27	.86	4.225
Cash/Assets	7458	.001	0.002	0	0	.018	4.985	30.43
CEO Duality	7458	.065	0.247	0	0	1	3.519	13.384
Tangibility Ratio	7458	.259	0.177	0	.236	.841	.543	2.592
Sales Growth	7441	.12	0.332	-.792	.085	2.669	2.74	20.734
Liquidity	7455	2.579	2.596	.114	1.729	21.243	3.87	23.146
Firm Size	7458	7.326	1.570	2.724	7.165	13.787	.639	3.667
Firm Age_yrs	7458	37.888	21.361	1	33	160	1.33	5.411
Firm Age	7458	3.474	0.602	0	3.497	5.075	-.77	4.843
d_Compliance1	7458	.668	0.471	0	1	1	-.715	1.512
d_ CSR cmt	7458	.967	0.178	0	1	1	-5.242	28.475
d_ f_ CSR cmt	7458	.492	0.500	0	0	1	.032	1.001
Board Size	7458	9.454	2.852	4	9	24	.975	4.321
Proportion of Women	7458	.168	0.079	0	.143	.556	1.236	4.782
Board Independence	7458	.518	0.100	0	.5	.875	-.322	4.698

Table 2. CSR Expenditure and Compliance with the Companies Act (2013)

This table provides information on the availability of CSR expenditure data and compliance patterns of firms over the period 2016–2023. Panel A reports the distribution of firms for which CSR expenditure data are available. Panel B shows the number of firms that have complied with Section 135 of the Companies Act. The mandate requires eligible firms to spend at least 2% of average net profits on CSR activities. The panel distinguishes between compliant and under-compliant firms for each year.

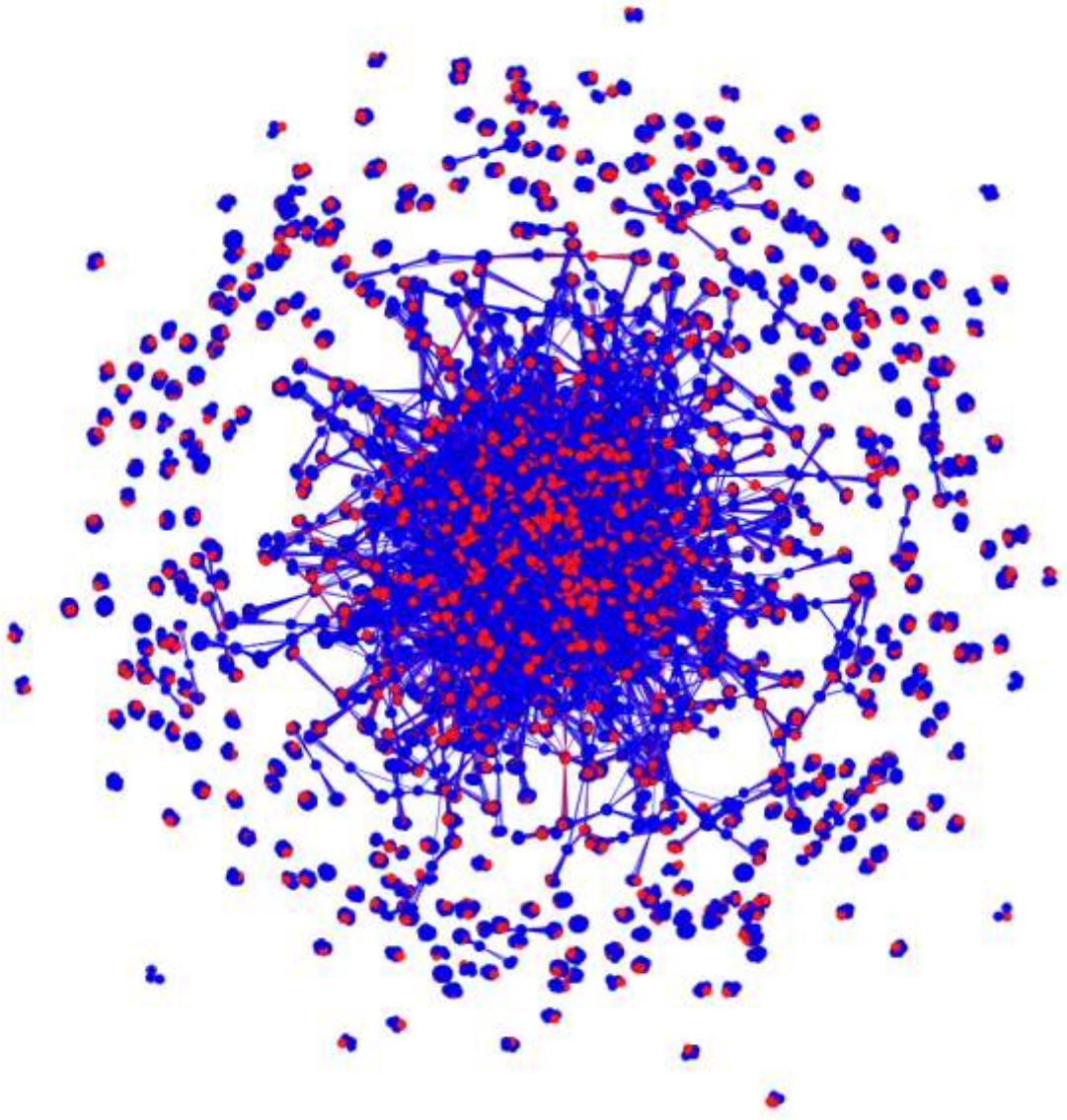
Panel A			
Year	**Companies**	**Percent**	**Cumulative Percent**
2016	704	9.44	9.44
2017	789	10.58	20.02
2018	847	11.36	31.38
2019	887	11.89	43.27
2020	949	12.72	55.99
2021	1,008	13.52	69.51
2022	1,083	14.52	84.03
2023	1,191	15.97	100.00
Total	7,458	100.00	

