Boardroom centrality and firm performance: Evidence from private firms*

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Abstract

Boardroom centrality, measured by directorship interlocks, positively influences future firm performance in private firms. The centrality-performance relationship is strong for private firms, where increased connectedness is likely to provide certification benefits, decrease transaction costs through reduction of information asymmetry, and improve access to critical resources, thereby contributing to sustainable competitive advantage, profitability and growth. Private firms with central boards also hoard less cash and have better employee productivity. Sub-sample analyses further reveal that networks are crucial for both distressed and young firms. This is consistent with better-connected directors providing firms with informational resources when they need them the most. Overall, the findings suggest that boardroom interlocks are positively associated with immediate economic benefits in private firms.

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1. Introduction

Boardroom centrality and firm performance have previously not been studied in the context of private firms. Boardroom centrality, i.e. networks established through directorship interlocks, plays a crucial role in exchange of information and critical resources (Benson et al. 2018; Fang et al. 2018; Horton et al. 2012; Intintoli et al. 2018; Javakhadze and Rajkovic 2018; Larcker et al. 2013). The closest private firm performance literature is written on outside directors' and entrepreneur's social and collaborator networks. It relies primarily on cross sectional surveys and small samples, and does not provide a unanimous prediction on whether the association of boardroom centrality and firm performance among private firms should be positive or negative. Empirically, a variety of negative (Hessels and Parker 2013; Lappalainen and Niskanen 2012; Lechner et al. 2006; Watson 2007), non-existing (Havnes and Senneseth 2001), and positive (Arosa et al. 2010; Baum et al. 2000; Bratkovic et al. 2009; Hernández and Nieto 2016; Partanen et al. 2018; Robson and Bennett 2000) associations between networks and performance has been documented in private firms. Hence, the aim of this study is to test the performance implications of boardroom centrality in private firms.[1]

Previous research studying the centrality-performance relationship in public firms, documents both negative and positive association. On one hand, well-connected, but too 'busy' boards are negatively associated with performance according to studies focusing on large firms (Ferris et al. 2020; Fich and Shivdasani 2006; Hauser 2018). On the contrary, the association of boardroom centrality and firm performance is positive in a broader sample that also includes non-S&P 500 firms (Ferris et al. 2003; Horton et al. 2012; Larcker et al. 2013). Cashman et al. (2012) suggest that boardroom centrality can have either a positive or negative effect on performance, depending on the context and sample. This implies that the association of firm performance and boardroom centrality is likely to have its peculiarities in private firms, where boards are dramatically different from large firms (Linck et al. 2008).

[1] We measure firm performance through operating performance in the form of return on assets and sales growth.

Board structure can be seen as a rational response to the needs, uncertainty and changing conditions of the operating environment (Harris and Raviv 2008; Linck et al. 2008). For instance, compared to public firms, access to finance can constitute a critical growth constraint for private firms (Beck and Demirguc-Kunt 2006; Hutchinson and Xavier 2006). According to the resource dependence theory (Pfeffer and Gerald 1978), managers cope with uncertainty and inter-organizational dependence by attempting to reduce other's power on them and if possible, gain power over the other. One such option is to engage in inter-firm collaboration especially if the inter-organizational dependence is high (Finkelstein 1997; Pfeffer and Gerald 1978). Consequently, in private firms additions to boards are likely to be related to critical resources and growth constraints, such as advisory (Brunninge et al. 2007; Hernández and Nieto 2016; Maseda et al. 2015), financing (Broughman 2013; Eisenberg et al. 1998) and different collaboration and internationalization partnerships that positively affect performance (BarNir and Smith 2002; Haahti et al. 2005; Hessels and Parker 2013; L. Li et al. 2018; Wynarczyk and Watson 2005).

Higher private firm boardroom centrality is likely to have substantial benefits with respect to organizational legitimacy, lower transaction costs and sustainable value creation. Since private firms are more opaque (Ball and Shivakumar 2005; Burgstahler et al. 2006) and have more stringent loan contract terms compared to public firms (Ackert et al. 2007), boardroom centrality can increase their credibility (Certo 2003; Fahlenbrach et al. 2010). Specifically, Javakhadze et al. (2016) finds that boardroom centrality not only contributes towards stricter contract enforcement and more efficient decision making, but also improves access to capital thereby reducing transaction costs. All in all, increasing boardroom centrality is likely to improve access to critical resources, build sustainable competitive advantage and support long-term value creation (Barney 1991). Therefore, we hypothesize that boardroom centrality is likely to be positively associated with firm performance in private firms.

To our knowledge, this is the first empirical study on boardroom centrality in private firms. Studying determinants of performance in private firms is of particular relevance to the economy. Private firms represent 99% of all firms and account for 65.9% of new job creation in the US and 85% in the European Union (Airaksinen et al. 2016). Furthermore, boardroom centrality is associated with access to critical

financing resources (Broughman 2013; Javakhadze et al. 2016), which relax growth constraints and therefore, the economic value the increments in boardroom centrality can generate, are likely to be more substantial for private than public firms (Becchetti and Trovato 2002). We construct a boardroom network using directorship interlocks in small and medium private enterprises operating in Finland and Sweden.

Finland and Sweden provide intriguing data for the study of the centrality-performance relation.[2] The foundation for this rests on the comprehensive mandatory public disclosure. Private firms are required to file financial statements and information on board members and executives in the national trade registers with public access. Such data is extremely difficult to obtain from the United States, where private firms are not subject to public disclosure. In Finland and Sweden, the relatively high taxation, tax-driven financial reporting of private firms, low threshold for statutory audits, and extremely low ratio of gray economy to GDP mitigate the concerns that central boards would systematically and materially inflate or deflate their reported performance. Overall, Swedish and Finnish data provide extensive mapping of information routes, i.e. board interlocks, and high-quality disclosure of firm performance. This enables accurate estimation of centrality-performance relation in private firms.

We use Bureau van Dijk's Orbis database to get director-level as well as accounting information for our sample. Orbis provides data on boards with unique identification numbers for each director, appointment, resignation, and validity dates, as well as an indicator whether the director is current or previous. We use this information to construct a boardroom network comprised of 107,022 unique directors belonging to 34,019 unique Finnish and Swedish firms. For network construction, we include both public and private firms in our analysis. Following studies on network theory of social capital (N. Lin 1999), we use four distinct but related measures of board centrality. We calculate degree, closeness,

[2] Granular and high-quality Nordic data is previously used in studying firm performance and board structure (Eisenberg et al. 1998), dividend-based earnings management (Kasanen et al. 1996), and determinants of foreign currency denominated debt (Keloharju and Niskanen 2001). These studies also show that results obtained from using Nordic data are largely generalizable.

and eigenvector centrality, and aggregate dyadic constraint, which Horton et al. (2012) refer to as 'brokerage position'.

DEGREE centrality measures the total number of direct linkages a firm has. Presumably, a firm is more connected if it has more channels of information. CLOSENESS centrality, on the other hand, takes into account how close a firm is to other firms. Firms with higher CLOSENESS can reach other firms easily and therefore receive information quickly and in better quality. EIGENVECTOR centrality measures not only the firm's direct connections but also the strength of its indirect connections. A firm that is connected to highly-connected firms presumably has more channels of information and communication exchange. Finally, BROKERAGE position quantifies the extent to which a firm can serve as an effective broker of information. Broker firms join other loosely-connected networks and therefore control the flow of information between firms. We create the aforementioned four measures for each firm every year. Due to the potentially high correlation between network measures and firm size, we follow Larcker et al. (2013) and create quintiles of these measures every year based on quintiles of firm size, since creating quintiles of the network measures mitigates the effects of outliers and makes interpretation of regressions easier.[3] Last, we also include NSCORE, the first principal component of the four measures of connectedness, in our analysis.

We find that well-connected firms have significantly higher future performance than less-connected ones. Specifically, well-connected firms exhibit higher one-year-ahead changes in return on assets and return on equity as well as growth in sales and assets. This association holds after controlling for the influence of industry, year, size, past sales growth and profitability, firm age, tangibility, and financial slack. Consistent with our prediction, we also find that well-connected private firms have better future sales growth than do well-connected public firms. To assess the effect of networks on performance efficiency, we use two tests. In our first test, we look at one-year-ahead changes in financial slack. We find that well-networked boards hoard less cash as compared to less-networked firms. Javakhadze and

[3] The correlations provided in Table 2 indicate that there is a lower correlation between firm size and networks. We therefore repeat our analyses without the size adjustment. Our results remain unchanged. Our results are also valid after removing the top quintile of firm size, indicating that large firms are not driving our results.

Rajkovic (2018) find similar evidence in public firms of 39 countries. Our second test uses one-year-ahead changes in sales per employee as a measure of employee productivity. We find that well-connected boards have better future changes in sales per employee than do less-connected boards. Our findings also suggest that the centrality-performance link is stronger for firms with lower leverage. Sub-sample analyses further identify circumstances where firms are likely to gain substantial benefits from director networks. Specifically, we find that networks are associated with higher future profitability in both distressed (firms with negative past performance facing adverse circumstances) and young firms (firms with high growth potential). Overall, our results support the notion that, ceteris paribus, private firms on average experience a net gain from being better connected.

A potential limitation to our study is posed by the assumption that directorship interlocks, i.e. formal networks, are the primary channels of information and resource exchange, despite the fact that managers can also have connections that are informal and not related to their profession. Although our network measures might not capture the total breadth of a director's network, there are several factors mitigating the concerns potentially raised by this. Specifically, the informal and formal networks are positively correlated (Hwang and Kim 2009) and informal ties to other organizations complement formal connections, as they can be used strategically to manage resource dependence (Westphal et al. 2006). Furthermore, the directors holding the most formal connections (i.e. board seats) can be too busy to efficiently manage a firm, which might result in weaker profitability (Fich and Shivdasani 2006; Hauser 2018). Therefore, our network measures are most likely to under-, not overestimate the boardroom centrality-performance relation.

Our findings can also have several alternative causal explanations. For instance, previous research shows that directors are attracted to, and are more likely to accept positions in better-connected boards (Masulis and Mobbs 2014). On the other hand, directors can prefer sitting on boards that are performing well. In these cases, our findings will simply reflect a match between quality directors and, as Larcker et al. (2013) refer to them, 'prestigious firms'. To mitigate these concerns of endogeneity, we perform three tests.

First, we test the positive centrality-performance link on a sub-sample of firms that have the same degree centrality in the current and previous year. Since there are no changes in their direct networks, any increase in informational networks will potentially be exogenous to these firms. We continue to document a positive centrality-performance link. This suggests that increases in future performance can be attributed to the level of connectedness of the current board. This mitigates concerns that firm prestige can lead to better connections. Second, we look at determinants of boardroom networks and find no evidence of past performance influencing a change in our network measures. In our third specification, we study a unique sample of firms that newly initiate an interlock and compare them to a set of firms that remain isolated for the entire sample period. We find that newly-interlocked firms outperform those that never form an interlock during the sample period. This further implies that firms benefit from having an extended boardroom network, and illustrates that the positive centrality-performance link is not likely to be due to endogenous matching.

