Management Decision

Board network centrality and financial performance: the mediating role of sustainability performance

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Abstract

Purpose – This study empirically investigates whether sustainability performance acts as a mediating mechanism linking board network centrality to financial outcomes.

Design/methodology/approach – Drawing on a sample of 888 publicly listed European firms, we construct a network based on board interlocks and compute five centrality measures: degree, closeness, betweenness, eigenvector, and N-score (a composite measure capturing overall centrality). We employ structural equation modeling to investigate the mediating role of sustainability performance, measured through firm-level ESG indicators.

Findings – Our results indicate that board network centrality has a positive indirect effect on financial performance through improved sustainability performance, even in the absence of a direct link. By identifying sustainability performance as a mediating channel, this study theorizes how firms can leverage the social capital embedded in board networks to achieve tangible performance benefits.

Originality/value – In today's interconnected global landscape, firms derive strategic advantages not only from internal capabilities but also from their embeddedness in external networks. Among these, board networks, formed through board interlocks, constitute a key source of social capital, providing networked firms with access to valuable resources and enhanced legitimacy based on their network position. However, empirical evidence on the relationship between board network centrality and firm performance remains inconclusive, underscoring the need to explore potential mediating mechanisms.

Keywords Board network, Board interlocks, Sustainability, ESG, Financial performance, Social capital, Legitimacy, Social network analysis

Paper type Research article

Introduction

Board networks generated by directorship interlocks – i.e., social ties based on individuals simultaneously serving on multiple boards of directors (Mizruchi, 1996) – have long been recognized as a crucial source of social capital that enables firms to access valuable information and knowledge residing beyond organizational boundaries (Barroso-Castro *et al.*, 2016). These ties give rise to an inter-firm network (Mariolis and Jones, 1982), embedding firms in a web of relationships that can significantly influence their strategic behavior and organizational outcomes (Fayad *et al.*, 2024; Sauerwald *et al.*, 2016). While interlocks constitute the relational basis of the board network, it is the position a firm holds within this

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network – captured by its network centrality – that determines the extent to which it can access and leverage the benefits of network embeddedness (Singh and Delios, 2017; Wang *et al*., 2021). Network centrality refers to a central position within network relationships, reflecting how well-connected a firm is within the broader board network (Larcker *et al*., 2013).

Prior studies have highlighted the value of centrality in board networks, showing that firms holding more central positions benefit from enhanced visibility, informational advantages, and greater influence (Larcker *et al*., 2013; Zhao, 2021). However, despite these insights, empirical findings on the relationship between board network centrality and firm performance remain inconclusive (Lamb and Roundy, 2016; Martin *et al*., 2015; Rumokoy *et al*., 2024). While many studies find a positive association (Kim, 2005; Larcker *et al*., 2013; Wang *et al*., 2021; Zhao, 2021), others show negative or null effects (Andres *et al*., 2013; Huggins, 2010; Tao *et al*., 2019). These conflicting results suggest that a well-connected board, by itself, may not guarantee performance benefits and call for a deeper understanding of the mechanisms through which board network centrality may (or may not) lead to superior outcomes.

Recent research has begun to explore the boundary conditions under which board connectedness influences firm performance, highlighting the role of uncertainty, firm relative resources, power imbalance, ownership concentration, and CEO ownership (Martin *et al*., 2015; Zona *et al*., 2018). However, surprisingly little attention has been paid to the mechanisms through which board network may lead to higher performance, leaving considerable room for further analysis (Fayad *et al*., 2024; Smith and Sarabi, 2021). This study aims to address this gap by proposing a theoretically grounded yet empirically underexplored mechanism, i.e., sustainability performance.

Firms that hold central positions in board networks are often more exposed to stakeholder scrutiny and institutional expectations. To meet these demands and solidify their status within the network, central firms are more likely to engage in sustainability initiatives that demonstrate adherence to accepted sustainability standards (Lueg and Radlach, 2016; Schaltegger and Hörisch, 2017). In this context, sustainability performance serves as a signal of legitimacy, enabling firms to build reputational capital, mitigate relational risk, and enhance their position within the network (Lee and Raschke, 2023; Zhao, 2021). By doing so, sustainability becomes a vehicle through which firms can transform their centrality into tangible financial advantages, while mitigating contingencies such as uncertainty, mistrust, or the fear of opportunism (Martin *et al*., 2015; Zona *et al*., 2018). Prior research supports this view, showing that board network centrality is positively related to sustainability performance (Amin *et al*., 2020; Ding *et al*., 2022; Harjoto and Wang, 2020; Nandy *et al*., 2020), and that sustainability, in turn, has a positive effect on financial outcomes (Amui *et al*., 2017; Miroshnychenko *et al*., 2017). These insights converge on the theoretical proposition that sustainability may act as a mediating mechanism through which central firms convert their network position into competitive advantage.

Nevertheless, no prior study has empirically tested this mediation pathway. To address this gap, we investigate the following research question:

> Does sustainability performance mediate the relationship between board network centrality and firm financial performance?

To answer this question, we conducted a social network analysis of board interlocks among publicly listed European firms to obtain board-level centrality measures (Wang *et al*., 2021), computing four widely used node-level centrality measures: degree, closeness, eigenvector, and betweenness centrality (Jackson, 2010; Larcker *et al*., 2013). In this view, the study captures the multifaceted nature of board network centrality, examining multiple nuances of firms' positions within the network generated by board interlocks. Specifically, degree centrality reflects the number of board interlocks connecting a board to others, whereby a higher degree may indicate greater access to social capital. Closeness centrality denotes the efficiency with which a board can reach other boards within the network, thereby capturing its potential for timely access to information or resources. Betweenness centrality captures the

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extent to which a board serves as an intermediary or bridge in the network, indicating its capacity to mediate resources or information flows between otherwise unconnected boards. Eigenvector centrality accounts not only for the number of a board's interlocks but also for the centrality of boards it is connected to, thereby reflecting its embeddedness within a network of influential boards (Homroy and Slechten, 2019). Lastly, in line with previous studies (Amin *et al*., 2020; Larcker *et al*., 2013), we calculated the overall centrality by averaging the quintile rankings of the four measures of board network centrality, defined as the *N-score*.

We then employed structural equation modeling to test the indirect effect of board network centrality on financial performance via sustainability performance. Our results reveal a robust and significant mediation effect, whereby board network centrality improves financial performance primarily through the intermediate enhancement of sustainability outcomes, even when no direct effect is observed. Our results withstand a number of robustness tests, including those that account for endogeneity concerns.

Our research provides several contributions. First, to the best of our knowledge, this is the first study to empirically examine sustainability performance as a mediating mechanism linking board network centrality to financial performance. In particular, our findings highlight the strategic role of sustainability in unlocking the value of board network centrality, a pathway of growing relevance in today's stakeholder-driven corporate landscape. In doing so, we contribute to expanding knowledge on the strategic factors and underlying mechanisms through which board network centrality impacts firm behavior and performance (Fayad *et al*., 2024). Second, by moving beyond the simple count of interlocks and focusing on a firm's position within the board network, we provide a more nuanced understanding of how inter-corporate networks shape firm outcomes.

The rest of the paper is structured as follows. The second section presents the theoretical background of board networks, corporate sustainability, and financial performance, which leads to the development of hypotheses. The third section outlines the research design and methodology. The fourth section reports the empirical results and robustness tests. Finally, the fifth section discusses the findings and their theoretical and managerial implications, and outlines the study's limitations and future research directions.

Theoretical background and hypothesis development

A social capital perspective on board network centrality and financial performance

According to the social capital theory (Adler and Kwon, 2002), the critical resources of a firm extend beyond internal boundaries, encompassing external resources embedded in the structure and quality of its relationships with external actors (Lin, 1999; Rossoni *et al*., 2018). These relationships form a type of social capital – defined as the sum of actual or potential resources embedded within, available through, and derived from the network of relationships possessed by a firm (Nahapiet and Ghoshal, 1998). In an increasingly interconnected business environment, where firms operate as open systems rather than closed entities, social capital has become a key determinant of competitive advantage and firm success (Pfeffer and Salancik, 1979; Tsai, 2000).

Within this framework, the board of directors plays a pivotal role in developing and mobilizing social capital (Carpenter and Westphal, 2001; Hillman *et al*., 2000). One key mechanism through which boards contribute to this process is the formation of board interlocks, i.e., connections established when directors simultaneously serve on multiple boards (Davis, 1996; Mizruchi, 1996). These interlocks represent a structural mechanism that connects firms and gives rise to a broader corporate board network, which is distinct from other forms of social networks due to its formal, institutional nature and potential for strategic influence (Ramsawak *et al*., 2024; Sauerwald *et al*., 2016; Zona *et al*., 2018).

Empirical research has shown that board interlocks can facilitate information exchange and strategic resource acquisition (Hillman and Dalziel, 2003; Rossi *et al*., 2018), enhance a firm's access to external knowledge and intellectual capital (Blanco-Alcántara *et al*., 2019), as well as increase firms' ability to attract R&D investments from institutional investors (Edacherian

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et al., 2024). The inter-corporate ties generated by board interlocks enable firms to reinforce their internal capabilities, affording them greater access to and control over valuable resources from a broader network (Wang *et al*., 2021).

However, mere connectedness is not sufficient to reap these benefits. Rather, it is the structural positioning of a board – its "well-connectedness" – that determines the extent to which a firm can leverage its board network (Larcker *et al*., 2013). In this sense, *board interlocks create the social structure*, while the position a firm holds within the network, i.e., board network centrality, *governs the firm's ability to extract value from it*.

Larcker *et al*. (2013) conceptualize board well-connectedness as a multidimensional construct, operationalized through different network centrality measures in social network theory. A board may be well-connected if it: (1) has many direct ties to other boards (degree centrality), (2) is closely embedded within the network (closeness centrality), (3) acts as a broker between otherwise disconnected boards (betweenness centrality), or (4) is connected to other well-connected boards (eigenvector centrality). These different forms of centrality serve as channels through which firms can gain access to timely information, reduce uncertainty, and improve strategic decision-making.

From a social network perspective, recent research on board networks has explored its impact on financial performance, producing mixed findings (Lamb and Roundy, 2016; Ramsawak *et al*., 2024). While some studies suggest that well-connected boards can have a negative or no effect on firm performance (Martin *et al*., 2015; Zona *et al*., 2018), the majority of empirical evidence supports a positive impact (Garcia-Bernardo and Takes, 2018; Ni Sullivan and Tang, 2013; Wang *et al*., 2021).