Panel B					
Year	**Under Compliance**		**Compliance**		**Total**
	Frequency	Percent	Frequency	Percent	
2016	320	45.45	384	54.55	704
2017	329	41.7	460	58.3	789
2018	317	37.43	530	62.57	847
2019	294	33.15	593	66.85	887
2020	302	31.82	647	68.18	949
2021	214	21.23	794	78.77	1008
2022	330	30.47	753	69.53	1083
2023	367	30.81	824	69.19	1191
	2473		4985		7458

Figure 1. Board interlock network for NSE listed companies

The figure represents the board interlock network for all NSE listed companies. Here nodes are directors while edges that connect them are the firms they are a part of. Male directors are represented by blue nodes while women directors are denoted by red nodes. Panel A of the figure represents the interlock network for the year 2016, while Panel B for the year 2023.

Panel A: Board interlock network for directors of all the NSE listed companies for the year 2016



Panel B: Board interlock network for directors of all the NSE listed companies for the year 2023

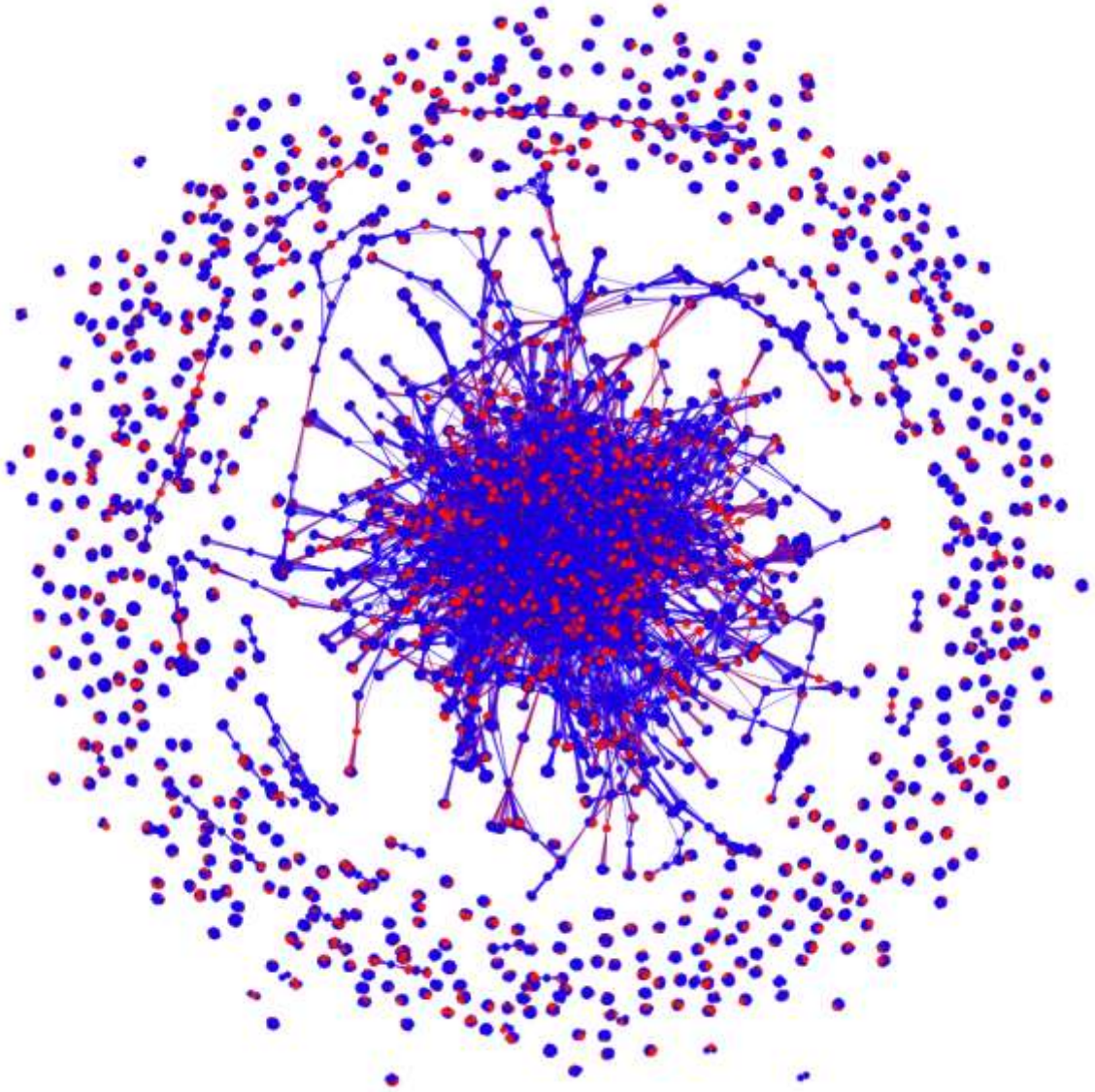


Table 3

Top 10 most central firms

Panel A shows the top 10 most influential firms in the network, based on the average betweenness and eigenvector centralities of women directors for the years 2016 and 2023. Panel B denotes the firms that exhibit a persistent influence**.**

Panel A								
	Betweenness				**Eigenvector**			
	2016		**2023**		**2016**		**2023**	
Sl. No.	**Firm**	**Average Centrality**	**Firm**	**Average Centrality**	**Firm**	**Average Centrality**	**Firm**	**Average Centrality**
