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Abstract

Purpose: Corporate success depends partially on the quality of knowledge accessible to the executive board. One route of access to such knowledge is the appointment of directors who already hold directorships with prominent other corporate actors. Such director appointments provide interlocks to a corporate knowledge ecosystem (Haunschild and Beckman, 1998). The purpose of this paper is to examine how linkages between companies belonging to different sectors impact firm performance and to examine how linkages created by female directors, as opposed to male directors, shape performance.

Design/methodology/approach: This paper investigates the interlocks created between UK FTSE 350 companies from 2010 to 2018. It draws on network analysis to map the roles that male and female directors play in linking firms with varying sector classifications. The paper provides an examination of the impact of these roles on firm performance, through a panel data regression analysis.

Findings: This paper finds that there is an increase of inter-industry brokers over the period, and that men are still dominant in both the network and creating inter-industry ties amongst companies. However, the role of women in establishing these ties appears to be changing, and women are more important when it comes to create inter-industry ties among key economic sectors.

Originality: This paper provides a novel approach to examine the interplay between gendered inter (and intra) sectoral linkages and firm performance. It provides an original application of the two-mode brokerage analysis framework proposed in Jasny and Lubell (2015).

Keywords: Interlocking directorates; gender; brokerage; networks; resource dependency theory

1. Introduction

Interlocking directorates happen when a director who is affiliated with one company also sits on the board of directors of another. This is a multilevel decision involving the director who is taking a new appointment, the appointing company board, as well as all other corporations he/she is affiliated with. Over the years, interlocks are no longer seen as a controlling mechanism but as a knowledge transfer mechanism. This has been associated to resource dependency theory (Pfeffer and Salancik, 1978), where interlocks can be seen as a source of information, reducing uncertainty for companies.

We construct this work on the assumption that interlocks indeed act as transfer mechanisms between companies. We investigate the gender composition of the boards when interlocks can facilitate a knowledge transfer mechanism between companies belonging to various sectors. The study is done on UK FTSE 350 companies, and we look at their boards of directors from 2010 to 2018. The year 2010 marks an important milestone for efforts to achieve gender equality on executive boards. Following the Cadbury Report of 1992 (Cadbury, 1992), the Higgs Review (Higgs, 2003), and the Tyson Report (Tyson, 2003), highlighting underrepresentation of women in executive boards in the UK and the important contributions by women to boards, the 30% Club was established in August 2010. The 30% Club is a self-organised group campaigning for an increase in representation of women on public company boards in the UK. Since gender on the executive board is a topic of interest for this study, our data goes back to 2010, and the study focuses on the period after this intervention, the establishment of the 30% club.

To achieve the objectives of this study, we make use of Network Analysis concepts. Interlocks can be considered as evidence of inter-organisational network ties, and hence we can construct networks of directors and companies, namely interlocking directorate networks (Heemskerk *et al.*, 2016). Within these networks, we analyse the concept of brokerage. Brokerage is defined as "a relation in which one actor mediates the flow of resources or information between two other actors who are not directly linked" (Fernandez and Gould, 1994, p. 1457). Hence, we use brokerage as a means of understanding the potential of a transfer mechanism of these interlocking directorate networks between 2010 and 2018.

This paper is structured as follows: the next section provides an overview of the literature on interlocking directorates, focusing on interlocks as a transfer mechanism, the intersection of gender diversity and interlocking directorates, and the use of legislation to promote gender equality on corporate boards. This section concludes with a presentation of the hypotheses that this paper seeks to address. This is followed by a data and methods section, noting the data sources and methodology (including the model specification). A results section follows, detailing the modelling results. In addition, there is a section where we discuss making use of an alternative measure of performance, to act as a robustness check. The final section provides a conclusion, an overview of the main results and limitations, along with avenues for future research.

2. Literature review & hypotheses

Network research initially focused on examining how individuals' embeddedness can have an impact on their behaviour (Granovetter, 1985). Later on, this notion was extended to organisations, for example in the works of Burt (1982), Mizruchi (1992), and Gulati (1995). There are various social and economic relationships by which companies can be interconnected and perceived in network terms, and interlocking directorates is one example of such relationships.