Well-connected boards are better positioned to access strategic information on industry trends, regulatory developments, and market dynamics (Mizruchi, 1996). They can also leverage trusted social ties to reduce information asymmetries when negotiating contracts (Schoorman *et al*., 1981), and they have privileged access to external actors, such as potential partners, investors, and policymakers (Golden and Zajac, 2001; Nicholson *et al*., 2004). In addition, well-connected boards serve as platforms for the diffusion of value-enhancing innovations in corporate governance, compensation schemes, and strategic practices (Barroso-Castro *et al*., 2016; Horton *et al*., 2012). Collectively, these mechanisms contribute to *higher investment efficiency* (Zhao, 2021), enhanced innovation capabilities (Smith and Sarabi, 2021), and superior access to strategic alliances and R&D funding (Ni Sullivan and Tang, 2013), ultimately leading to *stronger financial results* (Horton *et al*., 2012; Rossoni *et al*., 2018).

In line with this stream of research, we argue that firms occupying more central positions within the board interlock network are better positioned to access critical external resources, respond more effectively to opportunities, and thus achieve superior financial results. Accordingly, we hypothesize:

H1. Board network centrality has a positive effect on financial performance.

The mediating role of corporate sustainability: a legitimacy perspective

A firm's legitimacy denotes the general perception – by customers, regulators, partners, and the public alike – that its actions are desirable and appropriate in accordance with a *"socially constructed system of norms, values, beliefs, and definitions"* (Suchman, 1995, p. 574). Legitimacy constitutes a valuable "currency" that firms use to uphold their "license to operate" in the business landscape (Gehman *et al*., 2017). Indeed, it serves as a fundamental prerequisite for competing for resources, establishing institutional and business relationships, and thus generating and capturing value from business activities (Starr and Macmillan, 1990). Firms rely on legitimacy to consolidate their competitive advantage and, over time, strengthen their market position (Ashforth and Gibbs, 1990).

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A firm's legitimacy is increasingly tied to its sustainability performance, specifically to its ability to mitigate adverse impacts on ecosystems and communities, and minimize the risks of misconduct, such as violations of regulatory requirements (Gehman *et al*., 2017). In recent decades, social and environmental concerns have contributed significantly to a surge in stakeholders' demands for corporate engagement with sustainability issues (Fischer *et al*., 2020) and to the adoption of stricter regulatory measures targeting the corporate sector (Aragón-Correa *et al*., 2020). These changes intensified pressure on firms to conform to new norms and expectations, which envision a more prominent role for the business sector in enhancing societal and environmental well-being (Mio *et al*., 2020).

In this view, legitimacy has been a central focus of corporate sustainability research. For instance, Silva (2021) examined the use of the United Nations' Sustainable Development Goals (SDGs) in non-financial reports by 87 FTSE 100 companies, demonstrating that companies conciliate business practices with sustainable goals to enhance legitimacy in response to external stakeholder pressures. Richards *et al*. (2017) found that firms' investment in sustainability certifications is associated with legitimacy narratives that emphasize environmental and civic engagement. Schaltegger and Hörisch (2017) investigated the motives underlying sustainability management practices among large firms across ten developed countries, finding that legitimacy-seeking represents the dominant rationale for adopting practices such as sustainability reporting and stakeholder engagement. Less recently, Ditlev-Simonsen and Midttun (2011) investigated the motivations behind corporate social responsibility of Norwegian firms, highlighting legitimacy-oriented factors – such as branding and reputation-building – as the primary drivers. Windolph *et al*. (2014) examined the relative importance of profit-driven versus legitimacy-driven motivations for corporate sustainability in German firms, finding that legitimacy concerns were the dominant motivation.

However, from a legitimacy perspective, sustainability is not achieved in isolation (Olateju *et al*., 2021; Schaltegger and Hörisch, 2017). Rather, a firm's sustainability performance is connected to its interactions with the external environment (Nandy *et al*., 2020), which dictates norms and expectations that shape the legitimacy of the firm's conduct (Thomas and Lamm, 2012).

In this view, prior research has also examined the impact of board network centrality on various measures of sustainability and social responsibility performance. For instance, Li *et al*. (2023), analyzing Chinese listed firms, found a significant positive association between board network centrality and the quality of CSR disclosure. Similarly, Nandy *et al*. (2020), in a cross-country study involving firms from 17 countries, reported that higher board network centrality is positively linked to the adoption of CSR practices. Homroy and Slechten (2019), focusing on FTSE-350 firms, observed a significant negative relationship between board network centrality and GHG emissions across various centrality measures. Harjoto and Wang (2020) further supported these findings by showing that board network centrality positively influences ESG performance among non-financial firms in the FTSE-350 index.

According to these contributions, central firms within board networks are better positioned to anticipate and respond to stakeholders' environmental and social concerns. Board network centrality aids firms in navigating regulatory, social, and market uncertainties, allowing them to anticipate changes and avoid regulatory infringements or reputational backlash (Lissillour *et al*., 2023). Board network centrality facilitates the understanding of emerging regulations, enabling firms to align their practices and operations with evolving sustainability requirements (Amui *et al*., 2017; Nandy *et al*., 2020). Additionally, board network centrality confers access to information about sustainability standards, enabling firms to adapt their practices to evolving performance expectations (Homroy and Slechten, 2019). Board network centrality also heightens firm visibility, bringing reputational concerns to the forefront. Thus, central firms are more likely to report their sustainability efforts to broaden their consensus (Chahine *et al*., 2019; Li *et al*., 2023), ultimately driving greater sustainability performance (Zhao, 2021).

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As strong sustainability performance enhances a firm's legitimacy, it may function as a mechanism linking board network centrality to tangible competitive advantages, by providing the societal validation needed to leverage the strategic benefits of board network centrality (Zhao, 2021). Legitimacy indeed hones the exchange of knowledge and resources across organizations and facilitates opportunities for joint business initiatives – such as strategic alliances and partnerships – (Shah, 2011) by mitigating contingencies associated with the negative outcomes of board networks, including information asymmetries, resource imbalance, and fear of opportunistic behavior (Martin *et al.*, 2015; Zona *et al.*, 2018).

Specifically, in the context of inter-firm networks established through board interlocks, strong sustainability performance signals the presence of valuable resources and capabilities – in terms of management structures and control mechanisms – that provide the accountability and transparency needed to reassure third parties about a firm's trustworthiness (Brønn and Vidaver-Cohen, 2009). Indeed, the adoption of sustainability practices has been found to reduce information asymmetry and perceived risk, ultimately enhancing market expectations and firm valuation (Amui *et al.*, 2017; Awaysheh *et al.*, 2020; Minutolo *et al.*, 2019; Miroshnychenko *et al.*, 2017). Moreover, strong sustainability performance enhances a firm's reputation and legitimacy in the eyes of stakeholders, which can translate into better stock performance (Kim *et al.*, 2021; Nekhili *et al.*, 2021). Consistent sustainability performance also denotes a firm's capability to adapt to environmental changes through innovation and resilience, thereby mitigating the risks of disruptions and failures due to exogenous shifts and reinforcing third parties' confidence in the firm's long-term viability (Hockerts, 2015; Walsh and Dodds, 2017). Moreover, sound sustainability commitments denote a firm's ethical values and vision, which can "lubricate" collaboration among "like-minded" organizations, by reducing risks of conflicts over strategic priorities (Rondinelli and London, 2019). As a result, strong sustainability performance contributes to enhancing a firm's overall appeal to potential partners by reinforcing a perception of reliability and credibility, particularly among those seeking trustworthy, long-term relationships that align with their values and priorities.

Based on these considerations, we posit that legitimacy derived from strong and consistent sustainability performance acts as a mechanism for unlocking the competitive advantages of board network centrality, enabling firms to translate social capital accrued from board interlocks into tangible business benefits. Thus, we hypothesize:

H2. Sustainability performance mediates the relation between board network centrality and financial performance.

Figure 1 shows the conceptual model.

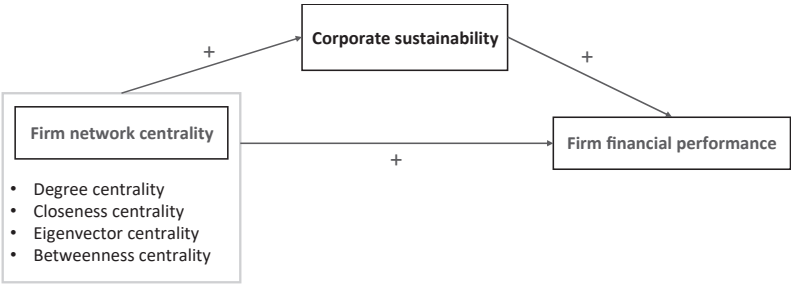

Figure 1. Theoretical model. Source(s): Figure by authors

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Research methods

Sample and data

This research employs a purposive sampling approach, where population members are selected based on their characteristics that match the research purpose, i.e., to assess the impact of board network centrality on the financial performance of European public firms and to investigate whether this effect is mediated by corporate sustainability. Since we consider the network as originating from board interlocks, the study focuses on European firms whose directors simultaneously hold multiple positions on the boards of different firms and for which financial performance (measured through Tobin's Q) and corporate sustainability (measured through ESG scores) data are available.

To create the sample, we intersected firms from two distinct databases, namely BoardEx and Refinitiv Eikon, for the period from 2015 to 2022. This is an appropriate time period to conduct our analyses for two main reasons. First, it ensures that our assessment of sustainability practices and their impact on firm performance is based on robust and comprehensive information, as the availability and reliability of ESG have increased significantly since 2015. Second, the timeframe allows us to observe the delayed effects of network centrality through board interlocks. The strategic benefits of these interlocks often unfold gradually, affecting firm performance over several years. In particular, we analyze board interlocks between 2015 and 2020, and consider their effect on sustainability and financial performance in 2021 and 2022, respectively. By doing so, we capture a more complete picture of these dynamics, as this allows us to include the time lag between our independent, mediator, and dependent variables.

Information on interlocking directorates was collected from the BoardEx database, which provides data about directors and executives of 4,842 European firms. We confined our focus to public firms with available information on interlocking directorates for the specified period. These data allowed us to map directors who simultaneously held positions on the boards of different firms and to construct the network of firms' boards. In line with prior research, we built an inter-firm network where firms constituted the nodes, with a firm included only if it shared at least one board member with another firm within the reference period. Directors serving on multiple boards constituted the edges of the network; accordingly, an edge between two nodes indicated that the two firms shared at least one board member during the reference period (Amin *et al*., 2020; Chuluun *et al*., 2017; Harjoto and Wang, 2020; Larcker *et al*., 2013; Rumokoy *et al*., 2024). Isolated nodes – i.e., firms with zero interlocking directors or executives with other firms – were excluded from the network, restricting the sample to 1,317 firms. We used UCINET software for social network analysis (SNA), arranging the network data in an edge-list format in order to compute four centrality measures: degree centrality, eigenvector centrality, closeness centrality, and betweenness centrality.