1	NCC Ltd.	0.014501	Computer Age Management Services Ltd.	0.0091	Wipro Ltd.	0.705859	Tata Consumer Products Ltd.	0.581988
2	Uno Minda Ltd.	0.014501	Whirlpool Of India Ltd.	0.005738	Indian Hotels Co.Ltd.,THE	0.649297	Deepak Nitrite Ltd.	0.491877
3	Schaeffler India Ltd.	0.014501	Kfin Technologies Ltd.	0.005738	Larsen & Toubro Ltd.	0.6479925	Ambuja Cements Ltd.	0.477882
4	Bosch Ltd.	0.009215	Sutlej Textiles & Industries Ltd.	0.005738	Tata Chemicals Ltd.	0.592735	Dabur India Ltd.	0.404015
5	Abb India Ltd.	0.009215	Eih Associated Hotels Ltd.	0.00533	Bosch Ltd.	0.555078	ACC Ltd.	0.388186
6	Torrent Pharmaceuticals Ltd.	0.0088485	JK Lakshmi Cement Ltd.	0.005033	Abb India Ltd.	0.555078	Mahindra & Mahindra Ltd.	0.3189737
7	LT Foods Ltd.	0.008215	Cg Power & Industrial Solutions Ltd.	0.0049865	Rallis India Ltd.	0.479175	Metropolis Healthcare Ltd.	0.3167285
8	Torrent Power Ltd.	0.0080347	Sun Pharmaceutical Industries Ltd.	0.004444	JSW Steel Ltd.	0.479175	Computer Age Management Services Ltd.	0.306855
9	Atul Ltd.	0.007817	Vst Industries Ltd.	0.004444	Sobha Ltd.	0.479175	Britannia Industries Ltd.	0.289802

10	Gujarat Alkalies & Chemicals Ltd.	0.007635	Petronet Lng Ltd.	0.004281	Ambuja Cements Ltd.	0.47407	KEC International Ltd.	0.274787

Panel B					
Sl. No.	**Firms with Persistent Influence**	**Betweenness**		**Eigenvector**	
		2016	**2023**	**2016**	**2023**
1	Bosch Ltd.	0.009215		0.555078	
2	ABB India Ltd.	0.009215		0.555078	
3	Ambuja Cements Ltd.			0.47407	0.477882
4	Computer Age Management Services Ltd.		0.0091		0.306855