2.1. Interlocks as a transfer mechanism

The research on interlocking directorates suggest different paradigms as explanations for why interlocks are created (Smith and Sarabi, 2021a). Over the years, the idea of interlocks as a controlling mechanism has changed into interlocks as a transfer mechanism. Numerous theoretical frameworks have emerged to explain the reasons behind interlocks formation: management control, financial control, class hegemony, and resource dependency (Burt, 1983; David and Westerhuis, 2014; DiMaggio and Powell, 1983; Hillman and Dalziel, 2003; Mizruchi, 1992; Selznick, 2011; Sheard, 1993, 1993; Zajac, 1988).

The formation of interlocks can be investigated within the aforementioned paradigms and from the perspective of both directors and companies. Stokman *et al.* (1988) and Zajac (1988) have both studied interlock formations from the perspective of individuals, rather than as inter-organisational relationships. Useem (1986) suggests that directors sitting on multiple boards take advantage of the "business scan"; they expand their range of relationships and experience by being on multiple boards, which in turn means more board memberships for them. As Davis (1993) states in his study, heavily interlocked directors are more prone to be chosen for new board positions. Interlocks can also be considered to reflect dense social ties among an elite; the literature suggest that as well as an inter-organisational phenomenon, interlocks can also be viewed as an interclass phenomenon, and ties created for organisational purposes can have an impact on inter-firm political unity (Mizruchi, 1989, 1992).

Focusing on inter-organisational ties, the purpose of director interlocks can be the establishment of control or coordination. Pfeffer and Salancik (1978) argue that interlocks, similar to mergers and acquisitions, are organisational strategies for managing the organisation's relationship with its environment, for instance by tackling competitive uncertainty. This avenue of research, which has

given rise to the resource dependency paradigm provides a convincing explanation why interlocks are formed (O'Hagan and Green, 2004). But there has been no definite answer for whether reducing uncertainty through interlocks means higher profits for companies. There have been suggestions that interlocks positively affect the profitability of companies (Burt, 1983; Carrington, 1981; Pennings, 1980). But the majority of studies have shown a negative correlation between the two (for example: Fligstein and Brantley, 1992). The literature suggests that these varying results are due to the different types of interlocks that are formed. For instance, Mizruchi and Stearns (1988) demonstrate that in a sample of 22 large US manufacturing companies, those with declining profits in a given year were more likely to appoint a director from a financial institution to their boards. Similar findings, in other business sectors, have been reported by Lang and Lockhart (1990) and (Richardson, 1987).

O'Hagan and Green (2004) argue that the financial control paradigm, discussed by Mintz and Schwartz (1985), should be seen as a separate branch of resource dependency. This paradigm offers more attention to financial companies, suggesting they play a more central role than others in interlocking networks.

Apart from financial resources, interlocks are also seen as opportunities for exchange of knowledge and strategy, and consequently increased knowledge of top decision makers (Beckman and Haunschild, 2002; Carpenter and Westphal, 2001; Lorsch and Young, 1990; Sanders and Tuschke, 2007; Useem, 1986).

In his research, Useem (1982: 210) reports that several directors considered their board appointments as learning tools for "top management education". Directors can also see the consequence of management decisions first hand in their monitoring roles, and hence gain knowledge on how efficient various practices are (Haunschild, 1993). Acquiring knowledge about

business practice is also facilitated through communication with other directors during meetings. The important aspect to consider here is that the information gained in this way can be highly influential as it originates from trusted sources and is more up to date, compared with information from secondary sources (Davis, 1991; Kahneman *et al.*, 1982; Useem, 1982; Weick, 1995).

Extant literature often discusses these interlocks from the resource-based perspective, examining how these interlocks act as a mechanism for knowledge and advice exchange. Furthermore, when these interlocks occur across sectors, it has been argued that this allows for a wider variety of expertise and resources to be exchange across firms. Hernández-Lara and Gonzales-Bustos (2018) investigate the relationship between interlock ties and firm innovative performance. They find a negative influence of intra-industry ties and a positive influence of extra (or inter) industry ties on innovation. Resource dependency theory argues that inter industry ties provide access to further knowledge and advice, whilst intra industry ties are more closely related to conformist behaviour within an industry.