We then merged board network information with the Refinitiv Eikon database, from which we retrieved data on firms' financial performance and ESG scores. Other firm-level information used as controls in the analysis was also retrieved from both the BoardEx and Refinitiv Eikon databases. After dropping missing data, the final sample size comprised 888 observations.

Measures

Dependent variables. Based on prior studies, we measured the firm's financial performance using Tobin's Q, one of the most widely used and comprehensive financial indicators to describe a firm's performance (Awaysheh *et al*., 2020; Kim *et al*., 2021). It is measured through the following formula (Awaysheh *et al*., 2020):

$$Tobin's\ Q = (Total\ Assets - Book\ Value\ of\ Common\ Equity + Market\ Capitalization)/(Total\ Assets)$$

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Data to measure Tobin's Q were retrieved from Refinitiv Eikon as of December 31, 2022, to include a time lag with respect to the independent variables, measured as of 2020, and the mediator, measured as of 2021. This approach allows us to analyze the causal effects while avoiding the potential recursive effects between the dependent and independent variables.

Independent variables. Given the study's focus on relationships between variables at the firm-level, we used node-level centrality measures as independent variables. The board network was constructed by considering each firm's board as a node in the network, and establishing an edge between two boards, *i* and *j*, if they share at least one director simultaneously during the analyzed period 2015–2020. Based on this network – built using data from BoardEx – we computed four widely adopted centrality measures (Jackson, 2010; Larcker *et al*., 2013): (1) degree centrality (*DEGR*); (2) closeness centrality (*CLOSE*); (3) eigenvector centrality (*EIGEN*); (4) betweenness centrality (*BETW*). These measures reflect the multidimensional nature of network centrality, as emphasized in social network theory, which has developed several connotations of centrality to interpret actors' positioning within a network and the potential advantages associated with their structural location (Jackson, 2010; Larcker *et al*., 2013). In addition, to account for the overall embeddedness of a firm within the board network, we also computed the *N-score*, a composite indicator that aggregates the four centrality dimensions described above (Amin *et al*., 2020; Larcker *et al*., 2013). The concept and operationalization of each centrality measure are described below.

Degree centrality measures the total number of direct connections (or edges) a node holds with other nodes in the network through interlocking directors. In this context, the benefits of board network centrality may depend on the quantity of direct ties a firm maintains, as a higher number of relationships with diverse boards enables broader pathways for the exchange of information and resources. Degree centrality is calculated as:

$$DEGR_i = \sum_{j \neq i} d_{i,j}$$

where $d_{i,j}$ is equal to 1 if boards *i* and *j* shared at least one director over the analyzed period, 0 otherwise.

Closeness centrality captures the proximity of a board to all other boards in the board network, by summing the lengths of the shortest paths – via interlocking directorates – between the focal firm and all other firms. This measure reflects a firm's ability to efficiently access other firms through its board connections. A higher closeness score indicates that a firm can reach others more directly, with fewer intermediaries, thus facilitating faster access to information, resources, and opportunities within the network (Homroy and Slechten, 2019). Closeness centrality is calculated as:

$$CLOSE_i = \frac{1}{\sum_{j \neq i} l_{i,j}}$$

where $l_{i,j}$ is the distance between board *i* and *j*.

Eigenvector centrality captures the quality of a firm's connections within the board network by considering not only the number of its ties but also the centrality of the boards to which it is connected through interlocking directorates. Unlike degree centrality, which assigns equal weight to all connections, eigenvector centrality assigns greater importance to ties with highly connected nodes. A node's eigenvector score is proportional to the sum of the eigenvector scores of the nodes to which it is directly connected. This measure thus reflects a board's influence within the network, as it embeds the idea that connections to prominent or strategically positioned boards amplify a board's centrality and potential access to valuable information, resources, or prestige. Eigenvector centrality is calculated as:

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$$EIGEN_i = \lambda^{-1} \sum_{j \neq i} d_{i,j} e_j$$

where λ is the eigenvalue, $d_{i,j}$ is a dummy that gauges value 1 if boards i and j shared at least one director over the analyzed period, 0 otherwise, and e_i is the eigenvector of board j.

Betweenness centrality serves as a proxy for a board's control over the flow of information or resources within the board network. It captures the extent to which a board acts as an intermediary or bridge in the network, by sitting on the shortest paths (i.e., geodesic distances) connecting otherwise unconnected boards. In the context of interlocking directorates, a firm with high betweenness centrality may occupy a structurally advantageous position, allowing it to broker relationships, influence communication, and access non-redundant information circulating through the network. Betweenness centrality is calculated as:

$$BETW_i = \frac{P_i(j,k)}{P(j,k)}$$

where $P(j,k)$ is the number of the shortest paths between boards j and k, and $P_i(j,k)$ is the number of the shortest paths between boards j and k that go through i.

Lastly, the *N-score* captures the overall embeddedness of a firm's board within the interlocking directorate network and serves as an alternative, aggregate proxy for centrality (Amin *et al.*, 2020; Larcker *et al.*, 2013). It is a composite measure of overall board network centrality, defined as the equal-weighted average of the quintile rankings of the four centrality metrics described above: degree, closeness, eigenvector, and betweenness centrality (Larcker *et al.*, 2013). *N-score* is calculated as:

$$N - score_i = Quint\left(\frac{1}{4}\{Quint\,(DEGR_i) + Quint\,(CLOSE_i) + Quint\,(EIGEN_i) + Quint(BETW_i)\}\right)$$

Mediator variable. The call for sustainability requires firms to engage in environmental, social, and governance (ESG) practices to enhance their sustainability performance (Lee and Raschke, 2023). In line with prior research, we measured corporate sustainability using the environmental, social, and governance (ESG) performance scores provided by Refinitiv Eikon (Bruna *et al.*, 2022; Gebhardt *et al.*, 2022; Seckin-Halac *et al.*, 2021). ESG performance allows considering the multidimensionality of sustainability issues, including various dimensions: *E* refers to issues like resource use, emission, pollution, eco-innovation, and climate change; *S* refers to aspects such as workforce, human rights, and product responsibility; *G* refers to aspects such as management structure, shareholders management, and transparency. By taking into account a variety of aspects of firms' ESG performances, Refinitiv Eikon generates an overall ESG performance and provides impartial and comparable quantifications of ESG ratings (Lu *et al.*, 2022). Each score ranges from 0 to 100.

Specifically, Refinitiv Eikon's E, S, and G scores are based on more than 630 quantitative and qualitative metrics, which are compiled and updated annually by Refinitiv's analysts. For the present study, firms' scores were retrieved for the year 2021 in order to examine the impact of board network measures computed across six years (i.e., 2015–2020) on ESG performance at t+1.

We opt for the absolute ESG values, rather than annual variations, for three main reasons. First, ESG practices commonly have gradual effects, and fluctuations observed in single-year changes may not fully capture their long-term influence. Second, annual ESG variations can sometimes reflect short-term events or reporting adjustments rather than true shifts in a firm's underlying sustainability practices. Such events risk introducing volatility and noise into the

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data, complicating interpretation. Third, using absolute ESG scores is consistent with prior studies in this domain, which frequently employ absolute measures of ESG to assess their impact on financial performance (Awaysheh *et al*., 2020; Gao and Lyu, 2024; Nekhili *et al*., 2021). Aligning with established methodologies thus facilitates direct comparisons with existing research and enhances the validity of our findings.

Control variables. In examining the relationships between network centrality, ESG, and financial performance, we controlled for several variables. First, we included key corporate governance variables as controls in this study, as prior research has shown that board composition can significantly affect firm performance. We control for *Board size*, measured as the natural logarithm of the total number of directors sitting on the board (Zhao, 2021). Prior research has primarily found a positive relationship between board size and firm sustainability performance (Aguilera *et al*., 2021). Indeed, larger boards are typically characterized by a higher degree of diversification in terms of expertise and stakeholder representation, which enables the firm to address a wide range of ESG dimensions (Shu *et al*., 2024). In line with prior research, we also control for the percentage of non-executive independent directors (*NED%*), as independent directors are expected to enhance governance through effective monitoring, which may influence both ESG performance and financial outcomes (Harjoto and Wang, 2020; Li *et al*., 2023). The percentage of women directors on the board (*Women%*) is also included, as board gender diversity has been associated with improved decision-making, an enhanced corporate reputation, and greater sensitivity to sustainability issues, resulting in positive effects on both sustainability and financial performance (Adams and Ferreira, 2009; Hosny and Elgharbawy, 2022). Moreover, we control for the average age of the board (*BOD age*), as it may reflect directors' experience and risk preferences, which can influence strategic decisions related to ESG initiatives and financial performance (Chakravarty and Rutherford, 2017; Collevecchio *et al*., 2024; Kim, 2005). We also added the most commonly used firm-level control variables in line with prior studies (Awaysheh *et al*., 2020; Kim *et al*., 2021; Omer *et al*., 2014; Zona *et al*., 2018); *Firm size*, measured by the natural logarithm of total assets, a continuous variable indicating the value of firms' total assets; *Leverage*, measured by the ratio of debt to equity; *Firm age*, measured by the natural logarithm of the number of years since the firm was founded. In addition, since Tobin's Q is a market-based measure of financial performance, we also include controls that account for the relationship between a firm's fundamentals and investor expectations: *Sales growth* is the change in sales divided by last year's sales (Lu *et al*., 2021); *OCF* is the natural logarithm of operating cash flows (Sun *et al*., 2024); *SD_OCF* is the operating cash flow volatility, measured through the standard deviation of operating cash flow over the last five years (Li and Zaiats, 2017), included to account for financial stability.

We also included country and sector dummy variables that capture unmeasured differences by country and sector (Kennedy, 2003). Board-level variables, sector, and country were retrieved from BoardEx, while other firm-level variables were gathered from Refinitiv Eikon.

All continuous variables are winsorized at the 1 and 99 percentiles of the distribution to mitigate the potential influence of extreme outliers.