Table 4

Pairwise Correlations

The table presents the pairwise correlations among the variables used in the study. In the correlation matrix, p-values below 0.05 are marked with an asterisk.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) CSR Expenditure	1									
(2) Degree_Women	0.382*	1								
(3) Eigenvector_Women	0.420*	0.888*	1							
(4) Betweenness_Women	0.237*	0.866*	0.775*	1						
(5) ROA	0.295*	0.123*	0.119*	0.086*	1					
(6) Q ratio	0.236*	0.164*	0.174*	0.121*	0.320*	1				
(7) Dividend/Assets	0.334*	0.194*	0.206*	0.127*	0.435*	0.411*	1			
(8) Leverage	-0.133*	-0.083*	-0.074*	-0.056*	-0.474*	-0.161*	-0.244*	1		
(9) Cash/Assets	-0.036*	-0.032*	-0.001	-0.012	0.023*	0.046*	-0.018	-0.018	1	
(10) Firm Age	0.219*	0.163*	0.176*	0.098*	0.073*	-0.014	0.136*	-0.021*	-0.068*	1
(11) Tangibility Ratio	0.021	0.023*	0.005	0.005	-0.055*	-0.093*	-0.086*	0.251*	-0.043*	0.066*
(12) CEO Duality	0.01	0.002	-0.006	0.019	-0.002	0.001	-0.003	0.009	-0.042*	0.027*
(13) Sales Growth	-0.012	-0.003	-0.013	-0.01	0.198*	0.101*	0.004	-0.093*	0.015	-0.090*
(14) Liquidity	-0.012	-0.050*	-0.055*	-0.034*	0.171*	0.080*	0.133*	-0.345*	-0.013	-0.031*
(15) Firm Size	0.798*	0.451*	0.459*	0.291*	0.143*	0.031*	0.193*	-0.017	-0.130*	0.292*
(16) Board Size	0.452*	0.412*	0.399*	0.177*	0.130*	0.062*	0.174*	-0.035*	-0.069*	0.232*
(17) Proportion of Women	-0.070*	-0.161*	-0.133*	-0.097*	-0.044*	0.022*	-0.026*	-0.035*	0.012	-0.127*
(18) Board Independence	-0.120*	0.004	0.015	0.049*	-0.013	-0.025*	-0.042*	-0.02	-0.008	0.045*
(19) Proportion of Women Directors from Elite Institutions	0.135*	0.189*	0.189*	0.146*	0.085*	0.145*	0.157*	-0.054*	0.008	-0.013

Variables	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
(1) CSR Expenditure									
(2) Degree_Women									
(3) Eigenvector_Women									

(4) Betweenness_Women									
(5) ROA									
(6) Q ratio									
(7) Dividend/Assets									
(8) Leverage									
(9) Cash/Assets									
(10) Firm Age									
(11) Tangibility Ratio	1								
(12) CEO Duality	-0.01	1							
(13) Sales Growth	-0.036*	-0.007	1						
(14) Liquidity	-0.264*	0.046*	0.039*	1					
(15) Firm Size	0.073*	0.015	-0.020*	-0.149*	1				
(16) Board Size	0.123*	0	-0.014	-0.096*	0.524*	1			
(17) Proportion of Women	-0.105*	-0.013	0.041*	0.091*	-0.185*	-0.302*	1		
(18) Board Independence	0.035*	0.074*	-0.027*	-0.015	-0.042*	-0.142*	0.039*	1	
(19) Proportion of Women Directors from Elite Institutions	-0.069*	-0.027*	0.005	0.043*	0.126*	0.039*	0.085*	0.053*	1

Figure 1

Change in Centrality Measures Over Time

The figure demonstrates the change in the firm level average centrality of women directors across the period of study. The y axis of the bar charts represents the Degree, Betweenness and Eigenvector centrality. The x axis plots the years (from 2016 to 2023)