Furthermore, intra-industry links between firms often attract increased levels of regulatory interest. For example, in the US, this has resulted in the creation of antitrust regulation regarding intra industry (or sector) regulation: the Clayton Antitrust Act of 1914. This act prevents anticompetitive behaviours, specifically prohibiting types of interlock ties (Caiazza *et al.*, 2019). It prohibits interlocking directorates ties between competing companies of a certain size. This act has been followed by several additional statuary provisions aimed at regulating interlocks in specific industries, such as banking and utilities (Baccini and Marroni, 2016). This does not mean that there is no connection between these firms, rather they may not be directly linked. Abdelbadie and Salama (2019) applied a resourced based perspective to examine the impact of indirect interlock ties on US banking practices. Indirect interlock ties are of particular importance in the US, in the

context of antitrust regulation. The European case contrasts with this, as European antitrust legislation does not directly tackle the issue of director interlocks; it does not follow the approach of the Clayton Act in the USA (Petersen, 2016). In the UK, company law is based in common law, and therefore does not regulate in detail the specific roles and structure of corporate boards; rather there is a practice of self-regulation (Johanson and Østergren, 2010).

Although the resource dependency theory is often utilised to examine director interlocks, numerous other theoretical frameworks have been utilised to better understand corporate governance and interlock patterns. For instance, agency theory has been frequently applied to explain the negative relationship between firm performance and interlockings directorates. Agency theory would suggest that director with multiple appointments are too busy to be effective monitors within the firm, rather they act as a conduit for knowledge and advice between firms (Ferris *et al.*, 2003; Kaczmarek *et al.*, 2014).

2.2. Gender diversity & interlocking directorates

What has been discussed so far, from the resource dependency paradigm and associated studies, emphasises primarily on directors and their characteristics. Their networks and connections to other directors can be seen as an attribute and the source of their information and knowledge, which they disseminate through interlocks. But we should also consider how the gender of these directors, more specifically interlocking directors, can act as an important resource which may be utilised by companies. Hence, women representation on corporate boards has become an important issue, extensively discussed by scholars (for example, see Buallay *et al.*, 2020; Burke, 1997; Burke and Mattis, 2013; Drago and Aliberti, 2019; Kirsch, 2018; Nguyen *et al.*, 2020; O'Hagan, 2017).

The literature on board gender diversity is somewhat focused on identifying barriers to the appointment of women to corporate boards (for example Burke, 1997; Singh and Vinnicombe,

2004). But a different approach is to investigate how gender diversity can contribute to board dynamics, processes, and performance, ultimately being translated into firm performance (Adams and Ferreira, 2009; Garanina and Muravyev, 2020; Green and Homroy, 2018; Gulamhussen and Santa, 2015; Isidro and Sobral, 2015; Lückerath-Rovers, 2013; Singh *et al.*, 2008). These studies have suggested that boards with more women experience more debates, and women can have significant impact on decision making processes in the boardroom. Women can also bring with them their distinct characteristics to boards which can have an impact on their interactions. For example, Hillman *et al.* (2002), in a study of US boardrooms, found that women directors tend to have higher degrees, and come from non-business backgrounds.

Ruigrok *et al.* (2007) suggest that diversity in the boardroom results in an "increased complexity" of interactions between directors, which has yet to be effectively explored in scholarly work. We focus on the role of women since they may represent an increased complexity in boardroom dynamics while their individual characteristics, qualifications, and capabilities, represent a unique resource for companies. Looking more specifically at women directors participating in interlocks and taking the resource dependency paradigm, O'Hagan (2017) suggests that women interlocks have greater impact on corporate performance than simply larger women representation on boards. This is an interesting insight which supports the idea that diversity on interlocks is also beneficial for companies.

Other areas of the literature have found no effect on performance as a result of increased female representation on boards of directors (Marinova *et al.*, 2016; Mazzotta *et al.*, 2017), or in some cases a negative impact. For instance, Smith *et al.* (2006) note that increased gender diversity on boards of directors could potentially result in an ineffective board, that takes longer to make decisions, as conflicts can occur more easily on diverse boards. This can increase coordination

costs and results in a negative impact on financial performance. Ararat and Yurtoglu (2020) find that female representation only predicts increased firm value when female directors have active roles, such as committee memberships in their study on firms in Turkey; they note that otherwise there is no evidence of an impact of female representation on firm performance.