Results

Descriptive analysis

Table 1 presents the descriptive statistics, while Tables 2 and 3 provide a breakdown of the sample by country and sector, respectively. The mean value of Tobin's Q is 1.58, and the standard deviation is 1.14. This indicates that the overall financial performance of these European listed firms is not very high, and the distribution is relatively concentrated. The mean ESG score is 62.98, with a standard deviation of 17.22. The minimum value is 3.75, and the maximum value is 95.14. This shows that the firms in the sample exhibit significant differences in terms of sustainability performance.

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Table 1. Summary statistics

Variable	Mean	SD	Min	p25	p50	p75	Max
Tobin's Q	1.58	1.14	0.56	0.98	1.16	1.70	7.52
ESG	62.98	17.22	3.75	51.94	65.42	75.59	95.14
DEGR	5.57	5.14	1	2.00	4.00	8.00	43.00
CLOSE	245.77	61.34	1	219.97	252.71	284.84	373.58
EIGEN	0.061	0.088	0	0.005	0.026	0.084	1
BETW	1861.28	3194.61	0	22.60	963.03	2372.59	46192.95
N-score	2.96	1.45	1	2	3	4	5
N_DEGR	0.006	0.005	0.001	0.002	0.004	0.048	0.048
N_ CLOSE	0.272	0.075	0.001	0.245	0.282	0.421	0.421
N_BETW	0.004	0.007	0.00	6.62E−06	0.002	0.117	0.118
Firm size	22.64	1.84	18.54	21.43	22.54	23.72	27.51
Leverage	1.27	1.84	−2.59	0.40	0.82	1.43	12.68
Sales growth	0.57	1.23	−0.69	−0.22	0.18	0.96	4.33
OCF	13.63	8.68	0	0.00	18.20	19.59	24.27
SD_OCF	8.88 E+08	3.64 E+09	8.99 E+05	4.82 E+07	1.40 E+08	4.10 E+08	6.59 E+10
BOD size	2.36	0.37	1.10	2.08	2.40	2.64	3.40
NEDs %	0.51	0.25	0	0.33	0.50	0.67	1
Females %	0.29	0.13	0	0.21	0.30	0.38	0.67
BOD age	58.11	4.19	41.75	55.60	58.00	60.57	82.00
Firm age	3.44	0.97	0	2.83	3.37	4.30	4.80

Note(s): N_DEGRE, N_CLOSE and N_BETW denotes normalized values of degree, closeness and betweenness centrality, respectively

Source(s): Table by authors

Table 2. Sample breakdown: country

Country	%	Country	%	Country	%
Germany	12.84%	Denmark	3.60%	Greece	1.24%
France	11.71%	Finland	3.60%	Portugal	1.24%
Sweden	10.92%	Russian Federation	3.49%	Czech Republic	0.45%
Switzerland	10.25%	Republic of Ireland	3.38%	Cyprus	0.34%
Italy	7.32%	Poland	2.93%	Malta	0.34%
Spain	6.76%	Turkey	2.82%	Hungary	0.23%
Netherlands	4.28%	Austria	2.36%	Liechtenstein	0.23%
Norway	3.94%	Luxembourg	1.80%	Monaco	0.11%
Belgium	3.83%				

Source(s): Table by authors

Regarding the firm's network, the centrality measures show high standard deviations. Degree has a mean value of 5.57, indicating that firms have, on average, approximately six connections. According to our purposive sampling approach, all firms in the sample have at least one connection, with a maximum of 43 connections. Closeness ranges from 1 to 373.58, with a mean value of 245.77 and a standard deviation of 61.34. This means that, on average, firms can easily reach all other firms in the network, but the effectiveness of these contacts varies significantly from one another. Eigenvector ranges from 0 to 1, with a mean value of 0.06. Betweenness has a minimum value of 0 (the firm does not play an intermediatory role) and a maximum value of 46,193. Moreover, it shows an extremely high standard deviation

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Table 3. Sample breakdown: sector

Sector	%	Sector	%
Banks	8.6%	Clothing and Personal Products	2.3%
Pharmaceuticals and Biotechnology	5.4%	General Retailers	2.1%
Construction and Building Materials	5.1%	Steel and Other Metals	2.0%
Engineering and Machinery	4.7%	Food and Drug Retailers	1.7%
Real Estate	4.6%	Beverages	1.5%
Oil and Gas	4.2%	Household Products	1.2%
Specialty and Other Finance	4.1%	Utilities – Other	1.2%
Diversified Industrials	3.7%	Mining	1.1%
Telecommunication Services	3.7%	Renewable Energy	1.1%
Electronic and Electrical Equipment	3.6%	Forestry and Paper	0.8%
Chemicals	3.4%	Private Equity	0.6%
Automobiles and Parts	3.3%	Aerospace and Defense	0.3%
Software and Computer Services	3.3%	Consumer Services	0.3%
Health	3.2%	Containers and Packaging	0.3%
Business Services	2.9%	Life Assurance	0.3%
Electricity	2.8%	Publishing	0.3%
Transport	2.8%	Leisure Goods	0.2%
Media and Entertainment	2.7%	Education	0.1%
Food Producers and Processors	2.6%	Investment Companies	0.1%
Insurance	2.6%	Tobacco	0.1%
Information Technology Hardware	2.5%	Wholesale Trade	0.1%
Leisure and Hotels	2.4%		

Source(s): Table by authors

(more than 1.5 times the mean). Finally, the *N-score*, which is an overall measure of board centrality, is approximately 3, suggesting that the boards are, on average, well interconnected.

To check for consistency with previous research on board networks, centrality measures were also computed in normalized form. Descriptive statistics confirm that centrality measures exhibit mean, minimum, and maximum values consistent with those reported in previous studies on board networks employing a similar network structuring approach (Amin *et al*., 2020; Harjoto and Wang, 2020; Larcker *et al*., 2013; Rumokoy *et al*., 2024). Table 1 provides descriptive statistics for centrality measures, including both normalized and non-normalized values.

The reliability of the analytical results from the mediation analysis may be affected by strong multicollinearity among independent variables in the model. To test for this issue, in line with prior research, we perform the Pearson correlation test and the variance inflation factor (VIF) (Gujarati and Porter, 2009). The results are presented in Tables 4 and 5, respectively. As shown in Table 4, all correlation coefficients are below 0.7, which is the accepted threshold for multicollinearity problems (Mela and Kopalle, 2002), except for the degree and betweenness centrality measures, which have coefficients very close to or above this threshold. The results of the VIF test also show low values below 5, which confirm the absence of multicollinearity issues (Neter *et al*., 1985), except for degree and betweenness. Overall, the highest VIF values are observed for centrality measures. Therefore, we applied distinct models for each independent variable to avoid multicollinearity issues.

Mediation analysis

To test our hypotheses, we conducted a cross-sectional analysis using a structural equation model (SEM), which is consistent with previous research (Ali *et al*., 2020). Indeed, in mediation analysis, SEM is more appropriate than the causal steps approach because it allows for the testing of simultaneous path models and provides a reasonable way to control for

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Table 4. Pearson correlation analysis

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1) Tobin's Q	1																
(2) ESG	−0.037	1															
(3) DEGR	−0.056*	0.460***	1														
(4) CLOSE	−0.022	0.429***	0.655***	1													
(5) EIGEN	0.060*	0.082***	0.184***	0.162***	1												
(6) BETW	−0.012	0.339***	0.846***	0.482***	0.348***	1											
(7) N-score							1										
(8) Firm size	−0.316***	0.482***	0.451***	0.382***	0.358***	0.025	0.430***	1									
(9) Leverage	−0.095***	0.038	0.015	−0.002	0.019	−0.013	−0.002	0.162***	1								
(10) Sales growth	0.067**	−0.123***	−0.148***	−0.185***	−0.102***	0.03	−0.136***	−0.184***	0.022	1							
(11) OCF	0.057*	0.139***	0.049	0.119***	0.034	−0.008	0.086***	0.108***	−0.063**	−0.051	1						
(12) SD_OCF	−0.096***	0.188***	0.253***	0.153***	0.265***	0.053*	0.179***	0.436***	0.173***	−0.078**	−0.089***	1					
(13) BOD size	−0.196***	0.357***	0.339***	0.298***	0.250***	0.001	0.310***	0.544***	0.029	−0.101***	0.065**	0.201***	1				
(14) NEDs %	0.01	0.212***	0.151***	0.127***	0.106***	0.074**	0.171***	0.063**	0.037	−0.059*	0.013	0.042	−0.186***	1			
(15) Females %	−0.072**	0.279***	0.226***	0.178***	0.138***	−0.063**	0.173***	0.104***	0.015	−0.107***	0.087***	0.056*	0.080***	0.244***	1		
(16) BOD age	0.021	0.124***	0.069**	0.082***	0.035	−0.052*	0.056*	0.086***	−0.017	−0.081**	0.026	0.04	−0.045	0.181***	−0.036	1	
(17) Firm age	−0.034	0.160***	0.160***	0.128***	0.107***	0.002	0.134***	0.114***	−0.033	−0.085***	0.036	0.061*	0.147***	−0.064**	0.118***	0.077**	1

Note(s): *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source(s): Table by authors

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Table 5. VIF test

Variable	VIF	1/VIF
DEGR	8.65	0.12
BETW	5.33	0.19
N-score	4.23	0.24
CLOSE	2.51	0.40
Firm size	2.32	0.43
BOD size	1.73	0.58
EIGEN	1.64	0.61
ESG	1.64	0.61
SD_OCF	1.33	0.75
NEDs %	1.3	0.77
Women %	1.25	0.80
Firm age	1.1	0.91
BOD age	1.1	0.91
Leverage	1.07	0.93
Sales growth	1.06	0.94
OCF	1.06	0.94
Mean VIF	2.33	

Source(s): Table by authors

measurement error (Hayes, 2009; Iacobucci *et al*., 2007; Zhao *et al*., 2010). Five distinct models were structured to examine the effect of each network centrality measure (i.e., *DEGR*, *CLOSE*, *EIGEN*, *BETW*, and *N-score*) separately. To enhance the interpretability of the coefficients, we used all standardized variables in the models. The results of the SEM models are reported in Table 6, which shows the direct effects of the independent variables on ESG and Tobin's Q in the first and second steps, respectively.