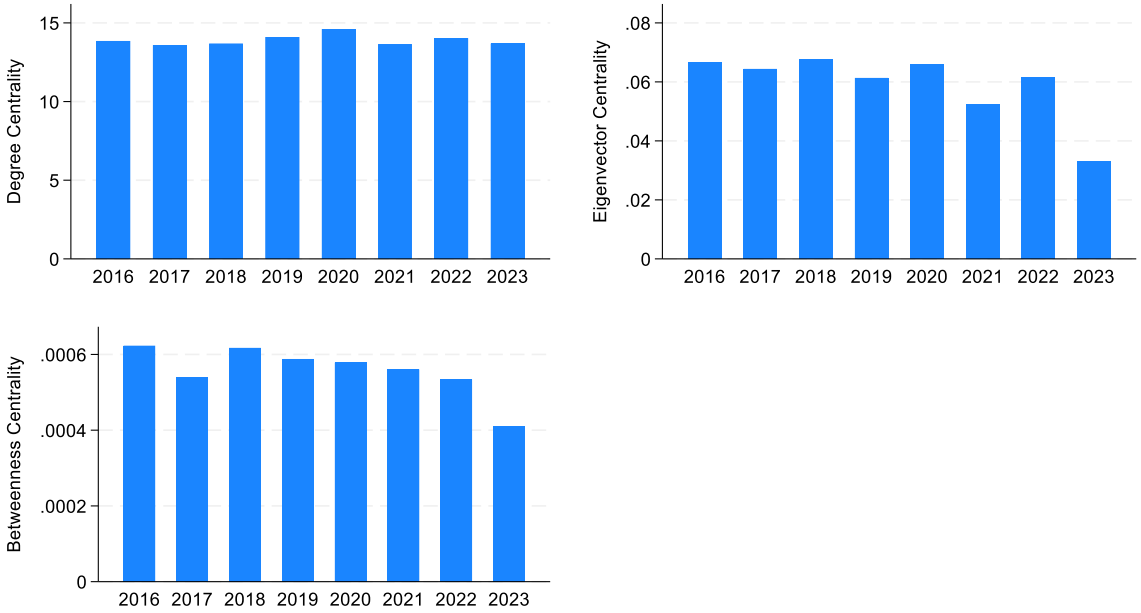


Table 5

Average of Firm-Level Centrality Measures of Women Directors Over Time

The tables present the average firm level centralities of women directors. The averages are given for degree, betweenness and eigenvector centralities for the sample period (2016-2023). The statistics are presented for all the firms in sample and not just for the firms where CSR information is available.

Degree Centrality of Firm (Women Directors)					
Year	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
2016	1082	13.85	11.98	3	68
2017	1157	13.59	11.93	3	76
2018	1229	13.68	12.18	3	94
2019	1268	14.1	12.6	3	84
2020	1320	14.61	12.13	3	72
2021	1379	13.65	10.78	3	66
2022	1537	14.03	12.02	3	86
2023	1686	13.69	11.08	3	88

Betweenness Centrality of Firm (Women Directors)					
Year	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
2016	1082	0.0006231	0.001646	0	0.014501
2017	1157	0.0005394	0.001359	0	0.008831
2018	1229	0.0006173	0.001623	0	0.012153
2019	1268	0.000588	0.001568	0	0.014915
2020	1320	0.0005784	0.00141	0	0.011929
2021	1379	0.0005604	0.001273	0	0.009117
2022	1537	0.0005339	0.00118	0	0.01032
2023	1686	0.0004095	0.000864	0	0.0091

Eigenvector Centrality of Firm (Women Directors)					
Year	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
2016	1082	0.0665	0.104	0.0016	0.7059
2017	1157	0.0644	0.1056	0.0016	0.7522
2018	1229	0.0676	0.1108	0.0016	0.9715
2019	1268	0.0613	0.1031	0.0015	0.8292
2020	1320	0.066	0.1038	0.0015	0.6851
2021	1379	0.0522	0.0788	0.0016	0.5674
2022	1537	0.0614	0.0972	0.0017	0.6999
2023	1686	0.0331	0.0529	0.0013	0.582

Table 6

Average Women Director Degree Centrality and Firm's CSR Expenditure.

This table reports the baseline regression results of the average degree centrality of women directors on the firm's board on the firm's CSR expenditure. The sample includes non-financial NSE-listed firms from 2016 to 2023 available in the CMIE Prowess Database. The dependent variable in all models is the logarithmic transformation of the CSR expenditure the firm incurred in the present year. The main variable of interest is the degree centrality computed from the board interlock network using Gephi. Table A1 in the appendix defines all variables. Additionally, all the independent variables are lagged by one year. All continuous variables are winsorised at the first and the ninety-ninth percentile. Standard errors are clustered at the firm level for models (2) through (4) and are given in parentheses. *** p < 0.01; ** p < 0.05; * p < 0.1.

	(1)	(2)	(3)	(4)
VARIABLES	CSR Expenditure			
Degree	0.00556***	0.00547***	0.00578***	0.00569***
	(0.00112)	(0.00156)	(0.00159)	(0.00159)
Return on Assets	7.513***	7.579***	7.249***	7.310***
	(0.249)	(0.521)	(0.534)	(0.538)
Q Ratio	0.0360***	0.0390***	0.0355***	0.0394***
	(0.00630)	(0.00964)	(0.00968)	(0.00997)
Dividend/Assets	3.426***	3.077***	3.244***	2.877***
	(0.557)	(0.713)	(0.686)	(0.700)
Leverage	-1.176***	-1.150***	-1.124***	-1.102***
	(0.0905)	(0.154)	(0.161)	(0.160)
Cash/Assets	6.109	8.072	11.52*	13.67**
	(4.887)	(5.636)	(5.888)	(5.887)
Firm Age	0.0346	0.0357	0.0304	0.0310
	(0.0211)	(0.0340)	(0.0354)	(0.0354)
CEO Duality	0.0523	0.0398	0.0478	0.0365
	(0.0512)	(0.0666)	(0.0693)	(0.0687)
Tangibility Ratio	0.823***	0.824***	0.817***	0.821***
	(0.0742)	(0.116)	(0.137)	(0.136)
Sales Growth	-0.208***	-0.183***	-0.200***	-0.170***
	(0.0373)	(0.0502)	(0.0460)	(0.0520)
Liquidity	0.0168***	0.0163*	0.0168*	0.0165*
	(0.00642)	(0.00971)	(0.00969)	(0.00975)
Firm Size	0.891***	0.891***	0.900***	0.900***
	(0.00950)	(0.0173)	(0.0183)	(0.0183)
Board Size	0.0186***	0.0177**	0.0147*	0.0139*
	(0.00529)	(0.00790)	(0.00819)	(0.00815)
Proportion of Women	0.461***	0.312	0.484**	0.346
	(0.170)	(0.211)	(0.207)	(0.217)
Board Independence	-0.0956	-0.106	-0.0719	-0.0862
	(0.128)	(0.177)	(0.181)	(0.181)
Constant	-7.138***	-7.118***	-7.173***	-7.151***