Extant literature has also examined the demographics (nationality and business education) and behaviours of female directors compared to their male counterparts (Bennouri *et al.*, 2018), in particular in relation to risk taking behaviours (Abou-El-Sood, 2021; Belaounia *et al.*, 2020; Lenard *et al.*, 2014; Mastella *et al.*, 2021). Much of the literature suggests that female directors are more risk adverse, and less competition driven (compared to male directors), resulting in less risk-taking behaviour. This is exemplified by Kroes (2009), when she suggest that if it was Lehman Sisters instead of Lehman Brothers that the crisis would not have happened the way it did. Ryan and Haslam (2007) note that women directors often outperform male directors on tasks with increased risk. However, Croson and Gneezy (2009) argue that whilst the notion that women are more risk adverse could apply to the general population, in managerial positions, differences in risk taking behaviour are smaller and even non-existent. Zalata et al. (2019) tackle the question of whether female CEOs' risk and ethical behaviour actually differ compared to their male counterparts in a study of the US corporate system. They find that female CEOs are more risk-averse than male CEOs; yet this is not because they are more sensitive to ethical issues. Rigolini *et al.* (2021) provide a subsequent analysis of female CEO appointments; in their analysis of Norwegian firms, they find that the appointment of a female CEO, following a male CEO, tends to reduce the level of risk of the firm.

2.3. Board gender diversity & quotas

The interventions that have occurred to increase the number of women on boards and diversify the compositions of boards justify their cause by arguing that diversified boards mean better performance for companies. For example, the European Commission in its 2012 proposal for the directive set to improve gender balance in listed companies (among non-executive directors) states that: "The proposed Directive will lead to breaking down the barriers that women face when aiming for board positions and to improved corporate governance, as well as enhanced company performance." (European Commission, 2012, p. 5). Policy makers aiming for diversified boards make use of consultancy studies suggesting that companies with boardroom diversity perform better than others (Catalyst, 2007; Credit Suisse, 2012; McKinsey, 2007). But it is also suggested that addressing the question whether diversified boards improve performance needs more academic research, focusing on three issues: data limitations, selection, and casual inference (Adams, 2016).

The approach by policy makers to achieve gender diversity on boards of directors varies from country to country (Mokadem and Muwafak, 2020). There is a number of legislative approaches used by policy makers, ranging from hard binding laws, soft non-binding laws, to voluntary approaches. An example of a hard binding law to achieve a gender balance on boards is the introduction of quotas; however, quotas are often a controversial issue in many countries. One of the most prominent examples of a hard binding law was the introduction of quotas in Norway in 2003, to ensure 40% of directors on the boards of publicly listed firms are the underrepresented sex (Strøm, 2015). Non-compliance with this law would result in harsh sanctions, including heavy fines and even the dissolution of the firm. Hard binding legislative approaches can also be observed in Italy, Germany, France, and Belgium (Rebérioux and Roudaut, 2019; Seierstad and Huse, 2017).

A soft non-binding legislative approach is observed in Spain, where there are limited to no sanctions for non-compliance. Many argue that these soft law approaches lead to minimal improvement in gender diversity, and often only result in short term results (de Cabo *et al.*, 2019; Conde-Ruiz *et al.*, 2019; Piscopo and Clark Muntean, 2018).

A further approach to promote gender diversity on corporate boards is the voluntary (or self-regulation) option. For this approach governance codes, often with a comply or explain element, are utilised to promote gender diversity in the boardroom. There is often debate whether this approach can be truly effective, especially without any legislative action or enforcement (Mensi-Klarbach *et al.*, 2019). An example of an institutional environment pursuing the voluntary and self-regulation approach is the UK. Whether there are hard, soft, or voluntary measures in place to encourage gender equality depends on the institutional and cultural environment (Carrasco *et al.*, 2015).