Our first hypothesis (HP1) posited that board network centrality, measured in terms of degree, closeness, eigenvector, and betweenness, has a positive effect on financial performance. However, the results from the second step regressions (top of the table) show that only *DEGR* and *BETW* positively affect Tobin's Q ($p < 0.1$, $p < 0.01$, respectively), while the direct effect of *CLOSE*, *EIGEN*, and *N-score* is not significant. Therefore, HP1 is only partially supported. At the same time, *ESG* has a positive and significant effect on Tobin's Q, regardless of the centrality measure considered ($p < 0.01$ for *DEGR*, *CLOSE*, *BETW*, and *N-score*; $p < 0.05$ for *EIGEN*), and looking at the first step regressions, results show that all centrality measures directly and positively influence *ESG* ($p < 0.01$ for *DEGR*, *CLOSE*, *BETW*, and *N-score*; $p < 0.05$ for *EIGEN*). These results suggest a potential mediation effect of ESG on the relationship between network centrality and Tobin's Q. Indeed, the significance of the direct effect of the independent variables on the mediator and of the mediator on the dependent variable represents a first requirement for mediation.

However, to confirm the mediation hypothesis, testing only the direct effects is not sufficient. A necessary condition for establishing mediation is that the indirect effect must be significant (Zhao *et al*., 2010). We tested the significance of the indirect effects using the Sobel test (Sobel, 1982, 1986) and the Monte Carlo test (Preacher and Selig, 2012), which are reported in Table 6 at the bottom. The results show a positive and significant coefficient for the indirect effects of each network centrality measure ($p < 0.05$ for *DEGR*, *CLOSE*, *BETW*, and *N*-score; $p < 0.1$ for *EIGEN*). We employed two approaches to confirm the indirect influence of network centrality on financial performance, namely Baron and Kenny's (1986) approach and Zhao *et al*.'s (2010) approach. According to Baron and Kenny's approach, mediation is established if Step 1 (i.e., the effect of the independent variable on the mediator), Step 2 (i.e., the effect of the mediator on the dependent variable), and Sobel's test for the indirect effect are all significant. The significance of Step 3 (i.e., the effect of the independent variable on the

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Table 6. Mediation analysis: SEM results

	Model 1 DEGR	Model 2 CLOSE	Model 3 EIGEN	Model 4 BETW	Model 5 N-score
Tobin's Q					
ESG	0.109***	0.122***	0.106**	0.108***	0.120***
DEGR	0.0728*				
CLOSE		−0.00856			
EIGEN			0.0279		
BETW				0.0884***	
N-score					0.00133
BOD size	−0.0443	−0.0332	−0.075	−0.0428	−0.0344
NEDs %	−0.017	−0.0105	−0.0162	−0.0173	−0.0113
Females %	−0.0392	−0.0387	−0.0375	−0.0389	−0.0386
BOD age	−0.0139	−0.0145	−0.0103	−0.0135	−0.0147
Firm size	−0.360***	−0.324***	−0.320***	−0.358***	−0.328***
Leverage	−0.0125	−0.018	−0.0174	−0.0122	−0.0171
Sales growth	0.0483	0.0484	0.0446	0.0482	0.0486
OCF	0.0864***	0.0810***	0.0800**	0.0847***	0.0812***
SD_OCF	0.0555*	0.0644**	0.0611*	0.0486	0.0640**
Firm age	−0.0225	−0.0209	0.00256	−0.0231	−0.0205
ESG					
DEGR	0.141***				
CLOSE		0.138***			
EIGEN			0.0777**		
BETW				0.0896***	
N-score					0.120***
BOD size	0.118***	0.124***	0.179***	0.131***	0.110***
NEDs %	0.186***	0.189***	0.194***	0.193***	0.177***
Females %	0.129***	0.133***	0.128***	0.132***	0.122***
BOD age	−0.0174	−0.0232	−0.00577	−0.018	−0.0166
Firm size	0.475***	0.492***	0.498***	0.513***	0.451***
Leverage	−0.0192	−0.0154	−0.0288	−0.0235	−0.0176
Sales growth	−0.0148	−0.0125	−0.0171	−0.0148	−0.0110
OCF	0.00564	−0.00281	−0.0127	−0.000931	0.00315
SD_OCF	−0.00014	0.0109	0.0207	0.000918	0.0109
Firm age	0.0193	0.03	0.0229	0.0207	0.0230
Dummy country	Yes	Yes	Yes	Yes	Yes
Dummy sector	Yes	Yes	Yes	Yes	Yes
Observations	888	888	888	888	888
Significant testing of indirect effects					
Sobel	0.015**	0.017**	0.008*	0.010**	0.014**
Monte Carlo	0.015**	0.017**	0.008*	0.010**	0.015**
Mediating testing methods: Baron & Kenny and Zhao, Lynch & Chen					
Step 1 - ESGn: centrality (X → M)	0.141***	0.138***	0.078***	0.090***	0.120***
Step 2 - Tobin's Q: ESG (M → Y)	0.109***	0.122***	0.106**	0.108***	0.120***
Step 3 - Tobin's Q: centrality (X → Y)	0.073*	−0.009	0.028	0.088***	0.001
RIT (indirect effect/total effect)	0.17	2.04	0.23	0.11	0.92
RID (indirect effect/direct effect)	0.21	1.97	0.3	0.12	10.88
Mediation effect (Baron and Kenny, 1986)	Partial	Full	Full	Partial	Full
Mediation effect (Zhao *et al*., 2010)	Partial	Full	Full	Partial	Full

Note(s): *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source(s): Table by authors

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dependent variable) determines whether the mediation is partial or full. The Zhao, Lynch and Chen approach requires only a significant indirect effect (as confirmed by the Monte Carlo test) for mediation to occur. Similar to the Baron and Kenny approach, the significance of Step 3 determines whether the mediation is partial or full.

To conduct the aforementioned tests, we employed the improved estimation technique proposed by Mehmetoglu (2018), which can be applied not only to latent variables but also to observed variables, as in our case. By combining the first three steps of the mediation analysis, this structural equation modeling method estimates all parameters at once and allows for post-estimation tests after the simultaneous estimation.

As shown in Table 6 at the bottom, both the Baron and Kenny approach and the Zhao *et al.* (2010) approach conclude that ESG has a positive mediation effect on the relationship between network centrality and financial performance. Step 1 is significant regardless of the centrality measure used. Indeed, our models show a positive and significant effect of each centrality measure on ESG ($p < 0.01$). Step 2 is also significant in each model applied, as ESG has a significant positive effect ($p < 0.01$) on Tobin's Q. In addition, both Sobel and Monte Carlo's tests (below in the table) show a positive and significant indirect effect for each centrality measure, confirming that the effect of network centrality on financial performance is mediated by sustainability performance, thus supporting hypothesis 2 (HP2). Finally, step 3 shows a significant direct effect for *DEGR* (Model 1; $p < 0.1$) and *BETW* (Model 4, $p < 0.01$), while the effect of *CLOSE* (Model 2) and *EIGEN* (Model 3) on Tobin's Q is not significant. Thus, we observe partial mediation of ESG for *DEGR* and *BETW*, while ESG fully mediates the effects of *CLOSE* and *EIGEN* on financial performance. When using the composite measure of overall board centrality (*N-score*), we find that the direct effect on Tobin's Q is not statistically significant, whereas the indirect effect through ESG remains positive and significant (Model 5, $p < 0.01$). This provides further support for a full mediation mechanism: when centrality is considered holistically, its effect on financial performance is entirely channeled through sustainability performance.

Regarding the control variables, the results indicate that board size, independent directors, and women directors have a positive impact on sustainability performance. These findings are consistent with the literature, which highlights the critical role of board characteristics in promoting corporate sustainability (Aguilera *et al.*, 2021). On the contrary, board-level control variables have no significant effect on financial performance. Firm-level control variables do not seem to play a significant role as drivers of firm performance, except for *Firm size*, which has a significant effect on both ESG and Tobin's Q. However, while it positively affects ESG, its impact on Tobin's Q is negative. Moreover, both *FOC* and its volatility (*SD_FOC*) have a positive and significant effect on financial performance.

Addressing endogeneity issues

Our analyses are not exempt from potential endogeneity issues. Endogeneity implies that the causal relationship between the independent and the dependent variables may be reversible. In this study, endogeneity may arise in both the first and second stages of the mediation analysis. As other studies on board interlocks and sustainability have pointed out (Li *et al.*, 2023), it is difficult to conclude whether sustainability performance depends on network centrality or whether the network is influenced by corporate sustainability. Indeed, more sustainable firms may attract directors with more interlocks; thus, the firm's network centrality may be influenced by its sustainability performance. Such a reverse causality may also affect the relationship between sustainability and financial performance (Soytas *et al.*, 2019). Specifically, it can be logically argued that firms with high financial performance may invest more in sustainability. In line with prior research (Chakravarty and Rutherford, 2017; Larcker *et al.*, 2013; Omer *et al.*, 2014), to address such potential endogeneity issues, we included a time lag in both stages of the SEM, measuring the mediator (ESG) at t+1 and the dependent variable (Tobin's Q) at t+2.

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To further mitigate any potential endogeneity concerns in our study that may persist after the lagged design, we performed two additional tests following an instrumental variable approach, aimed at confirming the hypothesized causality paths between network centrality and sustainability, as well as between the latter and financial performance, by instrumenting the endogenous variables of interest.

First, we run SEM models with an additional stage in order to include an instrumental variable for each network centrality measure. In line with previous research (El-Khatib *et al*., 2021; Omer *et al*., 2014), we consider the average degree, closeness, eigenvector, betweenness centrality, *and N-score* of other firms in the network operating in the same country and industry as the focal firm (*IV_DEGR*, *IV_CLOSE*, *IV_EIGEN*, *IV_BETW*, *IV_N-score*), excluding the firm of interest. Consistent with prior research, we assessed the validity of our instrumental variables using the first-stage F-statistic (Amin *et al*., 2020; Martin *et al*., 2015). The results, reported in Table 7, show highly significant F-statistics ($p < 0.001$) for each model, with values exceeding the commonly accepted threshold for instrument validity ($F > 10$) suggested by Stock *et al.* (2002) – i.e., 129.8 for DEGR, 425.5 for CLOSE, 87.7 for EIGEN, 30.8 for BETW, and 473.8 for *N-score*. These findings confirm the relevance of our instruments. The results reported in Table 7 are consistent with those of the main models. The only exception concerns the direct effect of *DEGR* on *Tobin's Q*, which is not significant in this case. Thus, when we instrumented degree centrality, its effect on financial performance is fully mediated by ESG.