	(0.126)	(0.184)	(0.189)	(0.190)
Observations	5,424	5,424	5,424	5,424
R-squared	0.765	0.767	0.773	0.774
Industry Fixed Effects	No	No	Yes	Yes
Time Fixed Effects	No	Yes	No	Yes
Cluster	No	Firm	Firm	Firm

Table 7

Average Women Director Betweenness Centrality and Firm's CSR Expenditure.

This table reports the baseline regression results of the average betweenness centrality of women directors on the firm's board on the firm's CSR expenditure. The sample includes non-financial NSE-listed firms from 2016 to 2023 available in the CMIE Prowess Database. The dependent variable in all models is the logarithmic transformation of the CSR expenditure the firm incurred in the present year. The main variable of interest is the betweenness centrality computed from the board interlock network using Gephi. Table A1 in the appendix defines all variables. Additionally, all the independent variables are lagged by one year. All continuous variables are winsorised at the first and the ninety-ninth percentile. Standard errors are clustered at the firm level for models (2) through (4) and are given in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

	(1)	(2)	(3)	(4)
VARIABLES	CSR Expenditure			
Betweenness	32.24***	33.86***	34.56***	36.10***
	(9.110)	(12.58)	(12.83)	(12.79)
Return on Assets	7.482***	7.551***	7.219***	7.282***
	(0.249)	(0.519)	(0.532)	(0.536)
Q Ratio	0.0377***	0.0407***	0.0369***	0.0407***
	(0.00629)	(0.00961)	(0.00967)	(0.00994)
Dividend/Assets	3.485***	3.122***	3.303***	2.923***
	(0.557)	(0.714)	(0.687)	(0.702)
Leverage	-1.190***	-1.162***	-1.134***	-1.110***
	(0.0906)	(0.154)	(0.161)	(0.160)
Cash/Assets	6.326	8.364	11.66**	13.89**
	(4.892)	(5.635)	(5.904)	(5.905)
Firm Age	0.0360*	0.0370	0.0305	0.0311
	(0.0211)	(0.0342)	(0.0355)	(0.0356)
CEO Duality	0.0485	0.0354	0.0446	0.0325
	(0.0513)	(0.0671)	(0.0696)	(0.0690)
Tangibility Ratio	0.822***	0.822***	0.804***	0.810***
	(0.0743)	(0.116)	(0.137)	(0.136)
Sales Growth	-0.209***	-0.184***	-0.199***	-0.170***
	(0.0374)	(0.0505)	(0.0462)	(0.0523)
Liquidity	0.0166***	0.0162*	0.0168*	0.0165*
	(0.00643)	(0.00968)	(0.00965)	(0.00971)
Firm Size	0.897***	0.896***	0.907***	0.906***
	(0.00936)	(0.0169)	(0.0178)	(0.0178)
Board Size	0.0233***	0.0223***	0.0196**	0.0186**
	(0.00521)	(0.00795)	(0.00830)	(0.00825)
Proportion of Women	0.454***	0.301	0.477**	0.335
	(0.170)	(0.212)	(0.207)	(0.217)
Board Independence	-0.0771	-0.0904	-0.0570	-0.0742
	(0.128)	(0.178)	(0.182)	(0.182)
Constant	-7.173***	-7.148***	-7.204***	-7.177***
	(0.125)	(0.185)	(0.191)	(0.191)

Observations	5,424	5,424	5,424	5,424
R-squared	0.764	0.766	0.772	0.774
Industry Fixed Effects	No	No	Yes	Yes
Time Fixed Effects	No	Yes	No	Yes
Cluster	No	Firm	Firm	Firm

Table 8

Average Women Director Eigenvector Centrality and Firm's CSR Expenditure.