We contribute to the centrality-performance literature in the following ways. First, and foremost, we provide empirical evidence of how boardroom centrality improves firm performance and efficiency in private firms – a setting never studied before. Second, we provide means to compare the dynamics of boardroom networks in private and public firms. Third, we show empirical evidence that networks are of more significance to private firms. Fourth, our institutional setting allows accurate estimation of centrality-performance relation due to comprehensive data on board interlocks and performance metrics not subject to material inflation or deflation. Finally, we extend the centrality-performance literature by providing further evidence on the impact of board connectedness as well as practical economic implications of initiating board interlocks.

The remainder of the paper is organized as follows. Section 2 presents a literature review. Section 3 describes the data and gives sample statistics on boardroom networks. Section 4 discusses our results and robustness tests. Section 5 provides alternative explanations and additional analyses. Section 6 concludes our findings.

2. Related Literature and hypotheses development

Social networks have recently started a new research avenue in corporate finance and financial accounting literature. Information is disseminated in the network of directors and executives, and it produces power and economic rents to those who can access and exploit it. The classical agency theory (Jensen and Meckling 1976) provides hypotheses for studying parties benefiting from the information disseminated in the network. Earlier applications of social networks in corporate finance focus on managerial entrenchment and monitoring of executives (El-Khatib et al. 2015; Hao et al. 2014; Horton et al. 2012). A larger strand of literature has examined how board interlocks can bring shareholders various economic benefits. Some of these studies are related to lower tax burden (Brown 2011; Brown and Drake 2014), innovation (Su et al. 2019), financing and investment (Intintoli et al. 2018), credit ratings (Benson et al. 2018), bank partnering in the syndicated loan market (Houston et al. 2018), corporate cash holdings policies (Javakhadze and Rajkovic 2018), and informed short-selling (Cheng et al. 2019). Most of these studies employ North American data on public firms. Only few studies combine social networks with performance, which according to Drucker (1954) is the ultimate test of the validity of business models.

2.1. Boardroom centrality and firm performance

Boardroom centrality can have either a positive or negative effect on performance depending on the context and sample (Cashman et al. 2012). Well-connected, but busy boards are negatively associated with performance according to studies focusing on large firms (Fich and Shivdasani 2006; Hauser 2018). However, for boards to be classified as ‘busy’, at least half of their independent directors should serve on three or more boards. According to Ferris et al. (2003) busy boards are mostly associated with large listed firms which is supported by approximately half of the multiple directorships being observed in Forbes 500 firms. They find that in Compustat firms with total assets in excess of $100 million, only 6% of directors are “busy” holding three or more board seats. In S&P 500 firms, the negative association between board busyness and performance has been attributed to inefficient monitoring (Fich and Shivdasani 2006).

On the contrary, the association of boardroom centrality and firm performance is positive in a broader sample also including non-S&P 500 firms. For instance, Horton et al. (2012) study a panel of over 4,000 UK firms and find that on average, connected boards have better future stock returns and return on assets. Similarly, studying a sample of all publicly traded companies on the NYSE, NASDAQ, and AMEX, as well as private companies with annual sales exceeding $1 billion, Larcker et al. (2013) find a positive relation between boardroom centrality and firm performance proxied with characteristic-adjusted returns, growth in return on assets and positive analyst forecast errors. The aforementioned findings on the relation of boardroom centrality and firm performance are both polarized and sample-dependent. The combination of the contradictory prior findings and the significant differences in board structure between small private and large listed firms (Linck et al. 2008) constitute the main reasons necessitating a revisit on the relation of boardroom centrality and performance in the private firm setting.

2.2. Differences in board structure between private and public firms and hypothesis development

Board structures of small and large firms are substantially different (Linck et al. 2008). Generally, the board structure is determined by balancing between the costs and benefits of monitoring and advising: monitoring limits entrenchment, while advising assists with firm development, strategy and growth (Linck et al. 2008). The demand for monitoring as a determinant of board structure is typically studied with agency theory (Bathala and Rao 1995; Boone et al. 2007; J. Li 1994). In private firms, where managerial ownership is typically higher than in other types of firms, powerful managers tend to compose a board structure that is more advantageous to themselves: consequently, outside director ownership, which is a significant determinant of board structure in large firms, is unrelated to board structure in small firms (Linck et al. 2008). Large firms have more numerous and independent boards, while firms with high growth opportunities, high R&D and high managerial ownership are associated with smaller and less independent boards (Linck et al. 2008). However, the most illustrative example of the decisive differences between private and public firm boards opens through the lens of agency theory. The fact that in contrast to public firms, the base case of zero agency costs resulting from 100% managerial ownership can be observed among private firms suggests that the main driver of new board

additions in private firms is not likely to be the need for monitoring, but rather advising and improving access to critical resources (Guney et al. 2020).

The importance of board networks is illustrated by the multitude of examples demonstrating their potential in improving private firms' access to critical resources, which typically include access to finance (Beck and Demirguc-Kunt 2006; Hutchinson and Xavier 2006), credibility Certo (2003), and means of collaboration (Barney 1991; Hessels and Parker 2013). In order to improve access to critical resources, firms can enter in formal or informal inter-firm collaborations the likelihood of which increases the higher the interdependence of the companies. According to the resource dependence theory, managers cope with such inter-organizational dependence and environmental uncertainty by attempting to reduce other's power on them and if possible, gain power over the other (Finkelstein 1997; Pfeffer and Gerald 1978).

Hence, board structure can be seen as a rational response to the changing conditions of the external environment (Linck et al. 2008). Director appointments are not exogenous of firm operations, but reflections of shocks that change the optimal number of directors (Harris and Raviv 2008). Consequently, board size and composition are systematically related to the needs of the organizations' environment and firms not adjusting to such needs have suboptimal performance (Pfeffer and Gerald 1978). In comparison to public firms, private firms face more serious growth constraints related to critical resources such as financing, management expertise and qualified personnel (Hessels and Parker 2013). For instance, their access to external finance is more limited (Beck and Demirguc-Kunt 2006; Hutchinson and Xavier 2006), which is illustrated by creditors requiring more collateral and covenants, and charging higher price on debt for private firms (Ackert et al. 2007). Additions to the board can improve access to finance. For instance, in startup firms increasing boardroom centrality by appointing independent directors can serve as an important mechanism balancing power between the entrepreneur and investors thereby improving access to finance (Broughman 2013). Similarly, in a country with bank-dominated financial markets, a bank officer may be one of the early additions to the board for a growing private firm (Eisenberg et al. 1998).

Prestigious well-connected boards can increase firm credibility and organizational legitimacy of young firms. Building on signaling theory, Certo (2003) finds that prestigious boards can improve IPO performance. In order to increase credibility, firms can seek to appoint outside CEOs to their boards (i.e. certification hypothesis) typically from firms, which are geographically close and have similar financial and investment policies, and comparable governance (Fahlenbrach et al. 2010). According to the certification hypothesis, a successful recruitment of such a CEO to the board demonstrates to external parties that a business leader considerate of her reputation thinks highly enough of the firm to join its board. Moreover, the certification effect might exist even though the director was too busy to actively contribute in the board: the appointment might still serve as a quality stamp for the firm thus securing its current value (Fahlenbrach et al. 2010).

Board interlocks represent a formal collaboration channel between companies. It is true that firms may choose to collaborate informally without sharing a directorship interlock. However, informal international collaborations are associated with a significant and negative effect on sales growth consistent with the notion that the effectiveness of internationalization is likely to be undermined in informal connections, which might not provide adequate protection against opportunistic behavior by collaborators or information spillovers to rival firms (Hessels and Parker 2013). Therefore, consistent with the resource dependence theory, more predictable power structure of formal firm collaboration e.g. via M&As, joint ventures and supply chain management are likely to secure the supply of critical resources and thereby build sustainable competitive advantage supporting long-term value creation (Barney 1991).

Resource dependence is associated with M&As (Finkelstein 1997). Board interlocks significantly increase the likelihood of takeover transactions and are also associated with a shorter duration of the negotiations (Renneboog and Zhao 2014). The enhanced knowledge and information advantage supported by shared directors can also increase the quality and potential synergies of the M&A transaction between the two firms. For example, in a sample of 1664 acquisitions of listed US firms 1996-2008, the average acquirer abnormal return from two days before to two days after the acquisition

announcement was 0,12% in transactions with a directorship interlock and -2.34% in non-connected transactions (Cai and Sevilir 2012).

Joint ventures represent a less intensive form of collaboration compared to mergers, but they are still associated with significant benefits. Networks help private firms to achieve competitive advantage (Barney 1991; Hessels and Parker 2013) through organizing and sharing interdependent actions which facilitates greater value creation than in the absence of such relationship development (Holm et al. 1999). Cooperation raises the value of business relationships, where especially commitment contributes to profitability (Holm et al. 1996). In fact, L. Li et al. (2018) find that alliances matter more than in-house resources for firm performance. For instance, cooperative strategies enriching knowledge base about export markets can be associated with higher performance (Haahti et al. 2005). Similarly, close inter-firm partnerships with the members of supply chain experience significantly higher growth rates (Wynarczyk and Watson 2005).

Collectively the aforementioned studies suggest that boardroom centrality is likely to be extremely beneficial especially during the early life cycle of a growth-oriented firm. Specifically, it can improve access to critical resources such as advisory, certification, legitimacy and strategic partnerships, and relax financing constraints, which is likely to contribute to firm performance. Consistent with independent directors having a positive effect on firm performance in private firms (Arosa et al. 2010) we formulate the following hypothesis with respect to boardroom centrality:

> *H1: Boardroom centrality is positively associated with firm performance in private firms.*

Board networks are likely to contribute to firm growth by facilitating access to advisory, attracting business partners and investors, and improving access to financing. The advisory and information benefits of networks are demonstrated in their contribution to venture capital firms' performance, measured as the proportion of investments that are successfully exited through an IPO or a sale to another company (Hochberg et al. 2007). Networks are also associated with venture capital investments (Noyes et al. 2014), superior investment fund performance (Rossi et al. 2018) and with the location of

foreign direct investment (Chen and Chen 1998). In the private firm setting, close inter-firm partnerships with the members of supply chain are associated with significantly higher growth rates (Wynarczyk and Watson 2005). Similarly, well-connected directors may function as a source of country-specific knowledge, which assists in boosting sales growth (Hernández and Nieto 2016). Despite the multitude of their potential benefits, the strongest channel through which boardroom centrality contributes to firm growth is likely to be the relaxation of the most typical growth constraint of private firms, i.e. limited access to finance (Beck and Demirguc-Kunt 2006; Broughman 2013; Eisenberg et al. 1998; Hutchinson and Xavier 2006; Javakhadze et al. 2016; Javakhadze and Rajkovic 2018). These arguments are summarized in the hypothesis below:

H2: Boardroom centrality is positively associated with growth in private firms.