Second, we employed an alternative method to SEM to perform mediation analysis: the two-stage least squares (2SLS) approach, which allows us to introduce an instrumental variable for our mediator. Following prior research (Zhou *et al*., 2023), we gauged the average ESG of other firms operating in the focal firm's country and industry (*ESG_ind_country*) as an instrument for ESG, which was introduced in the first-stage regressions. The results of 2SLS analyses are reported in Table 8. The first-stage estimation results (shown in the table below) indicate that both the instrument and centrality measures are significantly and positively related to ESG. Also in this case, we assessed the relevance of our instrument using the first-stage F-statistic, which confirms its validity for each model ($F > 10$ and $p < 0.001$). The second-stage estimation models (top of the table) show the effect of the instrumented mediator, i.e., the predicted value of ESG from the first stage, on financial performance. As expected, it has a positive and significant effect on Tobin's Q, while network centrality has no significant effect in the second stage, except for betweenness centrality (*BETW*, Model 4). As argued above, the significance of coefficients is a necessary but not sufficient condition to establish a mediation effect; therefore, we have to look at the effect decomposition. Since we cannot apply the *medsem* post-estimation technique by Mehmetoglu (2018) after 2SLS models, we performed the mediating analysis (reported at the end of the table) by decomposing the mediation effects into indirect, direct, and total effects. Following the Zhao *et al.* (2010) approach, for a mediation effect to be confirmed, it is sufficient to find a significant indirect effect. Results show a positive and significant indirect effect for each model, thus confirming the mediating effect of ESG on the relationship between network centrality and financial performance. In particular, degree, closeness, and eigenvector have a non-significant direct effect, showing a full mediation. In contrast, the direct effect of betweenness on Tobin's Q is positive and significant ($p < 0.05$), indicating a partial mediation. Regarding robustness check 1 (Table 7), the 2SLS tests confirm the results from the main models, with the only difference being degree centrality, whose effect on financial performance is fully mediated by ESG when the instrumental variable is included.

Robustness checks

We performed further sensitivity tests to check the robustness of the mediating effect of ESG on the relationship between network centrality and financial performance.

First, we tested our results using an alternative measure of financial performance, i.e., Return On Assets (ROA). The inclusion of ROA allows us to determine whether our findings

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Table 7. Rob check 1: SEM results with instrumental variable approach

	Model 1 DEGR	Model 2 CLOSE	Model 3 EIGEN	Model 4 BETW	Model 5 N-score
Tobin's Q					
ESG	0.0832**	0.122***	0.111***	0.108***	0.120***
DEGR	0.0605				
CLOSE		−0.00856			
EIGEN			0.0207		
BETW				0.0884***	
N-score					0.00133
BOD size	−0.0169	−0.0332	−0.0708	−0.0428	−0.0344
NEDs %	−0.0123	−0.0105	−0.0181	−0.0173	−0.0113
Females %	−0.0516	−0.0387	−0.0401	−0.0389	−0.0386
BOD age	0.0198	−0.0145	−0.0147	−0.0135	−0.0147
Firm size	−0.326***	−0.324***	−0.321***	−0.358***	−0.328***
Leverage	−0.0163	−0.018	−0.0196	−0.0122	−0.0171
Sales growth	0.0418	0.0484	0.0469	0.0482	0.0486
OCF	0.0874***	0.0810***	0.0832***	0.0847***	0.0812***
SD_OCF	0.0506	0.0644**	0.0609*	0.0486	0.0640**
Firm age	−0.0303	−0.0209	−0.0138	−0.0231	−0.0205
ESG					
DEGR	0.141***				
CLOSE		0.138***			
EIGEN			0.0728**		
BETW				0.0896***	
N-score					0.120***
BOD size	0.118***	0.124***	0.178***	0.131***	0.110***
NEDs %	0.186***	0.189***	0.195***	0.193***	0.177***
Females %	0.129***	0.133***	0.125***	0.132***	0.122***
BOD age	−0.0174	−0.0232	−0.00553	−0.018	−0.0166
Firm size	0.475***	0.492***	0.504***	0.513***	0.451***
Leverage	−0.0192	−0.0154	−0.0295	−0.0235	−0.0176
Sales growth	−0.0148	−0.0125	−0.013	−0.0148	−0.0110
OCF	0.00564	−0.00281	−0.00975	−0.000931	0.00315
SD_OCF	−0.00014	0.0109	0.0214	0.000918	0.0109
Firm age	0.0193	0.03	0.0181	0.0207	0.0230
Network centrality: DEGR CLOSE EIGEN BETW					
IV_DEGR	0.706***				
IV_CLOSE		0.764***			
IV_EIGEN			0.752***		
IV_BETW				0.684***	
IV_N-score					1.020***
Dummy country	Yes	Yes	Yes	Yes	Yes
Dummy sector	Yes	Yes	Yes	Yes	Yes
Observations	888	888	888	888	888
First-stage F-statistic	129.785***	425.457***	87.677***	30.761***	473.836***
Significant testing of indirect effects					
Sobel	0.012*	0.017**	0.008*	0.010**	0.014**
Monte Carlo	0.012*	0.017**	0.008*	0.010**	0.015**
Mediating testing methods: Baron & Kenny and Zhao, Lynch & Chen					
Step 1 - ESG: centrality (X → M)	0.141***	0.138***	0.073**	0.090***	0.120***
Step 2 - Tobin's Q: ESG (M → Y)	0.083**	0.122***	0.111***	0.108***	0.120***
Step 3 - Tobin's Q: centrality (X → Y)	0.061	−0.009	0.021	0.088***	0.001
RIT (indirect effect/total effect)	0.16	2.04	0.29	0.1	0.92
RID (indirect effect/direct effect)	0.19	1.97	0.39	0.11	10.88

(*continued*)

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Table 7. Continued

	Model 1 DEGR	Model 2 CLOSE	Model 3 EIGEN	Model 4 BETW	Model 5 N-score
Mediation effect (Baron and Kenny, 1986)	Full	Full	Full	Partial	Full
Mediation effect (Zhao *et al*., 2010)	Full	Full	Full	Partial	Full

Note(s): $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$
Source(s): Table by authors

hold when using a performance metric less influenced by market perceptions and more focused on internal operating performance (Rahman *et al*., 2023). Indeed, Tobin's Q is a market-based measure of performance that can be influenced by external factors, such as investor sentiment and market volatility, which may not accurately reflect the firm's underlying operating performance (Awaysheh *et al*., 2020). By contrast, ROA provides insight into the firm's profitability from its core business activities, offering a complementary perspective. The results, reported in Table 9 (Rob check 3), show that a full mediation occurs for each model considered, indicating a consistency across both market-based and accounting-based performance measures.

Second, because specific regulations on board interlocks may affect our results, we also carried out our model excluding firms in the financial sector. Although specific regulations limiting board interlocks are not prevalent across Europe (Petersen, 2016), some exceptions concern the financial sector, which often has different regulatory frameworks and corporate governance structures. For instance, Italy has introduced restrictions on interlocking directorates in the financial sector to prevent anti-competitive practices and improve corporate governance. To address potential confounding effects due to specific regulations and further validate our results, we conducted a robustness check by excluding the financial sector from our analyses. Results are reported in Table 10 (Rob check 4). Also in this case, the results hold, showing full mediation for each network centrality measure analyzed.

Discussion and conclusions

In this study, we examined the mediating effect of corporate sustainability on the relationship between board network centrality and firm performance. Drawing from the social capital theory emphasizing the value of networks and relationships in facilitating access to resources (Adler and Kwon, 2002), and legitimacy theory, which focuses on aligning organizational practices with societal expectations to gain legitimacy (Suchman, 1995), we argued that corporate sustainability is a critical mechanism through which a firm's centrality within its network, established through board interlocks, leads to enhanced financial performance.

By analyzing a network of 888 European firms linked through their board interlocks, we found evidence that both sustainable and financial performance can be enhanced through a more central network position. Specifically, our results show that while financial performance, measured in terms of Tobin's Q, appears to be positively influenced by the number of ties that firms have with other firms through board interlocks (i.e., degree centrality) and the degree to which firms hold an intermediary position in the network (i.e., betweenness centrality), the accessibility of other firms in the board networks (i.e., closeness centrality) and the importance or influence of the boards to which firms are connected through interlocked directors (i.e., eigenvector centrality) do not show a direct effect.

These results offer valuable insights into how the distinct characteristics of a company's position within board networks constitute strategic levers for its financial performance. Beyond the number of board interlocks a firm maintains (degree centrality), the findings

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Table 8. Rob check 2: 2SLS

	Model 1 DEGR	Model 2 CLOSE	Model 3 EIGEN	Model 4 BETW	Model 5 N-score
2nd stage: Tobin's Q					
ESG (predicted from 1st stage)	0.195**	0.222***	0.207***	0.192**	0.224***
DEGR	0.061				
CLOSE		−0.010			
EIGEN			0.013		
BETW				0.081**	
N-score					0.080**
BOD size	−0.055	−0.043	−0.090*	−0.054	−0.042
NEDs %	−0.033	−0.016	−0.024	−0.034	−0.015
Females %	−0.050	−0.061	−0.055	−0.050	−0.060
BOD age	−0.012	−0.026	−0.029	−0.012	−0.027
Firm size	−0.401***	−0.388***	−0.375***	−0.401***	−0.383***
Leverage	−0.011	−0.009	−0.008	−0.010	−0.009
Sales growth	0.050	0.082**	0.076**	0.049	0.081**
OCF	0.086***	0.092***	0.091***	0.085***	0.091***
SD_OCF	0.056	0.063*	0.059*	0.049	0.063*
Firm age	−0.024	0.008	0.034	−0.025	0.008
1st stage: ESG					
ESG_ind_country	0.515***	0.514***	0.537***	0.518***	0.508***
DEGR	0.114***				
CLOSE		0.063**			
EIGEN			0.051*		
BETW				0.068***	
N-score					0.078***
BOD size	0.081**	0.092***	0.133***	0.091***	0.080**
NEDs %	0.162***	0.170***	0.171***	0.169***	0.160***
Women %	0.092***	0.096***	0.090***	0.094***	0.089***
BOD age	−0.039	−0.042*	−0.032	−0.039	−0.038
Firm size	0.346***	0.381***	0.349***	0.378***	0.345***
Leverage	0.009	0.007	0.002	0.005	0.008
Sales growth	−0.008	−0.007	−0.011	−0.008	−0.006
OCF	0.009	0.002	−0.001	0.004	0.006
SD_OCF	0.023	0.034	0.043*	0.025	0.033
Firm age	0.023	0.030	0.022	0.025	0.026
Dummy country	Yes	Yes	Yes	Yes	Yes
Dummy sector	Yes	Yes	Yes	Yes	Yes
Observations	888	888	888	888	888
F-statistic 1st stage	379.4***	358.9***	381.7***	378.8***	357.4***
R-squared 1st stage	0.646	0.640	0.643	0.642	0.646
R-squared 2nd stage	0.277	0.363	0.367	0.281	0.363
Mediating analysis					
Indirect effect	0.022**	0.014*	0.011*	0.013*	0.017**
Direct effect	0.061	−0.01	0.024	0.081**	−0.012
Total effect	0.828**	0.0043	0.034	0.094***	0.0055
RIT (indirect effect/total effect)	0.27	3.29	0.46	0.14	1.35
RID (indirect effect/direct effect)	0.37	−1.44	0.84	0.16	3.54
Mediation effect (Zhao *et al.*, 2010)	Full	Full	Full	Partial	Full