It is important to note that the introduction of quotas in Norway was seen to result in a small selection of female directors with a high number of directorships, which have been referred to as "golden skirts" (Huse, 2012; Seierstad and Opsahl, 2011). These golden skirt directors represent busy or over boarded female directors. There has been much debate on the impact of directors that are busy or over boarded on firm performance (Cashman *et al.*, 2012; Ferris *et al.*, 2003). Many argue that directors with several appointments are ineffective having too many commitments, and that this especially impacts their monitoring role (Fich and Shivdasani, 2012; Hamdan, 2018). Others argue that whilst these busy directors are not effective monitors, they often have extensive contacts and connections, making them an excellent source of knowledge and advice on the board of directors (Field *et al.*, 2013; Harris and Shimizu, 2004).

In the UK, the regulatory body, the Financial Reporting Council (FRC), which sets the UK's Corporate Governance and Stewardship Codes is cautioning new regulations regarding over boarded directors, with the aim of encouraging these directors to resign one or more of their positions. The FRC suggests that there should be a clear justification for appointing any busy directors in the company annual report and notes that firms should carefully reflect on these types of appointments (FRC, 2018).

2.4. Hypotheses

Overall, the literature discussed clearly suggests that interlocks can be considered as a resource for companies to mitigate uncertainty. It is evident that interlocks are instrumental in providing a mechanism for transfer, whether it is for transfer of resources or knowledge. In this study, we make use of these findings of the literature, and we draw specifically on the idea that gender diversity on boards complements interlock resources. We assume here that interlocks contribute to knowledge transfer and proceed to explore changes in brokerage roles for directors on boards in inter- industry relationships.

Therefore, we derive a set of hypotheses from resource dependency theory on how firm sectoral brokerage, and more specifically gendered brokerage, may have an impact on a firm's financial performance. Resource dependency theory argues that a firm (or board) with a high level of linkages to external environments is expected to better access various resources (such as knowledge and advice) (Nicholson and Kiel, 2007). Therefore, we expect that firms that connect to other industries (an external environment) will perform better (in terms of accounting measures of performance).

Hypothesis 1: Companies holding brokerage roles linking to companies belonging to different sectoral classifications will reap performance benefits from these roles.

Whilst the relationship between female directors and performance is not clear, (as demonstrated in the extant literature), we hypothesise that female brokerage will have positive impact on firm performance. Female directors bring a different set of characteristics to the corporate board, including a different set of linkages and brokerage opportunities compared to male directors (Brown *et al.*, 2002; Singh *et al.*, 2008). Female directors contribute to board diversity, providing the board with a greater range of social capital, which can bridge the board to new resources (Booth-Bell, 2018; Larcker and Tayan, 2013; You *et al.*, 2018). Therefore, brokerage chains involving female directors (or a combination of male and female directors) have the potential to have positive consequences for firm level outcomes (Dunn, 2012; Glass and Cook, 2016).

Hypothesis 2: Gendered brokerage, specifically including female directors, will have increased performance benefits compared to male brokerage.

This hypothesis is tested by making use of a network approach, analysing the interlocking directorates network to identify the brokerage positions male and female directors hold in the UK corporate system.

3. Data & Methods

This study focuses on the case of the UK, an institutional setting that takes a voluntary non-binding approach to gender equality on boards of directors, that is very much centred on the comply or explain approach. This approach is a result of the anti-regulatory sentiments present in the UK, where there is little appetite for interventionist solutions (Doldor, 2017). In the UK, it is interest groups, researchers, and other civil society actors that play key roles in promoting gender diversity. Yet even these diversity campaigns are rarely in favour of the implementation of quotas or hard legislation (Sarabi and Smith, 2021; Seierstad *et al.*, 2017), rather the argument for gender diversity is built around the business case (rather than the ethical consideration as observed in Norway).

Civil society actors, NGOs and interest groups have been found to be key stakeholders in a range of sustainability issues, including gender diversity, and can shape firm practices in the long term (Sisaye, 2021).

In the UK, compared to other countries which have quota or legislative regimes, there are fewer female directors. Therefore, this study has the potential to inform on whether it is not the level of female directors or diversity on the board that contributes to increased performance, but the roles that female directors can potentially play in linking to new sources of knowledge, advice, and resources. This study has the potential to inform on the business case argument for increased female representation on boards of directors, in an institutional environment that takes a self-regulatory approach.