For private firms, sales growth is not independent from the initial firm size. Specifically, Becchetti and Trovato (2002) reject the Gibrat's Law - i.e. independence of firm growth from its initial size – and show that in addition to firm size and age, limited access to financing is negatively and significantly related to firm growth. They demonstrate that uncertainty avoidance (see, Hofstede 1980), which is likely to be high in our sample countries, is associated with reduced access to financing. Boardroom centrality has the potential to relax the aforementioned financing related growth constraints of young and financially constrained firms. This is likely to happen through reduction of information asymmetries (Park et al. 2020) with certification benefits (Fahlenbrach et al. 2010), increases in diversity and experience of board directors (Barroso-Castro et al. 2020; Meoli et al. 2019) and through the direct contacts to financing organizations, which may contribute to firm growth by relaxing the financing related growth constraints (Javakhadze et al. 2016). Hence, our third hypothesis predicts that boardroom centrality is associated with higher sales growth in private firms:

H3: In comparison to public firms, boardroom centrality is associated with higher sales growth in private firms.

Boardroom centrality assists firms in operating more efficiently with less financial buffer and slack resources. Specifically, boardroom centrality relaxes the critical growth constraint of private firms i.e.

access to external finance, which reduces sensitivity of investment to internal finance (Javakhadze et al. 2016). Similarly, Chuluun et al. (2017) find that for well-connected firms innovation activities are associated with lower bond yield spreads and uncertainty. Trust from the financiers allows firms to operate with lower cash buffer and less slack resources. Slack represents potentially utilizable resources that can be directed for the achievement of organizational goals (George 2005). Organizations use both financial and social slack to improve performance (Daniel et al. 2004). Financial slack is a predictor of risk-taking (Wiseman and Bromiley 1996). For example the dot-com bubble (1999-2002) and financial crisis of 2008 decreased risk-taking proxied with investment in growth options and innovation. Subsequently, this was accompanied with accumulation of cash buffer, which demonstrates that especially cash and cash equivalents are used to finance growth options and R&D (Jalilvand and Kim 2013). Collectively, the aforementioned studies suggest that better access to external financing allows firms to seize growth opportunities and operate more efficiently with less financial buffer and slack resources. We express these arguments in the following hypothesis:

H4: Boardroom centrality is associated with lower slack.

Boardroom centrality has also potential to positively influence employee productivity. This can happen for example through advising, facilitating IT-investments and improving access to higher quality workers. Specifically, skilled labor is one of the most important resources in building competitive advantage (Barney 1991) and hence a potential growth constraint for private firms (Hessels and Parker 2013). According to the upper echelon theory (Hambrick and Mason 1984) organizational outcomes are to a large extent influenced by the characteristics of the top management. This implies that success in attracting high quality directors can have a positive impact on the efficiency of the whole organization. Manello et al. (2020) find that firms with female senior managers actively participating in business alliance networks are associated with higher performance efficiency. Building on the upper echelon theory Chuang et al. (2009) find that top managers' age and education average are associated with the extent of IT adoption. This supports the idea of nominating directors that can identify IT investments necessary to maintain market position and improve efficiency. Among private firms, those growing and becoming international may be able to offer more attractive jobs and hence attract more

skilled labor (Gomez-Mejia 1988). Collectively, boardroom centrality improves access to high quality workers, facilitates internationalization, IT investments, and supports internationalization (Hernández and Nieto 2016). This is likely to translate into a central position in the global value chains thereby contributing to productivity and growth of smaller firms (Criscuolo and Timmis 2018). Consequently, we formulate the following hypothesis:

H5: Boardroom centrality is associated with higher employee productivity.

3. Data and sample selection

3.1. Construction and description of boardroom network

We obtain our sample from Bureau van Dijk's Orbis database, which is the data resource on private companies. Orbis contains financial and corporate structure information for over 300 million companies worldwide.[4] It provides data on boards with unique identification numbers for each director, appointment, resignation, and validity dates, as well as an indicator whether the director is current or previous.[5] We use this information to construct a data set comprised of 107,022 unique directors belonging to 34,019 unique Finnish and Swedish firms. For network construction, we include both public and private firms.[6] Our final sample is comprised of 515,927 director-year observations for the period 2012-2017. Using this data, we construct an undirected and unweighted network for each board based on their shared directorates.[7]

Studying the centrality-performance relation requires comprehensive mapping of information routes, i.e. board interlocks and reliable performance disclosure. Such data on private firms is extremely difficult to obtain from the United States where private firms are not subject to public disclosure. However, suitable data for examining the centrality-performance relation can be found from the Nordic

[4] Studies have used Orbis to assess the relationship between ownership and bank versus public debt (C. Lin et al. 2013), public tax return disclosure (Hoopes et al. 2018), firm listing status (Bartholdy and Olson 2017), family-firm performance (Zhou et al. 2017) and measurement of the value of intangibles (Clausen and Hirth 2016), among others.

[5] Orbis has higher data updating frequency than databases used in previous studies. The updating frequency for Finland is twice a month and weekly for Sweden. Orbis also follows all registered companies in Finland without restrictions on sector or area as well as directly verifies the accuracy of information provided from the company itself every year provided that it has more than nine employees.

[6] Excluding public firms from the sample would make our network incomplete and therefore affect the performance-centrality relationship.

[7] Definitions of undirected, unweighted and shared directorates are provided in Larcker et al. (2013).

countries of Finland and Sweden, where public and extensive disclosure is mandatory also for private firms.[8] Specifically, in these countries financial statement, board member, and CEO information for private companies is publicly available. No limited liability company is exempt from disclosure, not even the non-operating firms. Furthermore, several country characteristics in Finland and Sweden suggest that the publicly available financial statements are likely to reflect the true economic performance. First, the thresholds for statutory audits are among the lowest in the European Union (Morand and Joëlle Le Vourc'h 2011). Second, due to book-tax conformity, financial statements reported to tax authorities are largely similar to those reported to investors (Hung 2000). Third, the centrality-performance relation is not likely to be inflated by income-increasing earnings management (Chiu et al. 2013), because of the relatively high corporate taxation and the fact that the financial accounting of private firms is rather tax than capital market driven (Ball and Shivakumar 2005). Fourth, neither is the centrality-performance relation likely to be deflated by income-decreasing (illegal) earnings management (Brown and Drake 2014), since the ratios of grey economy to GDP in Finland and Sweden are among the lowest in the world (Cobham and Janský 2018). Hence, Finnish and Swedish data enables accurate estimation of centrality-performance relation in private firms.

On average, we have 31,128 firms and 82,178 directors per year in our sample for construction of the network measures. A very high percentage of firms in our sample, between 62.60 to 69.86 percent are isolated i.e. they have no boardroom interlocks with other firms. Given our sample of mostly small and medium-sized firms, the higher percentage of isolated firms is not surprising. Larcker et al. (2013) find that between 23 to 27 percent of US public firms are isolated, too. On average, connected firms have at least two first-degree links where first-degree links are defined as two companies sharing at least one director. We provide additional sample statistics in the next sections.

3.2. Network measures and firm characteristics

We employ four measures of social networks based on previous literature. Following Horton et al. (2012) and Larcker et al. (2013) we use closeness centrality, brokerage position, degree centrality, and

[8] We initially start with a sample of Nordic firms but drop Danish firms due to financial data unavailability; Norwegian firms due to board-level data unavailability; and Icelandic firms due to fewer observations.

eigenvector centrality to measure board connectedness for each year. These measures are defined as follows.

DEGREE measures a firm's total number of direct connections. Presumably, a firm is more central if it possesses relatively more channels of information exchange. Degree centrality illustrates the number of first-degree linkages to outside boards. Mathematically, it can be expressed as Eq. (1). Where $u(i,k)$ represents a direct link between firm i and k.

$$\text{DEGREE}_i = \sum\nolimits_{k \neq i} u(i,k) \tag{1}$$

CLOSENESS measures the centrality of a firm by capturing how close it is to all other firms in the network. It is defined as the ratio of the number of all other firms to the sum of all the distances between the firm and all other firms. A higher measure of closeness indicates that a firm is better networked and more central. Firms with a higher closeness measure can access information quickly and more accurately than do firms with a lower closeness measure. Mathematically, the measure can be expressed as in Eq. (2).

$$\text{CLOSENESS}_i = \frac{N-1}{\sum_{k \neq i} u(i,k)} \tag{2}$$

Where $u(i,k)$ represents the number of direct and indirect ties between firm i and k. Hence, CLOSENESS is the inverse of the mean distance between firm i and any other firm reachable from it in a network of N firms.

BROKERAGE, on the other hand, captures the degree of relative informational advantage a firm has over other firms in the network. It measures the extent to which a firm can serve as a broker of information. It is based on the concept of structural holes (Burt 1995, 2005). It gives firms the informational advantage to serve as a link between disconnected or loosely connected networks, thus giving them wider and faster access to information and more control on its diffusion. Mathematically, it can be expressed as in Eq. (3) and (4).

$$\text{BROKERAGE}_i = 1 - \text{AGGREGATE DC}_i \tag{3}$$

$$\mathrm{DC} = \left(P_{ik} + \sum_{q} P_{iq} P_{qk} \right)^2, \qquad \text{for } p \neq i, k \tag{4}$$

Where the aggregate dyadic constant (Eq. (4)) measures the redundancy of a firm's ties. The proportion of firm i's relations invested in firm k is denoted by p_{ik}; the sum of products in the parenthesis is the extent of firm i's relations invested in firm q's relations, which in turn are invested in firm k. The total sum of the terms in the parenthesis is the proportion of firm i's relations that are directly or indirectly invested in its connections with firm k. Horton et al. (2012) provide an illustrative numerical example that can be used to calculate these measures.

These measures primarily capture the strength of direct connections or centrality of the nodes in a network. However, another important measure of centrality is eigenvector centrality, which not only takes into account the direct connections but also the strength of indirect connections. A firm with connections to other firms which are in turn more connected, has potentially more channels of communication. Mathematically, eigenvector centrality can be described as in Eq. (5). Where $C_E(i)$ measures the sum of all adjacent vertices' eigenvector centrality scores.

$$\mathrm{EIGENVECTOR}_i = \frac{1}{\lambda} \sum_{k=1}^{1} A_{ik}\, C_E(i) \tag{5}$$

To calculate these measures, we use Pajek – a software program that uses methods in social network analysis – and techniques illustrated in De Nooy et al. (2018).[9] Similar to Larcker et al. (2013), we create quintile ranks for each of these three network measures every year to mitigate the effects of outliers and make regression results easier to interpret. We also create a fourth measure, NSCORE, based on the first principal component score of the four network measures.

After estimating the raw network measures for each firm, we merge them with financial data from Orbis.[10] Table 1 provides summary statistics for our sample composition by year. Every year, we have

[9] To calculate eigenvector centrality we use Gephi – "an open source software for exploring and manipulating networks".
[10] Orbis also provides delisting status, and delisting and initial public offering dates, which we use to classify firms as private or public when they are delisted or go public, respectively. We also exclude all subsidiaries from our sample since their decision-making as well as flow of information and capital is potentially affected by their parent companies.

between 18,561-20,332 firms. The total number of firm-year observations equals 96,967 for our baseline analysis for the sample period of 2012-2016.[11] On average, there are 2.53 directors per firm. The number of directors increases over time. This is consistent with board's tasks becoming more complex and thus requiring more board expertise and members (Linck et al. 2008). The panel also provides information on the number and percentage of isolated firms. We find that in our final sample, we have around 69.2 percent isolated firms. Given this large number, in robustness checks, we estimate our baseline results excluding the isolated firms. We obtain qualitatively similar results. The average CLOSENESS for the connected firms is around 0.001. Connected firms, on average, are connected to at least two other firms. Average profitability is around 5.63 percent every year.[12]

Table 1, Panel B provides pooled descriptive statistics for our final sample.[13] ASSETS is a firm's total assets while SALES is a firm's total operating revenue, both in millions of euros. Our sample has a range of mostly small and medium-sized firms with a few large firms. Average (median) total assets for sample firms is €13.95 (€3.13) million.[14] Average (median) firm age is 23.65 (21.00) years. Firms have around 27.7 (19.1) percent debt ratio and 12.5 (6.3) percent cash ratio. Return on assets (ROA) is around 5.6 (3.9) percent and return on equity (ROE) around 11.9 (10.6) percent.