This table reports the baseline regression results of the average eigenvector centrality of women directors on the firm's board on the firm's CSR expenditure. The sample includes non-financial NSE-listed firms from 2016 to 2023 available in the CMIE Prowess Database. The dependent variable in all models is the logarithmic transformation of the CSR expenditure the firm incurred in the present year. The main variable of interest is the eigenvector centrality computed from the board interlock network using Gephi. Table A1 in the appendix defines all variables. Additionally, all the independent variables are lagged by one year. All continuous variables are winsorised at the first and the ninety-ninth percentile. Standard errors are clustered at the firm level for models (2) through (4) and are given in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

	(1)	(2)	(3)	(4)
VARIABLES	CSR Expenditure			
Eigenvector	0.680***	0.714***	0.742***	0.775***
	(0.138)	(0.191)	(0.194)	(0.196)
Return on Assets	7.528***	7.602***	7.264***	7.332***
	(0.249)	(0.523)	(0.536)	(0.540)
Q Ratio	0.0356***	0.0382***	0.0350***	0.0385***
	(0.00631)	(0.00971)	(0.00970)	(0.0100)
Dividend/Assets	3.362***	3.005***	3.180***	2.809***
	(0.557)	(0.717)	(0.688)	(0.703)
Leverage	-1.174***	-1.143***	-1.121***	-1.095***
	(0.0906)	(0.155)	(0.161)	(0.160)
Cash/Assets	5.254	7.353	10.56*	12.87**
	(4.892)	(5.567)	(5.814)	(5.799)
Firm Age	0.0320	0.0327	0.0271	0.0273
	(0.0211)	(0.0342)	(0.0354)	(0.0354)
CEO Duality	0.0561	0.0427	0.0511	0.0386
	(0.0512)	(0.0669)	(0.0695)	(0.0687)
Tangibility Ratio	0.829***	0.829***	0.822***	0.829***
	(0.0742)	(0.116)	(0.137)	(0.136)
Sales Growth	-0.210***	-0.183***	-0.201***	-0.171***
	(0.0373)	(0.0503)	(0.0460)	(0.0520)
Liquidity	0.0172***	0.0166*	0.0174*	0.0170*
	(0.00642)	(0.00970)	(0.00965)	(0.00971)
Firm Size	0.887***	0.886***	0.896***	0.895***
	(0.00971)	(0.0177)	(0.0187)	(0.0188)
Board Size	0.0186***	0.0173**	0.0144*	0.0132
	(0.00529)	(0.00789)	(0.00814)	(0.00809)
Proportion of Women	0.421**	0.258	0.442**	0.289
	(0.170)	(0.211)	(0.206)	(0.216)
Board Independence	-0.110	-0.123	-0.0932	-0.110
	(0.128)	(0.176)	(0.181)	(0.181)
Constant	-7.057***	-7.025***	-7.077***	-7.043***

	(0.129)	(0.186)	(0.192)	(0.192)
Observations	5,424	5,424	5,424	5,424
R-squared	0.765	0.767	0.773	0.775
Industry Fixed Effects	No	No	Yes	Yes
Time Fixed Effects	No	Yes	No	Yes
Cluster	No	Firm	Firm	Firm

Table 9

Women Director Network Centrality and Corporate Social Responsibility: Two Stage Least Squares (2SLS)

This table presents the second-stage regression results from the two-stage least squares regression. The sample for the study comprises non-financial NSE-listed companies from 2016 to 2023. The instrument we have used for the endogenous regressor network centrality is the proportion of women directors who have attended an elite institution in India. The dependent variable is the log of the CSR expenditure incurred in a year, collected from CMIE Prowess data. Columns 1-3 show the 2SLS regression results for different measures of network centrality of women directors. The main variables of interest are Degree, Betweenness and Eigenvector Centrality. Table A1 in the appendix defines all variables. Additionally, all the independent variables are lagged by one year. All continuous variables are winsorised at the first and the ninety-ninth percentile. Standard errors appear in parentheses. *** p < 0.01; ** p < 0.05; * p < 0.1.

	(1)	(2)	(3)
VARIABLES		CSR Expenditure	
Degree_Women	0.0393***		
	(0.00876)		
Eigenvector_Women		4.348***	
		(0.950)	
Betweenness_Women			458.1***
			(111.7)
Return on Assets	7.517***	7.593***	7.364***
	(0.277)	(0.276)	(0.298)
Q Ratio	0.0205**	0.0200**	0.0198**
	(0.00857)	(0.00846)	(0.00947)
Dividend/Assets	2.631***	2.307***	2.980***
	(0.613)	(0.612)	(0.667)
Leverage	-0.956***	-0.947***	-0.914***
	(0.109)	(0.108)	(0.124)
Cash/Assets	11.69**	7.654	12.56**
	(5.598)	(5.640)	(6.108)
Firm Age	0.0375	0.0155	0.0455*
	(0.0238)	(0.0235)	(0.0263)
CEODuality	0.0219	0.0367	-0.0427
	(0.0556)	(0.0544)	(0.0638)
Tangibility Ratio	0.937***	0.956***	0.907***
	(0.101)	(0.101)	(0.109)
Sales Growth	-0.156***	-0.165***	-0.148***
	(0.0428)	(0.0419)	(0.0471)
Liquidity	0.0188**	0.0211***	0.0212***
	(0.00732)	(0.00724)	(0.00807)
Firm Size	0.808***	0.798***	0.794***
	(0.0262)	(0.0278)	(0.0318)