Note(s): ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Source(s): Table by authors

suggest that firms may gain a competitive advantage by serving as intermediaries within the board network. Betweenness centrality indeed serves as a proxy for the extent to which a board occupies a "bridging" or "intermediary" position in the network, potentially mediating

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Table 9. Rob check 3: ROA

	Model 1 DEGR	Model 2 CLOSE	Model 3 EIGEN	Model 4 BETW	Model 5 N-score
ROA					
ESG	0.112***	0.111***	0.116***	0.110***	0.109**
DEGR	−0.00636				
CLOSE		0.00271			
EIGEN			0.0676*		
BETW				0.00698	
N-score					0.00587
BOD size	−0.0281	−0.0293	−0.0228	−0.0296	−0.0302
NEDs %	−0.100***	−0.101***	−0.113***	−0.101***	−0.102***
Females %	0.041	0.0409	0.0549	0.0408	0.0405
BOD age	0.00248	0.00255	−0.00827	0.00269	0.00274
Firm size	−0.00471	−0.00862	−0.0296	−0.0103	−0.0117
Leverage	−0.0416	−0.041	−0.0447	−0.0408	−0.0408
Sales growth	0.0164	0.0164	−0.00121	0.0164	0.0166
OCF	0.190***	0.190***	0.174***	0.190***	0.191***
SD_OCF	0.0125	0.0117	0.0109	0.0105	0.0115
Firm age	0.0389	0.0388	0.0367	0.0385	0.0387
ESG					
DEGR	0.147***				
CLOSE		0.163***			
EIGEN			0.0825***		
BETW				0.0920***	
N-score					0.130***
BOD size	0.120***	0.121***	0.171***	0.133***	0.110***
NEDs %	0.177***	0.178***	0.184***	0.185***	0.166***
Females %	0.126***	0.128***	0.122***	0.128***	0.118***
BOD age	−0.0315	−0.0364	−0.0263	−0.0331	−0.0302
Firm size	0.464***	0.477***	0.510***	0.506***	0.438***
Leverage	−0.00251	0.00257	−0.00469	−0.00773	0.00244
Sales growth	−0.0437	−0.0444	−0.0497*	−0.044	−0.0378
OCF	0.0202	0.013	0.00525	0.0129	0.0178
SD_OCF	0.00209	0.0126	0.0174	0.00247	0.0132
Firm age	0.022	0.0332	0.0285	0.0236	0.0257
Dummy country	Yes	Yes	Yes	Yes	Yes
Dummy sector	Yes	Yes	Yes	Yes	Yes
Observations	847	847	847	847	847
Significant testing of indirect effects					
Sobel	0.16**	0.18**	0.010*	0.010**	0.014**
Monte Carlo	0.17**	0.18**	0.010*	0.010**	0.014**
Mediating testing methods: Baron & Kenny and Zhao, Lynch & Chen					
Step 1 - ESG: centrality (X → M)	0.147***	0.163***	0.0825***	0.0920***	0.130***
Step 2 - ROA: ESG (M → Y)	0.112***	0.111***	0.116***	0.110***	0.109**
Step 3 - ROA: centrality (X → Y)	−0.006	0.003	0.068*	0.007	0.006
RIT (indirect effect/total effect)	1.63	0.87	0.15	0.592	0.707
RID (indirect effect/direct effect)	2.59	6.67	0.17	1.45	2.41
Mediation effect (Baron and Kenny, 1986)	Full	Full	Partial	Full	Full
Mediation effect (Zhao *et al*., 2010)	Full	Full	Partial	Full	Full

Note(s): ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Source(s): Table by authors

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Table 10. Rob check 4: excluding financial sector

	Model 1 DEGR	Model 2 CLOSE	Model 3 EIGEN	Model 4 BETW	Model 5 N-score
Tobin's Q					
ESG	0.117**	0.125***	0.149***	0.119**	0.121**
DEGR	0.0362				
CLOSE		−0.0159			
EIGEN			0.0145		
BETW				0.0331	
N-score					0.00530
BOD size	−0.032	−0.0251	−0.0796	−0.0313	−0.0279
NEDs %	−0.0101	−0.00567	−0.00159	−0.00988	−0.00747
Females %	−0.0208	−0.0195	−0.0466	−0.0209	−0.0199
BOD age	−0.0146	−0.0156	−0.0416	−0.0147	−0.0155
Firm size	−0.425***	−0.403***	−0.384***	−0.421***	−0.412***
Leverage	−0.0117	−0.0156	−0.0081	−0.0125	−0.0137
Sales growth	0.0415	0.0419	0.0756**	0.0412	0.0420
OCF	0.109***	0.105***	0.117***	0.108***	0.106***
SD_OCF	0.266	0.272	0.147	0.261	0.274
Firm age	−0.0272	−0.0281	0.0355	−0.0273	−0.0270
ESG					
DEGR	0.137***				
CLOSE		0.150***			
EIGEN			0.0716**		
BETW				0.0804**	
N-score					0.153***
BOD size	0.143***	0.145***	0.199***	0.153***	0.132***
NEDs %	0.195***	0.197***	0.185***	0.203***	0.186***
Females %	0.109***	0.112***	0.123***	0.112***	0.103**
BOD age	0.00484	−0.00036	0.00786	0.00316	0.00730
Firm size	0.462***	0.466***	0.443***	0.502***	0.423***
Leverage	−0.00874	−0.00345	−0.0102	−0.0141	−0.00607
Sales growth	−0.0165	−0.0143	−0.0103	−0.0168	−0.0133
OCF	0.00704	−0.000672	−0.000557	0.000121	0.00476
SD_OCF	−0.0523	−0.00914	0.178	−0.0538	−0.00151
Firm age	0.0303	0.0406	0.017	0.0308	0.0325
Dummy country	Yes	Yes	Yes	Yes	Yes
Dummy sector (no financial sector)	Yes	Yes	Yes	Yes	Yes
Observations	744	744	744	744	744
Significant testing of indirect effects					
Sobel	0.016**	0.019**	0.011*	0.011*	0.019**
Monte Carlo	0.016**	0.019**	0.011*	0.011*	0.019**
Mediating testing methods: Baron & Kenny and Zhao, Lynch & Chen					
Step 1 - ESG: centrality (X → M)	0.137***	0.150***	0.0716**	0.0804**	0.153***
Step 2 - Tobin's Q: ESG (M → Y)	0.117**	0.125***	0.149***	0.119**	0.121**
Step 3 - Tobin's Q: centrality (X → Y)	0.036	−0.016	−0.019	0.032	0.005
RIT (indirect effect/total effect)	0.31	6.82	0.42	0.25	0.778
RID (indirect effect/direct effect)	0.44	1.17	0.74	0.34	3.49
Mediation effect (Baron and Kenny, 1986)	Full	Full	Full	Full	Full
Mediation effect (Zhao *et al.*, 2010)	Full	Full	Full	Full	Full

Note(s): $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Source(s): Table by authors

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interactions between otherwise unconnected boards (Burt, 2005). In light of social network theories, betweenness centrality denotes the degree to which a node can exert control over a network (Burt, 2003). Such an intermediary position indeed enables a node to control or oversee the flow of network resources (e.g. information or knowledge) across nodes, and thus filter or exploit exchanges among otherwise distant nodes (Granovetter, 1973). In this view, our findings suggest that betweenness centrality enhances a firm's capacity to extract and capture value from the board network, thereby strengthening its ability to translate social capital into more tangible benefits, owing to greater control over the board network.

Contrarily to betweenness centrality, closeness and eigenvector centrality do not relate to a node's ability to exert control or influence over the board network. According to social network theories, closeness centrality measures a node's proximity to other nodes in the network, which denotes the node's ability to efficiently and rapidly access information or resources from other actors within the board network (Scott, 2000). However, efficient access does not equate to control. Proximity to other actors in the network does not imply the ability to broker or mediate exchanges among such actors, nor does it exert influence by virtue of strategic network positioning (Uzzi, 2018). Similarly, eigenvector centrality measures a node's connection to other well-connected nodes. While this may constitute a proxy for prestige through association with influential actors (Shropshire, 2010), it does not capture a node's capability to exert direct control over network relations through its strategic positioning.

In light of these considerations, our findings suggest that capitalizing on social capital within board networks requires more than efficient access to information granted by network embeddedness; it necessitates a certain degree of control over network resources granted by a strategic board positioning. Such results may suggest that firms with high betweenness centrality are better positioned to extract value from the board network by selectively channeling information, facilitating collaborations, and shaping decision-making across otherwise unconnected boards. In contrast, closeness and eigenvector centrality do not afford the same kind of strategic influence over network dynamics.

In addition, the partial confirmation of our first hypothesis suggests that the effect of board network centrality on financial performance may be more nuanced than a simple direct relationship. Importantly, when considering the mediating role of corporate sustainability, all centrality dimensions exhibited a significant indirect effect on financial performance through ESG. This finding supports our second hypothesis and underscores the notion that both quantity and quality of board network ties indirectly enhance firm performance by fostering improved sustainability outcomes that contribute to legitimacy within the network. Indeed, ESG performance appears to be positively influenced by all dimensions of centrality examined. Further support is provided by our analysis using the composite measure of overall centrality (*N-score*). When employing this aggregate indicator, we find that the effect of board network centrality on financial performance is fully mediated by sustainability performance. This suggests that firms occupying central positions in the board interlock network do not benefit financially from centrality *per se*, but rather through their improved ESG engagement, which acts as the key transmission channel. Indeed, a central position within the board network facilitates access to sustainability-related knowledge, strengthens the external reputation, and enables firms to respond swiftly to diverse stakeholder needs (Chahine *et al*., 2019; Harjoto and Wang, 2020; Homroy and Slechten, 2019; Zhao, 2021), thereby enhancing corporate sustainability and allowing firms to convert the benefits of their network positioning into higher financial performance.