[Table 1 around here]

Panel C contains pooled sample averages (medians) by firm size quintiles. The network measures seem to be highly correlated with firm size. Therefore, to mitigate concerns of multi-collinearity, we follow Larcker et al. (2013) and calculate quintile ranks of network measures based on quintile ranks of firm size measured as the natural log of total assets. The difference between fifth and fourth quintile

[11] Since we use the one-year-ahead values of the dependent variable in all our specifications, we lose one year of data. The final sample size is 96,967 firm-year observations after removing all public firms and firms with missing accounting variables.
[12] One potential issue with Orbis' director level data is the non-availability of director termination date for the majority of the directors. In cases where the termination date is not available, we assume the directorship to be active. In robustness checks, we also test whether our results hold if we limit our analyses to network size computed in the last year of the sample. This enables us to reduce the effect of non-availability of archival data in potentially driving our results because Orbis' current data is the most accurate. All our inferences remain unchanged if we use this methodology. Our main results are also valid if we limit our sample to only 2016.
[13] We winsorize all continuous variables at the 1st and 99th percentile to reduce the effect of outliers.
[14] To limit the number of micro firms, we place a limit of €1 million in total assets for all sample years. Our results are also robust to strictly following the definition of small and medium-sized enterprises (SMEs) provided by the European Commission and available at https://ec.europa.eu/eurostat/web/structural-business-statistics/structural-business-statistics/sme. However, we include some micro and large firms in our final sample.

average total assets suggests that there are fewer large firms in the sample. The averages across all variables are similar indicating uniformity in the sample by size quintiles. It appears that large firms introduce skewness in the sample; however, their exclusion does not influence our results.

Table 2 provides average annual cross-sectional correlations. The network measures seem to be correlated with each other and with firm size. Larcker et al. (2013) suggest that the high correlation between firm size and network measures can prove problematic. Therefore, they form quintiles of centrality measures based on firm size quintiles in order to avoid creating another proxy for firm size. As a result, the correlation between size and centrality measures drops further. Unlike in Larcker et al. (2013) though, the correlation between centrality measures increases after making the adjustment for size. Therefore, in robustness checks, we repeat our analysis without making the firm size adjustment. Our results remain qualitatively the same. The next section presents our main results.

[Table 2 around here]

4. Empirical analysis

4.1. Firm performance

To assess the centrality-performance relationship (*H1*), we estimate the model in Eq. (6). We follow Horton et al. (2012) and Larcker et al. (2013) and use one-year-ahead changes in return on assets (ROA) and return on equity (ROE) as our main dependent variables. Based on previous research, we include a number of control variables to isolate their effect on firm performance. More specifically, we follow Larcker et al. (2013) and Horton et al. (2012) and include firm size, firm age, leverage, and lagged performance metrics as our main control variables. Additionally, we control for cash holding to account for investment opportunities (Biddle et al. 2009; Jensen 1986). We also include industry, county, and year fixed effects. We define industries based on the Fama and French (1997) 48-industry groups using four-digit standard industry classification codes. Following Larcker et al. (2013), we also include the lagged performance metrics to control for momentum in performance. We cluster the standard errors at the firm level and report robust *t*-statistics in all our results.[15]

[15] Clustering by firm and year to account for cross-sectional and time series dependence does not alter our results.

$$PERFORM_{t+1} = \alpha + \beta_1 PERFORM_t + SIZE_t + AGE_t + \Delta SALES_t + LVG_t + SLACK_t + TANG_t + \varepsilon \qquad (6)$$

Table 3 and Table 4 present our main results. Table 3 presents results from regressing firm-specific one-year-ahead changes in ROA on the quintile ranks of four measures of board centrality. Table 4 provides the same results with the dependent variable as one-year-ahead changes in ROE. The coefficients on our four measures of network centrality as well as the average measure are positive and statistically significant at the 1% level in all our specifications. This is in line with our predictions in the first hypothesis (*H1*), private firms with more central boards outperform those with less central boards. The coefficient on lagged profitability is negative and statistically significant indicating lower persistence in performance. The coefficient on leverage is positive and statistically significant in all the models. This is consistent with Larcker (2013) and the notion that levered firms have performance metrics to meet and have better growth. Firm age is positive since private firms are more likely to perform better as they grow older. Firm size is negative since smaller firms are riskier and have larger expected returns. Profitability also seems to be negatively correlated with cash holdings. This is primarily due to inefficiency and lack of investment opportunities.

[Table 3 and 4 around here]

4.2. Firm growth

In Table 5 and Table 6, we test our second hypothesis (*H2*) by replacing changes in ROA and ROE with growth in sales and assets. We follow Campello (2006) and Cooper et al. (2008) and use growth in sales and growth in assets as measures of firm growth.[16] The coefficients on the network measures remain positive and statistically significant in all these specifications. These regression results demonstrate that better-networked firms outperform less-networked firms in terms of growth in ROA, ROE, sales, and assets and are consistent with the notion that extended boardroom networks, ceteris paribus, provide a net gain to firms. The findings are also in line with our predictions in hypothesis *H2* and the findings of

[16] Cooper et al. (2008) show that asset growth is strong predictor of stock returns in public companies. We therefore use one-year-ahead changes in assets as a measure of growth in our specifications.

Horton et al. (2012) and Larcker et al. (2013) who show that firm connectedness and board centrality positively influence future firm performance and growth in the U.K. and U.S. public firms, respectively.

[Table 5 and 6 around here]

We next test our hypothesis *H3* – that networks are more essential for growth in private firms compared to public firms, given the asymmetric information environment of private firms. To do this we interact a dummy variable, equal to one if the firm is private and zero otherwise, with the raw network measures, standardized to range between zero and one. Table 7 provides results for this test. We use one-year-ahead sales growth as a proxy for firm growth. The primary reason for using sales growth instead of other performance measures is its stronger relation with networks in practice. We believe that the net gain provided by networks is reflected quickly and more substantially in sales growth than other measures of performance such as changes in ROA. Our main variable of interest is the interaction term. The interaction terms of PRIVATE with centrality measures in Table 7 are positive and statistically significant, the only exception being the interaction with BROKERAGE measure. The results in Table 7 confirm our hypothesis (*H3*) that networks are of more significance for growth in private than public firms.

[Table 7 around here]

4.3. Networks and performance efficiency

In order to assess how board centrality influences firm efficiency (*H4* and *H5*), we use financial slack and employee productivity as our dependent variables. The results from these regressions are presented in Table 8 and Table 9. Firms that are more central hoard less cash. Javakhadze and Rajkovic (2018) find similar evidence in public firms of 39 countries. Our results also show that firms with boards that are more central have better future employee productivity. We measure employee productivity following Cronqvist et al. (2009) as sales per employee. These results are consistent with our hypotheses *H4* and *H5* and indicate that boardroom networks assist in creating opportunities and accessing information on industry trends in a timely manner, thus translating into better firm performance and efficiency.

[Table 8 and 9 around here]

4.4. Robustness checks

In this section, we examine the robustness of our results given different specifications. We first repeat our analysis for different firm age groups and different mixes of capital structure. Firms strive towards optimizing their capital structure. In doing so, they can face different challenges. For instance, firms with lower debt can encounter constraints in acquiring external financing (Beck and Demirguc-Kunt 2006). Extremely low levels of debt may also be associated with lower investment opportunities. On the other hand, highly-leveraged firms tend to face agency problems (Fama and French 1998) and bankruptcy costs (Baxter 1967; Kim 1978; Stiglitz 1969).

To tackle these challenges, the boardroom networks play a vital role. Larcker et al. (2013) provide evidence that networks are more important for certain type of firms than others. Specifically, they show that younger firms and firms in financial distress tend to benefit the most from boardroom networks and have stronger performance-centrality relationship. We provide consistent evidence in Table 10. The table presents the results of regressing one-year-ahead changes in ROA on board centrality measures in samples of young (old) and low (high) leverage firms. The first two columns indicate that younger firms benefit more from the networks. Table 10 also shows that the performance-centrality relationship is stronger when firms have lower leverage. This result is not consistent with Larcker et al. (2013) and can be attributed to the riskiness of private firms with larger debts. In untabulated results, we also find that central firms with negative growth in ROA in the current year have better future performance. These results support the notion that firms in need of resources benefit more from boardroom networks.

[Table 10 around here]

Despite including country-level fixed effects throughout, we also test whether our results are driven by country-level omitted explanatory variables by estimating profitability regressions separately for Finnish and Swedish firms. The results in Table 10 show that our findings are robust at the country level. The effect seems to be slightly more positive for Finnish firms despite the lower sample size.

Table 11 presents additional robustness results. The first two columns present results with extended windows of performance. The two results indicate that firms with larger networks seem to outperform firms with fewer networks also in the long run.[17] Column (3) presents results with two-way, firm and year clustered standard errors. The two-way clustering accounts for both cross-sectional and time-series dependence in standard errors. Our results remain statistically significant.

Since the correlation between our network measures and firm size, reported in Table 2, are not as high as those reported by Larcker et al. (2013), we repeat our analysis without the size adjustment. The results reported in column (4) indicate that our findings are robust to the size adjustment. Similarly, the percentage of isolated firms (firms with no connections) is considerably higher in our sample. We therefore, test our results after excluding the isolated firms. The results provided in column (5) of Table 11 are consistent with those in Table 3. The coefficient is positive and statistically significant at the 1% level. These robustness tests show that our results are in line with the notion that networks help in generating growth and improving profitability.

[Table 11 around here]

5. Alternative Explanations and Additional Analyses

We acknowledge that there could be several alternative causal explanations for our results. For instance, it can be argued that profitable firms attract highly networked individuals (Masulis and Mobbs 2014). This can in turn increase a firm's overall centrality. Therefore, a case for reverse causality could be made. Larcker et al. (2013) address this issue and provide some causal evidence for board centrality and future firm performance. In line with their work, we also employ certain specifications that can mitigate the endogeneity concerns and show why a case for reverse causality is weak. First, we look at centrality-performance relationship by regressing one-year-ahead changes in profitability measures on current year quintiles of centrality measures. Second, we rerun our models on a subsample of firms for which there are no changes in firm's degree centrality from the previous year. The results of these specifications are reported in Table 12. Our main findings remain unchanged signifying that future firm

[17] In untabulated results, we also run year-by-year regressions and find that our results are statistically significant in three out of five years of our sample.

performance of connected firms is higher even in the sample of firms that have no changes in board connections from the previous year. This result mitigates the concern that board prestige can attract directors since the centrality of boards remain unchanged in our specification. Therefore, improvements in future performance can be attributed to the current connectedness of the firm. Finally, in tabulated results, we assess the determinants of board networks and we find no evidence of past performance influencing future changes in boardroom networks. This result implies that the case for reverse causality is weak.