Board Size	-0.0142	-0.0116	0.0182***
	(0.00923)	(0.00862)	(0.00617)
Proportion of Women	0.589***	0.216	0.687***
	(0.199)	(0.186)	(0.227)
Board Independence	-0.409**	-0.470***	-0.570***
	(0.162)	(0.166)	(0.200)
Constant	-6.585***	-6.082***	-6.482***
	(0.256)	(0.330)	(0.296)
Observations	5,424	5,424	5,424
R-squared	0.737	0.747	0.686
Industry Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
Anderson LR test (Underidentification)	105.64***	132.70***	51.11***
Cragg–Donald Wald F test (Weak identification)	105.06	132.31	50.57
Anderson–Rubin F-test	23.08***	23.08***	23.08***
Sargan (Overidentification)	0.00 (exactly identified)	0.00 (exactly identified)	0.00 (exactly identified)

Table 10

Women Director Network Centrality and Corporate Social Responsibility: Generalised Method of Moments (GMM)

This table presents the results from the generalised method of moments regression. The sample for the study comprises non-financial NSE-listed companies from 2016 to 2023. We have used the proportion of women directors who have attended an elite institution in India as an instrument for the endogenous regressor network centrality. The dependent variable is the log of the CSR expenditure incurred in a year, collected from CMIE Prowess data. Columns 1-3 show the GMM regression results for different measures of network centrality of women directors. The main variables of interest in the models are Degree, Betweenness and Eigenvector Centrality, respectively. Table A1 in the appendix defines all variables. Additionally, all the independent variables are lagged by one year. All continuous variables are winsorised at the first and the ninety-ninth percentile. Heteroskedasticity robust standard errors appear in parentheses. . *** p < 0.01; ** p < 0.05; * p < 0.1.

	(1)	(2)	(3)
VARIABLES		CSR Expenditure	
Degree_Women	0.0393***		
	(0.00808)		
Eigenvector_Women		4.348***	
		(0.870)	
Betweenness_Women			458.1***
			(106.9)
Return on Assets	7.517***	7.593***	7.364***
	(0.477)	(0.478)	(0.486)
Q Ratio	0.0205**	0.0200**	0.0198**
	(0.00887)	(0.00884)	(0.00971)
Dividend/Assets	2.631***	2.307***	2.980***
	(0.668)	(0.672)	(0.710)
Leverage	-0.956***	-0.947***	-0.914***
	(0.121)	(0.119)	(0.133)
Cash/Assets	11.69**	7.654	12.56**
	(5.187)	(5.097)	(5.707)
Firm Age	0.0375	0.0155	0.0455*
	(0.0242)	(0.0241)	(0.0264)
CEO Duality	0.0219	0.0367	-0.0427
	(0.0547)	(0.0534)	(0.0657)
Tangibility Ratio	0.937***	0.956***	0.907***
	(0.104)	(0.104)	(0.110)
Sales Growth	-0.156***	-0.165***	-0.148***
	(0.0545)	(0.0539)	(0.0573)
Liquidity	0.0188**	0.0211**	0.0212**
	(0.00940)	(0.00903)	(0.00995)
Firm Size	0.808***	0.798***	0.794***
	(0.0254)	(0.0266)	(0.0313)

Board Size	-0.0142	-0.0116	0.0182***
	(0.00862)	(0.00816)	(0.00642)
Proportion of Women	0.589***	0.216	0.687***
	(0.183)	(0.171)	(0.206)
Board Independence	-0.409**	-0.470***	-0.570***
	(0.159)	(0.164)	(0.198)
Constant	-6.585***	-6.082***	-6.482***
	(0.254)	(0.318)	(0.298)
Observations	5,424	5,424	5,424
R-squared	0.737	0.747	0.686
Industry FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Anderson LR test (Underidentification)	105.64***	132.70***	51.11***
Cragg–Donald Wald F test (Weak identification)	105.06	132.31	50.57
Anderson–Rubin F-test	27.77***	27.77***	27.77***
Sargan (Overidentification)	0.00 (exactly identified)	0.00 (exactly identified)	0.00 (exactly identified)