These findings corroborate the key role of the board network as a valuable inter-firm asset that facilitates leveraging social capital as a source of competitive and sustainable advantage, leading to higher firm performance, as highlighted by previous research (Adler and Kwon, 2002; Homroy and Slechten, 2019). However, we expand knowledge of such a relationship by showing that this effect is mediated by sustainability. By leveraging the social capital inherent in the board network, firms can adopt and implement sustainability practices that lead to a

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competitive and sustainable advantage by legitimating themselves (Larcker *et al*., 2013; Tsai, 2000), ultimately resulting in higher financial performance.

The sensitivity checks conducted using ROA as an alternative dependent variable bolster these conclusions. The mediation effect of corporate sustainability remained significant, indicating that the benefits of board network centrality through corporate sustainability extend beyond market perceptions to tangible improvements in operational efficiency. This consistency across different performance measures reinforces the robustness of our results and suggests that the relationship between board network centrality, corporate sustainability, and firm performance is substantive.

Contribution to literature

By providing a social network perspective on the relationship between board network centrality, sustainability performance, and financial performance, the study advances several contributions to the academic debate about firm performance and board network – i.e., inter-firm network relationships established through board interlocks.

First, to the best of our knowledge, this is the first study to empirically examine corporate sustainability as a mediating mechanism in the relationship between board network centrality and firm financial performance. While prior research has explored the direct effects of board network centrality on financial performance, the findings have been inconclusive, highlighting the need to investigate the underlying mechanisms that explain this relationship (Fayad *et al*., 2024; Smith and Sarabi, 2021). By identifying corporate sustainability as a mediator, our study provides a novel explanation for how board network can lead to enhanced financial outcomes. This mediating role of corporate sustainability offers a more nuanced understanding of the pathways through which social capital embedded in board networks translates into tangible competitive advantages.

Second, by focusing on corporate sustainability as an underlying mechanism, our research adds to the "business case" of sustainability (Dyllick and Hockerts, 2002), highlighting sustainability performance not only as a direct antecedent of financial performance but also as a crucial mechanism for translating social capital from board network into economic returns. Our study advances that, as sustainability challenges become increasingly pressing, good corporate sustainability performance enables firms to capitalize on their board network relationships, leading to higher financial performance. Thus, by relying on legitimacy theory, our research contributes to previous research that highlights firms' commitment to sustainability as a legitimizing factor within board networks (Chahine *et al*., 2019; Zhao, 2021).

Third, our research focuses on the network centrality of a firm within the board network, thus contributing to the understanding of specific network dynamics that positively influence sustainability and financial performance. More specifically, by focusing on four distinct measures of board network centrality (i.e., degree, closeness, betweenness, and eigenvector centrality), our study contributes to shedding light on the different roles that board network characteristics can play in determining firms' competitive advantage. Indeed, centrality measures offer a deeper understanding of a firm's structural position and influence within the board network. This includes how well-connected a firm is, how quickly it can access information, its role as an intermediary, and its connections to other influential firms.

Finally, while studies from the US typically dominate corporate governance research (Wiersema and Koo, 2022), our research focuses on publicly listed European firms. This not only expands the geographical scope of literature but also uncovers unique characteristics within the European context, enriching the global discourse and facilitating comparative analyses. Moreover, this focus allows us to capture the effects of board networks in a setting where corporate sustainability is becoming increasingly integral to business strategy, due to stringent regulatory requirements and heightened stakeholder expectations.

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Managerial implications

The study also provides implications for managerial practice. First, our results highlight the benefits of opening organizational boundaries for firm performance. Our study aligns with prior research in showing that board networks represent a valuable source of social capital that can drive firm performance (Kim, 2005; Larcker *et al*., 2013; Wang *et al*., 2021; Zhao, 2021), thus confirming that social capital is a key characteristic to consider when evaluating board composition.

Moreover, by showing a positive mediation effect of ESG, our results highlight corporate sustainability as a relevant mechanism for translating the benefits derived from board network into improved financial performance. In this view, good sustainability performance emerges as an increasingly necessary legitimacy factor allowing firms to benefit from their networks. In doing so, our findings remind managers that corporate sustainability does not occur in isolation, but instead requires firms to participate in collaborative efforts, build partnerships, and engage with diverse stakeholders. In this regard, the study suggests that board networks constitute a valuable avenue for fostering collaborative efforts to improve sustainability performance. Indeed, by serving on the boards of other firms and participating in cross-sectoral networks, directors can access and develop complementary, external resources and capabilities, as well as knowledge and information. Similarly, board networks can enhance the sharing of *"best practices"* among firms and across sectors, and facilitate access to new technologies and technology providers, thereby stimulating innovation. As a source of social capital, board networks can facilitate firms' access to sectoral sustainability networks or international sustainability partnerships (e.g. UN Global Compact), which can bring direct reputational benefits and institutional support. Board networks can facilitate firms in sensing, interpreting, and monitoring changes in the regulatory environment, thus reducing exposure to regulatory uncertainty and enhancing responsiveness to the increasingly rapid evolutions of sustainability regulations. Finally, board networks can secure institutional support by facilitating firms in lobbying public institutions at the national and international levels.

In addition, by examining the effects of different measures of network centrality on financial and sustainability performance, the study suggests that the benefits of board networks stem not only from the number of interlocks (i.e., degree centrality), but also from the quality of board network, and the network position also plays a role. When it comes to leveraging network relationships to improve ESG performance, the eigenvector centrality results advise firms to secure board networks with firms that are already characterized by a solid network of relations, thus favoring firms with a high number of interlocks over more isolated or marginalized organizations. Such "high quality" relationships allow firms to gain access to more extensive board networks and thus accrue greater advantages, thanks to a larger – and possibly more diverse – consortium of valuable resources, capabilities, and relations. Accordingly, firms should strategically seek out partners that are already well integrated into extensive board networks.

In the same vein, the closeness and betweenness centrality results highlight board network position as a strategic lever for financial performance through corporate sustainability. Managerial implications point to the need to monitor firms' positioning within board networks in order to assess the strategic implications of diverse configurations of inter-organizational relationships. On the one hand, the results for closeness centrality emphasize the importance of nurturing direct connections with firms in inter-organizational networks, thus reducing "intermediated" relations in order to secure greater advantages. Contrary to "intermediated" relations, direct relations – in the form of board interlocks – allow a firm to benefit from directors' social capital (e.g. complementary resources, knowledge, or information) without having to depend on the intercession of other organizations. On the other hand, the results for betweenness centrality highlight the benefits of playing the "intermediary" role for both sustainability and financial performance. By intermediating the relationship between two or more firms, firms may be able to exert a greater influence over their board network. This position may enable them to better control and monitor information flows within the board

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network, thereby accruing more significant advantages. Thus, we advise firms not only to consider their ability to form relationships through board interlocks but also to assess and monitor their position in the board network.

Limitations and further research

This study is not exempt from limitations. First, by showing that firm sustainability performance mediates the effect of board network centrality on financial performance, we contribute to deepening knowledge of the mechanisms that explain the value-creation potential of the board network. However, other mechanisms may be involved in the relationship between network centrality and financial performance (Hayes, 2018). Future research could explore legitimation mechanisms explicitly aimed at externally signaling firms' efforts toward sustainability improvement – such as sustainability certification programs (Todaro *et al*., 2019) – that might explain the link between the board network and financial performance.

Second, while our study focused on the mediating effect of sustainability performance – thereby contributing to the expansion of knowledge on the mechanisms that explain the positive association between board network and financial performance, as widely recognized in prior literature (Golden and Zajac, 2001; Peng, 2004; Smith and Sarabi, 2021; Zaheer *et al*., 2010; Zhao, 2021) – we acknowledge that corporate sustainability might also play a moderating role in this relationship. Specifically, future research could explore whether corporate sustainability influences the strength or direction of the relationship between board network centrality and financial performance.

Third, in analyzing the performance benefits stemming from firms' positioning in board networks, we focused on firms that have at least one interlock with another firm and thus participate in this specific form of inter-organizational network, regardless of the number and characteristics of directors simultaneously serving on the boards of the two firms. As a result, centrality measures were computed without accounting for the number of directors connecting the two boards, which may constitute a proxy for the strength of the tie between the two firms. Future studies may address this limitation by accounting for specific tie attributes (e.g. number of interlocked directors, years of continuous interlocking, etc.) as well as directors' demographics (e.g. seniority, sustainability experience, and competence, etc.) that may contribute to explaining the relationship between board network centrality and performance. In this regard, it is also important to acknowledge that these methodological choices in network structuring and centrality measure computation partially limit the direct comparability of our results to previous studies that, despite adopting a social network perspective on board interlocks, have employed different methodological approaches to network construction.

Fourth, by showing that corporate sustainability mediates the relationship between board network centrality and financial performance, we posit that corporate sustainability represents a valuable legitimacy factor that enables the firm to capitalize on its network centrality. However, the present study does not empirically assess the effect of corporate legitimacy. Therefore, further research should validate our arguments by introducing a legitimacy variable and applying a serial mediation model.

Fifth, we conducted a node-level analysis, focusing on the effect of board centrality for each firm within the network established through board interlocks. Future studies can adopt a whole-network perspective, placing the focus on dyad-level analysis to examine board network dynamics.

Sixth, as we focused on the effect of network centrality, we followed a purposive sampling approach to identify firms with at least one connection to conduct our analyses. Although our descriptive statistics reveal high heterogeneity in the ESG performance of the selected firms, focusing solely on tied firms could have led to potential sample selection bias. To address such an issue, future research might also include isolated firms in conducting a comparative analysis.

Seventh, while our study introduces temporal lags between the independent (centrality measures from 2015–2020), mediator (ESG scores in 2021), and dependent variables (Tobin's

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Q in 2022) to address reverse causality, this approach does not fully resolve potential autocorrelation biases, as ESG performance and financial performance indicators often exhibit temporal persistence. Future research could address this limitation by performing panel data analyses examining a longer time span. Such an approach would allow for more robust control over time-series autocorrelation issues and provide deeper insights into the dynamic relationships among network centrality, ESG performance, and financial outcomes. Additionally, incorporating methods that specifically account for autocorrelation, such as difference-in-differences models or dynamic panel data techniques, could further strengthen the validity of future studies in this domain.

Lastly, we have used Refinitiv Eikon's ESG scores for corporate sustainability. While this is a reliable source, future research could examine additional sources of ESG scores, such as Sustainalytics and MSCI.

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