[Table 12 around here]

To further demonstrate the importance of board networks as well as its practical implications, we conduct additional analyses on newly-interlocked boards. Specifically, we study a unique sample of firms that have no board interlocks in the previous year, but establish one in the current year. We compare these firms against a group of firms that never establish an interlock during the sample period. The pooled results shown in Table 13 indicate that any change in first-degree linkages, positively influences future firm performance. Our results are consistent with the notion that initiating directorship interlocks are associated with immediate economic benefits. However, our results do not imply that non-interlocking firms should initiate an interlock to achieve better performance. As Larcker et al. (2013) point out, firms in reality face financial and non-financial constraints in initiating an interlock and the process may not be easy. Though diversity of CEO's connections creates growth opportunities (Fang et al. 2018), an increase in board diversity improves decision-making efficiency only as long the increase in diversity does not give rise to formation of subgroups, and the board is free from conflicts and acts as a cohesive group (Van Peteghem et al. 2018). Furthermore, our network measures are calculated relative to other firms and since firms almost never have any discretion on how connected other firms are, we cannot estimate the exact economic benefits a firm gets upon increasing its network.

[Table 13 around here]

We acknowledge that there are limitations to our results. To begin with, our centrality measures are subject to several theoretical assumptions on the flow of information. First, we assume that formal

boardroom networks represent the only channels of information exchange while in reality, social networks go beyond formal interlocks. Second, the measures are simple and may not necessarily reflect the complex settings in practice. For instance, information exchange might occur through indirect routes as opposed to the shortest path. The second limitation concerns the interpretation of the results and their practical implications. Except for deaths, board changes are rarely exogenous. Instead, the number of directors will typically change to a new optimum following a shock (Harris and Raviv 2008). The effects of such shocks may vary by managerial ownership, which has a non-linear relationship with firm performance (Barnhart and Rosenstein 1998; Morck et al. 2000). Hence, the unavailability of the managerial ownership data poses a potential limitation to our results. Nevertheless, our methodology is consistent with the dominant previous literature that does not control for ownership (e.g. Larcker et al. 2013). Further, a firm's centrality measures are relative to the connections of other firms over which it may not have any control. Under these circumstances, the economic benefits network extension can provide are conditional on the quality of available directors and the costs related to acquiring them. Therefore, our results do not imply that initiating or increasing board interlocks always results in economic rents. Finally, we cannot eliminate the endogeneity concerns although we provide several specifications to mitigate them.

6. Conclusion

Board centrality constitutes a nascent stream of literature in corporate finance. Studies linking boardroom centrality and firm performance have previously concentrated on public firms in common law countries (Cashman et al. 2012; Ferris et al. 2003; Fich and Shivdasani 2006; Horton et al. 2012; Larcker et al. 2013). We contribute to this strand of literature by constructing a boardroom network for private firms – a setting never explored before – and demonstrate that the centrality-performance relation is stronger in these firms than in public firms. We use data from Finland and Sweden. The institutional setting in these countries has several benefits including extensive mandatory disclosure requirements imposed on private firms as well as financial statements free from caveats present in other settings. Specifically, this institutional enables us to accurately estimate the centrality-performance relation in private firms on an annual basis. Since board's tasks have become more complex requiring

continuously more board expertise and members (Linck et al. 2008), our approach provides a significant improvement to cross-sectional surveys used recently in related private firm research (Hernández-Carrión et al. 2017; Hernández and Nieto 2016; Hessels and Parker 2013; Maseda et al. 2015).

After constructing the boardroom network, we study its influence on future firm performance and efficiency. We confirm the findings of Horton et al. (2012) and Larcker et al. (2013) and show that private firms, ceteris paribus, earn a net benefit from having an extended boardroom network. Specifically, we show that our network measures are positively correlated with one-year-ahead growth in return on assets and other performance measures. We also find that firms with central boards have better performance efficiency. These results are robust to a range of sensitivity tests. Further analyses reveal that firms benefit from networks when they need the informational resources the most.

We also explore different plausible alternative explanations for our results. In particular, we address the endogenous matching of well-connected directors with better-performing firms. We find no evidence for board prestige or reverse causality based on our specifications. We also study a group of newly-interlocked firms and find that initiating board interlocks is associated with immediate economic benefits. Collectively, our results contribute to the social networks literature, which provides a promising avenue for deepening our understanding of corporate finance and governance.

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Table 1

Sample statistics.

Panel A provides sample averages by year. Isolated firms are those that are not connected to any other firms. Description of CLOSENESS, BROKERAGE, DEGREE, and EIGENVECTOR are detailed in Section 3.2. Note that these are raw network measures. Panel B provides pooled descriptive statistics. ASSETS is a firm's total assets while SALES is a firm's total operating revenue in millions of euros. AGE is firm age in years. LVG is the firm's non-current liabilities scaled by total assets. SLACK is the firm's cash and cash equivalents divided by total assets and multiplied by 100. TANG equals the ratio of firm's tangible assets scaled by total assets. ROA is the firm's net income scaled by total assets multiplied by 100. ROE is the firm's net income scaled by total shareholder funds multiplied by 100. EMPLOYEES is a firm's total number of employees. Panel C contains pooled sample averages (medians) by firm size quintiles and panel D presents averages by industry.

Panel A: Sample averages by year

	2012	2013	2014	2015	2016	Total / Sample Mean
Number of firms	18,561	18,901	19,378	19,795	20,332	96,967
Number of directors	41,518	44,462	47,910	53,294	58,218	245,402
Isolated firms	13,526	13,405	13,479	13,323	13,325	67,058
Percent isolated firms	0.729	0.709	0.696	0.673	0.655	0.692
CLOSENESS (connected firms)	0.000	0.001	0.001	0.001	0.002	0.001
BROKERAGE (connected firms)	0.109	0.120	0.131	0.145	0.161	0.135
DEGREE (connected firms)	2.049	2.125	2.225	2.286	2.397	2.231
EIGENVECTOR (connected firms)	0.005	0.004	0.005	0.007	0.007	0.006
ASSETS	13.218	13.542	13.813	14.415	14.682	13.951
AGE	21.731	22.646	23.624	24.584	25.454	23.651
ROA	5.373	5.182	5.551	5.904	6.093	5.631

Panel B: Pooled descriptive statistics

	Observations	Mean	STDEV	P25	Median	P75
CLOSENESS	96,967	0.000	0.002	0.000	0.000	0.000
BROKERAGE	96,967	0.042	0.146	0.000	0.000	0.000
DEGREE	96,967	0.688	1.486	0.000	0.000	1.000
EIGENVECTOR	96,967	0.002	0.026	0.000	0.000	0.001
ASSETS	96,967	13.951	38.694	1.827	3.127	7.633
SALES	96,967	12.317	31.403	0.801	3.050	8.677
AGE	96,967	23.651	16.202	12.000	21.000	29.000
LVG	96,967	0.277	0.278	0.028	0.191	0.456
SLACK	96,967	12.495	15.562	1.444	6.307	17.703
TANG	96,967	0.368	0.336	0.039	0.282	0.664
ROA	96,967	5.631	9.447	0.520	3.900	9.440
ROE	96,967	11.916	34.076	1.680	10.570	23.060
EMPLOYEES	85,924	64.632	518.373	3.000	13.000	35.000

Panel C: Sample averages (medians) by firm size quintiles

	1 (Small)	2	3	4	5 (Large)
CLOSENESS	0.000	0.000	0.000	0.000	0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
BROKERAGE	0.013	0.019	0.029	0.047	0.100
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DEGREE	0.302	0.401	0.572	0.805	1.344
	(0.000)	(0.000)	(0.000)	(0.000)	(1.000)
EIGENVECTOR	0.001	0.001	0.002	0.002	0.004
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ASSETS	1.375	2.023	3.162	6.293	56.127
	(1.379)	(2.002)	(3.098)	(5.901)	(24.395)
AGE	21.883	21.983	22.525	24.011	27.765
	(20.000)	(20.000)	(20.000)	(21.000)	(22.000)
ROA	5.432	6.282	6.284	5.764	4.412
	(4.060)	(4.710)	(4.420)	(3.900)	(2.800)
Observations	19,232	19,211	19,408	19,451	19,665

Panel D: Sample averages by industry

	Obs.	CLOSE	BROKER	DEGREE	EIGEN	ASSETS	AGE	ROA
Consumer non-durables	5,504	0.000	0.031	0.492	0.001	8.362	25.029	4.813
Consumer durables	917	0.000	0.028	0.569	0.001	14.324	32.219	5.392
Manufacturing	7,803	0.000	0.030	0.551	0.001	11.971	28.263	6.398
Oil and gas	78	0.000	0.011	0.282	0.000	3.737	22.218	4.961
Business equipment	2,563	0.000	0.032	0.537	0.001	11.988	20.183	7.253
Telephone and television	277	0.002	0.125	1.292	0.001	51.238	28.430	3.978
Wholesale and retail	19,169	0.000	0.018	0.412	0.001	9.504	26.107	6.806
Healthcare and medical equip.	1,055	0.000	0.042	0.467	0.001	14.449	19.372	8.615
Utilities	1,852	0.001	0.123	1.434	0.002	40.822	26.354	1.599
All other industries	57,749	0.000	0.050	0.803	0.003	15.273	22.070	5.230

Table 2

Correlation table.

This table contains the average annual cross-sectional correlations of raw network measures and other firm fundamentals. Description of CLOSENESS, BROKERAGE, DEGREE, and EIGENVECTOR are detailed in Section 3.2. SIZE equals the natural log of total assets. SLACK is the firm's cash and cash equivalents divided by total assets multiplied by 100. ROA is the firm's net income scaled by total assets multiplied by 100. ROE is the firm's net income scaled by total shareholder funds multiplied by 100. SALES is the firm's total sales. SALES_EMP is the sales per employee. ASSETS is a firm's total assets. Δ indicates percentage change from previous year to the current year.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
[1] CLOSENESS	1.00										
[2] BROKERAGE	0.54	1.00									
[3] DEGREE	0.49	0.83	1.00								
[4] EIGENVECTOR	0.11	0.26	0.31	1.00							
[5] SIZE	0.20	0.24	0.27	0.05	1.00						
[6] SLACK	-0.02	-0.04	-0.08	-0.03	-0.12	1.00					
[7] ΔROA	0.00	0.01	0.01	-0.00	0.01	0.04	1.00				
[8] ΔROE	0.00	0.00	0.00	-0.00	0.01	0.02	0.65	1.00			
[9] ΔSALES	0.01	0.01	0.02	0.00	0.02	0.00	0.17	0.13	1.00		
[10] ΔASSETS	-0.00	-0.00	-0.00	-0.00	0.10	0.07	0.15	0.10	0.20	1.00	
[11] ΔSALES_EMP	0.01	0.01	0.02	0.02	0.01	0.00	0.22	0.15	0.74	0.14	1.00

Table 3

Boardroom centrality and changes in return on assets (ROA).

This table contains results from regressing firm-specific one-year-ahead changes in ROA (i.e. FY1 ROA minus current ROA) on the quintile ranks of four measures of board centrality. Description of CLOSENESS, BROKERAGE, DEGREE, and EIGENVECTOR are detailed in Section 3.2. NSCORE is the first principal component formed through principal component analysis of the four centrality measures. Quintile ranks are formed using the centrality measures from director information every year, where higher (lower) values are assigned a rank 5 (1). ROA is the firm's net income scaled by total assets multiplied by 100. ΔSALES equals a firm's lagged change in total operating revenue. SIZE equals the natural log of total assets. AGE equals the natural log of firm's age. LVG is the firm's non-current liabilities scaled by total assets. SLACK is the firm's cash and cash equivalents divided by total assets. TANG equals the ratio of firm's tangible assets scaled by total assets. LAG(ΔROA) equals a firm's lagged change in ROA. Industry, country, and year fixed effects are included throughout. The t-statistics based on firm cluster robust standard errors are shown in parentheses. Levels of significance are indicated by *, **, and *** for 10%, 5%, and 1%, respectively.

Dependent variable:	One-year-ahead ΔROA				
	(1)	(2)	(3)	(4)	(5)
Quintile(CLOSENESS)	0.058***				
	(3.87)				
Quintile(BROKERAGE)		0.055***			
		(2.80)			
Quintile(DEGREE)			0.057***		
			(3.78)		
Quintile(EIGENVECTOR)				0.057***	
				(3.83)	
Quintile(NSCORE)					0.055***
					(3.74)
LAG(ΔROA)	-0.395***	-0.395***	-0.395***	-0.395***	-0.395***
	(-83.56)	(-83.55)	(-83.56)	(-83.56)	(-83.56)
ΔSALES	-0.002**	-0.002**	-0.002**	-0.002**	-0.002**
	(-2.12)	(-2.12)	(-2.12)	(-2.12)	(-2.12)
SIZE	-0.300***	-0.299***	-0.299***	-0.300***	-0.299***
	(-15.72)	(-15.44)	(-15.66)	(-15.71)	(-15.68)
AGE	0.232***	0.229***	0.232***	0.232***	0.232***
	(6.66)	(6.57)	(6.66)	(6.65)	(6.64)
LVG	2.106***	2.109***	2.106***	2.106***	2.107***
	(16.32)	(16.35)	(16.32)	(16.32)	(16.33)
SLACK	-0.034***	-0.034***	-0.034***	-0.034***	-0.034***
	(-16.24)	(-16.32)	(-16.25)	(-16.24)	(-16.25)
TANG	-0.472***	-0.480***	-0.472***	-0.472***	-0.473***
	(-4.63)	(-4.71)	(-4.63)	(-4.63)	(-4.64)
Intercept	1.885***	1.926***	1.879***	1.886***	1.883***
	(9.86)	(10.09)	(9.83)	(9.87)	(9.85)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.168	0.168	0.168	0.168	0.168
Observations	96,967	96,967	96,967	96,967	96,967

Table 4

Boardroom centrality and changes in return on assets (ROE).

This table contains results from regressing firm-specific one-year-ahead changes in ROE (i.e. FY1 ROE minus current ROE) on the quintile ranks of four measures of board centrality. Description of CLOSENESS, BROKERAGE, DEGREE, and EIGENVECTOR are detailed in Section 3.2. NSCORE is the first principal component formed through principal component analysis of the four centrality measures. Quintile ranks are formed using the centrality measures from director information every year, where higher (lower) values are assigned a rank 5 (1). ROE is the firm's net income scaled by total shareholder funds multiplied by 100. ΔSALES equals a firm's lagged change in total operating revenue. SIZE equals the natural log of total assets. AGE equals the natural log of firm's age. LVG is the firm's non-current liabilities scaled by total assets. SLACK is the firm's cash and cash equivalents divided by total assets. TANG equals the ratio of firm's tangible assets scaled by total assets. LAG(ΔROE) equals a firm's lagged change in ROE. Industry, country, and year fixed effects are included throughout. The t-statistics based on firm cluster robust standard errors are shown in parentheses. Levels of significance are indicated by *, **, and *** for 10%, 5%, and 1%, respectively.

Dependent variable:	One-year-ahead ΔROE				
	(1)	(2)	(3)	(4)	(5)
Quintile(CLOSENESS)	0.196***				
	(2.92)				
Quintile(BROKERAGE)		0.250***			
		(2.63)			
Quintile(DEGREE)			0.192***		
			(2.78)		
Quintile(EIGENVECTOR)				0.195***	
				(2.94)	
Quintile(NSCORE)					0.200***
					(3.04)
LAG(ΔROE)	-0.331***	-0.331***	-0.331***	-0.331***	-0.331***
	(-48.04)	(-48.03)	(-48.04)	(-48.04)	(-48.04)
ΔSALES	-0.006***	-0.006***	-0.006***	-0.006***	-0.006***
	(-2.62)	(-2.61)	(-2.62)	(-2.62)	(-2.62)
SIZE	-0.790***	-0.800***	-0.786***	-0.790***	-0.789***
	(-9.56)	(-9.64)	(-9.54)	(-9.57)	(-9.57)
AGE	1.228***	1.226***	1.228***	1.228***	1.228***
	(7.69)	(7.67)	(7.69)	(7.69)	(7.69)
LVG	4.077***	4.084***	4.077***	4.077***	4.080***
	(6.14)	(6.16)	(6.14)	(6.14)	(6.15)
SLACK	-0.063***	-0.063***	-0.063***	-0.063***	-0.063***
	(-9.59)	(-9.65)	(-9.60)	(-9.59)	(-9.59)
TANG	0.461	0.440	0.459	0.461	0.460
	(1.02)	(0.98)	(1.02)	(1.02)	(1.02)
Intercept	1.762**	1.904**	1.743**	1.765**	1.747**
	(2.22)	(2.39)	(2.20)	(2.23)	(2.20)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.122	0.122	0.122	0.122	0.122
Observations	96,967	96,967	96,967	96,967	96,967

Table 5

Boardroom centrality and growth in sales.

This table contains results from regressing firm-specific one-year-ahead changes in sales (i.e. the difference of current and FY1 SALES scaled by current SALES) on the quintile ranks of four measures of board centrality. Description of CLOSENESS, BROKERAGE, DEGREE, and EIGENVECTOR are detailed in Section 3.2. NSCORE is the first principal component formed through principal component analysis of the four centrality measures. Quintile ranks are formed using the centrality measures from director information every year, where higher (lower) values are assigned a rank 5 (1). ΔSALES equals a firm's lagged change in total operating revenue. ROA is the firm's net income scaled by total assets multiplied by 100. SIZE equals the natural log of total assets. AGE equals the natural log of firm's age. LVG is the firm's non-current liabilities scaled by total assets. SLACK is the firm's cash and cash equivalents divided by total assets. TANG equals the ratio of firm's tangible assets scaled by total assets. Industry, country, and year fixed effects are included throughout. The t-statistics based on firm cluster robust standard errors are shown in parentheses. Levels of significance are indicated by *, **, and *** for 10%, 5%, and 1%, respectively.

Dependent variable:	One-year-ahead ΔSALES				
	(1)	(2)	(3)	(4)	(5)
Quintile(CLOSENESS)	0.295**				
	(2.57)				
Quintile(BROKERAGE)		0.322**			
		(2.07)			
Quintile(DEGREE)			0.290**		
			(2.48)		
Quintile(EIGENVECTOR)				0.306***	
				(2.68)	
Quintile(NSCORE)					0.311***
					(2.71)
LAG(ΔSALES)	-0.073***	-0.073***	-0.073***	-0.073***	-0.073***
	(-11.23)	(-11.22)	(-11.22)	(-11.23)	(-11.23)
ΔROA	-0.301***	-0.301***	-0.301***	-0.301***	-0.301***
	(-9.78)	(-9.78)	(-9.78)	(-9.78)	(-9.78)
SIZE	-0.344**	-0.346**	-0.338**	-0.347**	-0.345**
	(-2.24)	(-2.26)	(-2.20)	(-2.27)	(-2.26)
AGE	-3.059***	-3.069***	-3.059***	-3.056***	-3.057***
	(-11.21)	(-11.25)	(-11.20)	(-11.20)	(-11.20)
LVG	1.657	1.671	1.657	1.656	1.661
	(1.48)	(1.49)	(1.48)	(1.48)	(1.48)
SLACK	-0.138***	-0.138***	-0.138***	-0.138***	-0.138***
	(-10.11)	(-10.18)	(-10.11)	(-10.10)	(-10.11)
TANG	-8.827***	-8.866***	-8.829***	-8.822***	-8.825***
	(-9.54)	(-9.61)	(-9.55)	(-9.54)	(-9.55)
Intercept	23.861***	24.072***	23.832***	23.857***	23.832***
	(15.90)	(16.06)	(15.88)	(15.90)	(15.87)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.020	0.020	0.020	0.020	0.020
Observations	96,967	96,967	96,967	96,967	96,967

Table 6

Boardroom centrality and growth in assets.

This table contains results from regressing firm-specific one-year-ahead changes in assets (i.e. the difference of current and FY1 ASSETS scaled by current ASSETS) on the quintile ranks of four measures of board centrality. Description of CLOSENESS, BROKERAGE, DEGREE, and EIGENVECTOR are detailed in Section 3.2. NSCORE is the first principal component formed through principal component analysis of the four centrality measures. Quintile ranks are formed using the centrality measures from director information every year, where higher (lower) values are assigned a rank 5 (1). ΔASSETS equals a firm's lagged change in total assets. ROA is the firm's net income scaled by total assets multiplied by 100. SIZE equals the natural log of total assets. AGE equals the natural log of firm's age. LVG is the firm's non-current liabilities scaled by total assets. SLACK is the firm's cash and cash equivalents divided by total assets. TANG equals the ratio of firm's tangible assets scaled by total assets. Industry, country, and year fixed effects are included throughout. The t-statistics based on firm cluster robust standard errors are shown in parentheses. Levels of significance are indicated by *, **, and *** for 10%, 5%, and 1%, respectively.

Dependent variable:	One-year-ahead ΔASSETS				
	(1)	(2)	(3)	(4)	(5)
Quintile(CLOSENESS)	0.002***				
	(3.63)				
Quintile(BROKERAGE)		0.002***			
		(2.60)			
Quintile(DEGREE)			0.002***		
			(3.56)		
Quintile(EIGENVECTOR)				0.002***	
				(3.49)	
Quintile(NSCORE)					0.002***
					(3.59)
LAG(ΔASSETS)	0.024***	0.024***	0.024***	0.024***	0.024***
	(4.91)	(4.89)	(4.91)	(4.91)	(4.91)
ΔROA	0.000	0.000	0.000	0.000	0.000
	(1.36)	(1.37)	(1.36)	(1.36)	(1.37)
SIZE	-0.005***	-0.005***	-0.005***	-0.005***	-0.005***
	(-7.77)	(-7.68)	(-7.74)	(-7.76)	(-7.76)
AGE	-0.015***	-0.015***	-0.015***	-0.015***	-0.015***
	(-13.76)	(-13.84)	(-13.76)	(-13.77)	(-13.78)
LVG	-0.052***	-0.052***	-0.052***	-0.052***	-0.052***
	(-14.36)	(-14.34)	(-14.36)	(-14.36)	(-14.35)
SLACK	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	(-3.78)	(-3.87)	(-3.78)	(-3.79)	(-3.79)
TANG	-0.003	-0.003	-0.003	-0.003	-0.003
	(-1.04)	(-1.13)	(-1.04)	(-1.05)	(-1.05)
Intercept	0.138***	0.139***	0.138***	0.138***	0.138***
	(23.60)	(23.83)	(23.56)	(23.61)	(23.58)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.018	0.018	0.018	0.018	0.018
Observations	96,967	96,967	96,967	96,967	96,967

Table 7

Boardroom centrality and growth in sales in private versus public firms.

This table contains results from regressing firm-specific one-year-ahead changes in sales (i.e. the difference of current and FY1 SALES scaled by current SALES) on the four measures of board centrality. Description of CLOSENESS, BROKERAGE, DEGREE, and EIGENVECTOR are detailed in Section 3.2. NSCORE is the first principal component formed through principal component analysis of the four centrality measures. ROA is the firm's net income scaled by total assets multiplied by 100. ΔSALES equals a firm's lagged change in total operating revenue. SIZE equals the natural log of total assets. AGE equals the natural log of firm's age. LVG is the firm's non-current liabilities scaled by total assets. SLACK is the firm's cash and cash equivalents divided by total assets. TANG equals the ratio of firm's tangible assets scaled by total assets. Industry, country, and year fixed effects are included throughout. The t-statistics based on firm cluster robust standard errors are shown in parentheses. Levels of significance are indicated by *, **, and *** for 10%, 5%, and 1%, respectively.

Dependent variable:	One-year-ahead ΔSALES				
	CLOSENESS	BROKERAGE	DEGREE	EIGENVECTOR	NSCORE
	(1)	(2)	(3)	(4)	(5)
NETWORK	-4.921	-3.025	-6.244*	-6.693*	-0.498
	(-1.54)	(-0.91)	(-1.83)	(-1.92)	(-1.60)
PRIVATE	-8.328***	-8.298***	-8.479***	-7.742***	-7.676***
	(-3.90)	(-3.31)	(-4.00)	(-4.10)	(-3.94)
NETWORK × PRIVATE	8.640**	5.551	9.129**	9.207**	0.809**
	(2.49)	(1.58)	(2.52)	(2.39)	(2.40)
LAG(ΔSALES)	-0.069***	-0.069***	-0.069***	-0.069***	-0.069***
	(-11.06)	(-11.05)	(-11.06)	(-11.06)	(-11.06)
ΔROA	-0.275***	-0.275***	-0.275***	-0.275***	-0.275***
	(-9.50)	(-9.51)	(-9.51)	(-9.51)	(-9.51)
SIZE	-0.493***	-0.501***	-0.497***	-0.457***	-0.502***
	(-3.31)	(-3.37)	(-3.30)	(-3.08)	(-3.34)
AGE	-3.429***	-3.414***	-3.396***	-3.423***	-3.402***
	(-12.83)	(-12.78)	(-12.68)	(-12.78)	(-12.72)
LVG	2.121**	2.083**	2.073*	2.092**	2.082**
	(2.00)	(1.96)	(1.95)	(1.97)	(1.96)
SLACK	-12.518***	-12.534***	-12.483***	-12.523***	-12.504***
	(-8.97)	(-8.98)	(-8.95)	(-8.98)	(-8.96)
TANG	-8.258***	-8.274***	-8.270***	-8.296***	-8.268***
	(-9.30)	(-9.34)	(-9.33)	(-9.36)	(-9.33)
Intercept	32.156***	31.815***	32.229***	31.329***	31.723***
	(11.30)	(10.33)	(11.40)	(11.71)	(11.67)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.019	0.019	0.019	0.019	0.019
Observations	102,876	102,876	102,876	102,876	102,876

Table 8

Boardroom centrality and changes in cash ratio.

This table contains results from regressing firm-specific one-year-ahead cash ratio (SLACK) on the quintile ranks of four measures of board centrality. Description of CLOSENESS, BROKERAGE, DEGREE, and EIGENVECTOR are detailed in Section 3.2. NSCORE is the first principal component formed through principal component analysis of the four centrality measures. Quintile ranks are formed using the centrality measures from director information every year, where higher (lower) values are assigned a rank 5 (1). SLACK is the firm's cash and cash equivalents divided by total assets. ROA is the firm's net income scaled by total assets multiplied by 100. ΔSALES equals a firm's lagged change in total operating revenue. SIZE equals the natural log of total assets. AGE equals the natural log of firm's age. LVG is the firm's non-current liabilities scaled by total assets. TANG equals the ratio of firm's tangible assets scaled by total assets. Industry, country, and year fixed effects are included throughout. The t-statistics based on firm cluster robust standard errors are shown in parentheses. Levels of significance are indicated by *, **, and *** for 10%, 5%, and 1%, respectively.

Dependent variable:	One-year-ahead SLACK				
	(1)	(2)	(3)	(4)	(5)
Quintile(CLOSENESS)	-0.050***				
	(-3.04)				
Quintile(BROKERAGE)		-0.057***			
		(-2.83)			
Quintile(DEGREE)			-0.052***		
			(-3.13)		
Quintile(EIGENVECTOR)				-0.050***	
				(-3.10)	
Quintile(NSCORE)					-0.048***
					(-2.93)
LAG(SLACK)	0.802***	0.802***	0.802***	0.802***	0.802***
	(222.87)	(223.01)	(222.87)	(222.86)	(222.89)
ΔROA	-0.019***	-0.019***	-0.019***	-0.019***	-0.019***
	(-4.30)	(-4.29)	(-4.30)	(-4.30)	(-4.30)
ΔSALES	-0.001*	-0.001*	-0.001*	-0.001*	-0.001*
	(-1.68)	(-1.69)	(-1.69)	(-1.68)	(-1.68)
SIZE	-0.343***	-0.342***	-0.343***	-0.342***	-0.344***
	(-16.04)	(-15.85)	(-16.05)	(-16.02)	(-16.10)
AGE	-0.028	-0.027	-0.029	-0.028	-0.028
	(-0.71)	(-0.68)	(-0.73)	(-0.72)	(-0.70)
LVG	-2.660***	-2.662***	-2.659***	-2.660***	-2.661***
	(-19.71)	(-19.72)	(-19.71)	(-19.71)	(-19.71)
TANG	-0.552***	-0.546***	-0.552***	-0.552***	-0.551***
	(-5.22)	(-5.16)	(-5.22)	(-5.22)	(-5.21)
Intercept	6.628***	6.592***	6.635***	6.628***	6.630***
	(29.44)	(29.36)	(29.46)	(29.44)	(29.44)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.690	0.690	0.690	0.690	0.690
Observations	96,967	96,967	96,967	96,967	96,967

Table 9

Boardroom centrality and changes in employee productivity.

This table contains results from regressing firm-specific one-year-ahead changes in sales per employee (i.e. the difference of current and FY1 SALES_EMP scaled by current SALES_EMP) on the quintile ranks of four measures of board centrality. Description of CLOSENESS, BROKERAGE, DEGREE, and EIGENVECTOR are detailed in Section 3.2. NSCORE is the first principal component formed through principal component analysis of the four centrality measures. Quintile ranks are formed using the centrality measures from director information every year, where higher (lower) values are assigned a rank 5 (1). SALES_EMP is a firm's total operating revenue divided by the number of employees. ROA is the firm's net income scaled by total assets multiplied by 100. ΔSALES equals a firm's lagged change in total operating revenue. SIZE equals the natural log of total assets. AGE equals the natural log of firm's age. LVG is the firm's non-current liabilities scaled by total assets. SLACK is the firm's cash and cash equivalents divided by total assets. TANG equals the ratio of firm's tangible assets scaled by total assets. Industry, country, and year fixed effects are included throughout. The t-statistics based on firm cluster robust standard errors are shown in parentheses. Levels of significance are indicated by *, **, and *** for 10%, 5%, and 1%, respectively.

Dependent variable:	One-year-ahead ΔSALES_EMP				
	(1)	(2)	(3)	(4)	(5)
Quintile(CLOSENESS)	0.197**				
	(2.14)				
Quintile(BROKERAGE)		0.310**			
		(2.45)			
Quintile(DEGREE)			0.205**		
			(2.18)		
Quintile(EIGENVECTOR)				0.199**	
				(2.18)	
Quintile(NSCORE)					0.204**
					(2.22)
LAG(ΔSALES_EMP)	-0.154***	-0.154***	-0.154***	-0.154***	-0.154***
	(-22.91)	(-22.91)	(-22.90)	(-22.91)	(-22.91)
ΔROA	-0.199***	-0.199***	-0.199***	-0.199***	-0.199***
	(-8.76)	(-8.75)	(-8.76)	(-8.76)	(-8.76)
SIZE	-0.745***	-0.761***	-0.743***	-0.746***	-0.745***
	(-6.21)	(-6.38)	(-6.20)	(-6.21)	(-6.22)
AGE	-0.653***	-0.647***	-0.652***	-0.653***	-0.652***
	(-2.99)	(-2.96)	(-2.99)	(-2.99)	(-2.99)
LVG	3.323***	3.320***	3.321***	3.322***	3.324***
	(3.64)	(3.64)	(3.64)	(3.64)	(3.64)
SLACK	-0.075***	-0.076***	-0.075***	-0.075***	-0.075***
	(-7.56)	(-7.62)	(-7.56)	(-7.56)	(-7.56)
TANG	-5.270***	-5.295***	-5.267***	-5.267***	-5.269***
	(-7.08)	(-7.15)	(-7.07)	(-7.08)	(-7.08)
Intercept	14.941***	15.026***	14.916***	14.942***	14.928***
	(12.39)	(12.48)	(12.37)	(12.39)	(12.38)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.039	0.039	0.039	0.039	0.039
Observations	73,418	73,418	73,418	73,418	73,418

Table 10

Robustness checks: network significance and country-level analysis.

This table contains robustness checks for our baseline model in Table 3. The dependent variable is one-year-ahead changes in ROA. ROA is the firm's net income scaled by total assets multiplied by 100. NSCORE is the first principal component formed through principal component analysis of the four centrality measures. Quintile ranks are formed using the centrality measures from director information every year, where higher (lower) values are assigned a rank 5 (1). Young (old) companies are defined as firms falling in the bottom two (top two) quintiles of firm age in a given year. Low (high) leverage firms are defined as firms falling in the bottom two (top two) quintiles of leverage in a given year. SLACK is the firm's cash and cash equivalents divided by total assets. ΔSALES equals a firm's lagged change in total operating revenue. SIZE equals the natural log of total assets. AGE equals the natural log of firm's age. LVG is the firm's non-current liabilities scaled by total assets. TANG equals the ratio of firm's tangible assets scaled by total assets. Industry, country, and year fixed effects are included throughout. The t-statistics based on firm cluster robust standard errors are shown in parentheses. Levels of significance are indicated by *, **, and *** for 10%, 5%, and 1%, respectively.

Dependent variable	One-year-ahead ΔROA					
	Young	Old	Low leverage	High leverage	Finland	Sweden
	(1)	(2)	(3)	(4)	(5)	(6)
Quintile(NSCORE)	0.079***	-0.005	0.088***	0.021	0.056**	0.052***
	(3.29)	(-0.22)	(2.82)	(1.13)	(2.23)	(2.88)
LAG(ΔROA)	-0.386***	-0.399***	-0.399***	-0.377***	-0.379***	-0.399***
	(-49.84)	(-54.17)	(-54.16)	(-42.57)	(-38.26)	(-74.82)
ΔSALES	-0.000	-0.003**	-0.002*	0.001	-0.003**	-0.001
	(-0.36)	(-2.32)	(-1.74)	(0.51)	(-2.09)	(-1.39)
SIZE	-0.307***	-0.274***	-0.333***	-0.235***	-0.206***	-0.339***
	(-9.10)	(-9.95)	(-7.85)	(-9.88)	(-6.87)	(-14.23)
AGE	0.221**	0.346***	0.302***	0.153***	0.153***	0.252***
	(2.17)	(3.45)	(3.94)	(3.46)	(2.59)	(5.93)
LVG	2.108***	2.083***	0.314	1.973***	1.969***	2.229***
	(10.05)	(10.51)	(0.18)	(9.35)	(10.08)	(13.74)
SLACK	-0.038***	-0.028***	-0.029***	-0.041***	-0.030***	-0.035***
	(-10.30)	(-9.22)	(-10.51)	(-7.83)	(-7.65)	(-14.45)
TANG	-0.641***	-0.392**	0.345	-0.778***	-0.043	-0.685***
	(-3.81)	(-2.53)	(1.45)	(-5.36)	(-0.28)	(-5.22)
Intercept	2.031***	1.279***	1.805***	1.833***	0.950***	2.308***
	(5.17)	(3.30)	(4.35)	(7.01)	(3.03)	(9.82)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	No	No
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.160	0.174	0.174	0.139	0.162	0.171
Observations	37,815	39,146	35,271	40,434	24,034	72,933

Table 11

Robustness checks: longer performance windows, two-way standard error clustering, network measures without size adjustment, and exclusion of isolated firms.

This table contains robustness checks for our baseline model in Table 3. In column (1) and (2) the dependent variable is two and three years of cumulative change in ROA, respectively. In all other columns, the dependent variable is one-year-ahead changes in ROA, where ROA is the firm's net income scaled by total assets multiplied by 100. NSCORE is the first principal component formed through principal component analysis of the four centrality measures. Quintile ranks are formed using the centrality measures from director information every year, where higher (lower) values are assigned a rank 5 (1). SLACK is the firm's cash and cash equivalents divided by total assets. ΔSALES equals a firm's lagged change in total operating revenue. SIZE equals the natural log of total assets. AGE equals the natural log of firm's age. LVG is the firm's non-current liabilities scaled by total assets. TANG equals the ratio of firm's tangible assets scaled by total assets. Industry, country, and year fixed effects are included throughout. The t-statistics based on firm cluster robust standard errors are shown in parentheses. In column (3), the clustering is based on both firm and year to account for both cross-sectional and time-series dependence. Levels of significance are indicated by *, **, and *** for 10%, 5%, and 1%, respectively.

Dependent variable	ROA_2	ROA_3	ROA_1	ROA_1	ROA_1
	Longer window	Longer window	Two-way clusters	Without size adjustment	Excluding isolated firms
	(1)	(2)	(3)	(4)	(5)
Quintile(NSCORE)	0.051**	0.068**	0.055**	0.054***	0.171***
	(2.09)	(1.97)	(2.93)	(3.65)	(2.80)
LAG(ΔROA)	-0.412***	-0.410***	-0.395***	-0.395***	-0.395***
	(-72.03)	(-55.10)	(-55.83)	(-83.56)	(-44.35)
ΔSALES	-0.001	-0.001	-0.002**	-0.002**	-0.001
	(-1.48)	(-0.91)	(-4.00)	(-2.12)	(-0.69)
SIZE	-0.333***	-0.275***	-0.299***	-0.305***	-0.173***
	(-10.61)	(-6.26)	(-10.74)	(-15.68)	(-5.38)
AGE	0.332***	0.410***	0.232***	0.231***	0.099*
	(5.75)	(5.05)	(8.96)	(6.62)	(1.69)
LVG	2.663***	3.199***	2.107***	2.107***	1.579***
	(13.49)	(11.58)	(17.18)	(16.33)	(7.48)
SLACK	-0.044***	-0.057***	-0.034***	-0.034***	-0.035***
	(-14.01)	(-12.40)	(-14.32)	(-16.25)	(-7.99)
TANG	-0.706***	-1.166***	-0.473*	-0.473***	-0.307*
	(-4.30)	(-4.93)	(-2.25)	(-4.63)	(-1.72)
Intercept	2.133***	1.768***	1.883***	1.935***	0.719
	(6.85)	(4.08)	(9.49)	(10.13)	(1.47)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.153	0.139	0.168	0.168	0.167
Observations	70,385	48,648	96,967	96,967	29,909

Table 12

Robustness check: addressing endogeneity concerns.

This table contains results from regressing firm-specific one-year-ahead changes in ROA (i.e. FY1 ROA minus current ROA) on the quintile ranks of measures of board centrality for firms with unchanged direct networks i.e. firms that have the same DEGREE centrality score for current and previous fiscal years. Description of CLOSENESS, BROKERAGE, DEGREE, and EIGENVECTOR are detailed in Section 3.2. NSCORE is the first principal component formed through principal component analysis of the four centrality measures. Quintile ranks are formed using the centrality measures from director information every year, where higher (lower) values are assigned a rank 5 (1). ROA is the firm's net income scaled by total assets multiplied by 100. ΔSALES equals a firm's lagged change in total operating revenue. SIZE equals the natural log of total assets. AGE equals the natural log of firm's age. LVG is the firm's non-current liabilities scaled by total assets. SLACK is the firm's cash and cash equivalents divided by total assets. TANG equals the ratio of firm's tangible assets scaled by total assets. LAG(ΔROA) equals a firm's lagged change in ROA. Industry, country, and year fixed effects are included throughout. The t-statistics based on firm cluster robust standard errors are shown in parentheses. Levels of significance are indicated by *, **, and *** for 10%, 5%, and 1%, respectively.

	One-year-ahead ΔROA				
	(1)	(2)	(3)	(4)	(5)
Quintile(CLOSENESS)	0.043**				
	(2.19)				
Quintile(BROKERAGE)		0.065**			
		(2.21)			
Quintile(DEGREE)			0.045**		
			(2.22)		
Quintile(EIGENVECTOR)				0.040**	
				(2.04)	
Quintile(NSCORE)					0.039**
					(1.97)
LAG(ΔROA)	-0.398***	-0.398***	-0.398***	-0.398***	-0.398***
	(-66.96)	(-66.95)	(-66.96)	(-66.96)	(-66.96)
ΔSALES	-0.002*	-0.002*	-0.002*	-0.002*	-0.002*
	(-1.88)	(-1.88)	(-1.88)	(-1.88)	(-1.88)
SIZE	-0.332***	-0.335***	-0.332***	-0.332***	-0.331***
	(-13.15)	(-13.12)	(-13.14)	(-13.13)	(-13.12)
AGE	0.251***	0.251***	0.251***	0.250***	0.250***
	(5.43)	(5.44)	(5.44)	(5.43)	(5.42)
LVG	2.077***	2.079***	2.077***	2.078***	2.079***
	(12.27)	(12.29)	(12.27)	(12.28)	(12.28)
SLACK	-0.035***	-0.035***	-0.035***	-0.035***	-0.035***
	(-13.20)	(-13.24)	(-13.20)	(-13.21)	(-13.21)
TANG	-0.542***	-0.547***	-0.542***	-0.542***	-0.543***
	(-4.07)	(-4.11)	(-4.07)	(-4.08)	(-4.08)
Intercept	2.332***	2.354***	2.327***	2.335***	2.333***
	(9.44)	(9.55)	(9.42)	(9.45)	(9.44)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.166	0.166	0.166	0.166	0.166
Observations	65,808	65,808	65,808	65,808	65,808

Table 13

Robustness check: future performance for newly interlocked firms.

This table contains results from regressing firm-specific one-year-ahead changes in ROA, ROE, SALES, and ASSETS on a sample of newly-interlocked and isolated firms. INTERLOCK is a dummy equal to 1 if the firm has any change in its first-degree network links after being previously isolated and 0 otherwise. First-degree links are defined as two companies sharing at least one board director. ROA is the firm's net income scaled by total assets multiplied by 100. ROE is the firm's net income scaled by total shareholder funds multiplied by 100. ΔSALES equals a firm's lagged change in total operating revenue. SIZE equals the natural log of total assets. AGE equals the natural log of firm's age. LVG is the firm's non-current liabilities scaled by total assets. SLACK is the firm's cash and cash equivalents divided by total assets. TANG equals the ratio of firm's tangible assets scaled by total assets. LAG(ΔROA) equals a firm's lagged change in ROA. LAG(ΔROE) equals a firm's lagged change in ROE. Industry, country, and year fixed effects are included throughout. The t-statistics based on firm cluster robust standard errors are shown in parentheses. Levels of significance are indicated by *, **, and *** for 10%, 5%, and 1%, respectively.

	One-year-ahead ΔROA	One-year-ahead ΔROE	One-year-ahead ΔSALES	One-year-ahead ΔASSETS
	(1)	(2)	(3)	(4)
INTERLOCK	0.430**	0.886	2.774**	2.623***
	(2.04)	(1.04)	(2.27)	(4.23)
LAG(ΔROA)	-0.401***		-0.275***	0.009
	(-61.94)		(-7.08)	(0.57)
LAG(ΔROE)		-0.341***		
		(-34.96)		
LAG(ΔSALES)	-0.002*	-0.010***	-0.094***	
	(-1.75)	(-2.88)	(-10.27)	
LAG(ΔASSETS)				-0.492***
				(-94.10)
SIZE	-0.397***	-1.032***	-0.242	-2.756***
	(-14.13)	(-9.02)	(-1.26)	(-30.10)
AGE	0.256***	1.372***	-2.622***	1.056***
	(5.07)	(6.09)	(-7.25)	(7.55)
LVG	2.354***	5.175***	2.458	-5.974***
	(12.43)	(5.27)	(1.64)	(-11.42)
SLACK	-3.410***	-7.311***	-14.948***	-7.441***
	(-12.00)	(-8.04)	(-8.84)	(-10.01)
TANG	-0.542***	-0.712	-7.628***	2.593***
	(-3.69)	(-1.14)	(-6.13)	(6.37)
Intercept	2.094***	0.725	14.890***	14.484***
	(6.79)	(0.60)	(7.62)	(15.96)
Industry Fixed Effects	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.169	0.129	0.023	0.275
Observations	52,833	51,368	52,833	52,833