The firms included in the analysis belong to the UK FTSE 350; these are large and medium sized firms listed on the London Stock Exchange. The time period for this analysis is 2010 to 2018; 2010 represents a milestone year for gender representation on boards of directors in the UK, along with the creation of the 30% club, a self-organised interest group that campaigns for increased female representation on FTSE boards of directors. Initially the 30% club campaigned for the top 100 firms in the UK to have at least 30% female representation on its board of directors. In 2015, when this target was in sight, the group set two new objectives (Sarabi and Smith, 2021). Firstly, they expanded the 30% representation goal to the top 350 firms in the UK (the FTSE 350), moving beyond the top 100 (FTSE 100). The second goal was for 30% female representation in senior management within FTSE 100 companies aligning with recommendations set out in Davies Review. This study examines the period of 2010 to 2018, capturing the establishment of the interest group, and when it revised its campaign objectives.

The company level data is collected from a combination of Companies House (extracted programmatically in R; Smith, 2019) and Bureau van Dijk's Orbis dataset. Companies House is a British government website that provides information on the directors who sit on the boards of UK firms, such as the start and end dates of their directorships. Companies House also provides firm level data including details on the sector the firm operates in. This data is used to construct the interlocking directorate network, which is a network of directors and firms; directors are linked to firms when they sit on the firm's board of directors. If a director sits on two boards, then these firms will interlock via the director. This network is referred to as a two-mode network; this is a network with two sets of actors, where ties can only occur between sets and not within (Borgatti and Everett, 1997). Metrics derived from this network are utilised to capture the gendered brokerage of a firm, which is subsequently used in a panel data analysis to test the hypotheses presented in this paper. Gender and sector information are utilised to construct these gendered brokerage metrics, where sectors are classified according to a firm's one digit SIC code. The analysis is restricted to the main component of the interlocking directorate network over the time period; that is the firms and directors that are embedded in the largest connected part of the network. We disregard other components as disconnected firms are unable to properly hold a brokerage position. As a result, our sample consists of firms with 2169 firm-year observations.

We make use of a two-mode variant of brokerage chains to examine how firms link to other firms belonging to the same or different sector in the two-mode system. The original brokerage chains were proposed for one-mode network and were developed by Gould and Fernandez (1989); and are therefore referred to as Gould-Fernandez (GF) roles. They proposed five brokerage roles that an actor can hold in a network while linking to actors that are members of the same or different groups in directed one-mode networks: coordinator, representative, gatekeeper, itinerant, and

liaison. These are presented in figure (1), where the colours represent group membership. The GF roles have been utilised in a wide range of empirical setting to examine brokerage patterns and how actors link between and within different groups; including firm innovation performance research (Belso-Martínez *et al.*, 2015), disaster response studies (Lind *et al.*, 2008), and analysis of international trade (Smith and Sarabi, 2021b). The coordinator role captures when an actor acts as a broker within their own group, indicating that they hold a particular important role for group level coordination. The representative role captures when an actor distributes information or goods outside the group, on behalf of their group. The gatekeeper role captures when an actor distributes outside information or goods to their group. The itinerant role captures when an actor acts as an external broker to another group. The liaison role represents inter group brokerage, linking together actors belonging to different groups.

Insert Figure 1 about here.

However, as the interlocking directorate network is a two-mode network, consisting of two sets of actors (firms and directors), these brokerage roles would only tell us about the linkages between firms belong to various sector classifications, and disregard important information about the directors that link them together (including gender). Therefore we make use of the two-mode extension of the brokerage roles proposed by (Jasny and Lubell, 2015), which are presented in figure (2). The representative and gatekeeper roles are the same in an undirected case, as the only difference between the two is the direction of the ties. Therefore, there are four two-mode GF roles. In figure (2), the circles represent firms and their colours their sector. The squares represent directors, and the direction of the line the director gender. For each role, there are four combinations of directors that link together the various firms. These roles can be read from top to

bottom of the brokerage chains and include the following director configurations, male-female, female-male, female-female and male-male. There are four configurations for each brokerage role, representing various level of gender heterogeneity in the brokerage position a firm holds linking together firms belonging to different sectors. These brokerage roles are used to test the hypotheses, examining the relationship between firm performance and these types of brokerage. For instance, does male only brokerage has a stronger impact on performance, reinforcing the "old boys" network often observed in the upper echelon of management (Heemskerk and Fennema, 2009).

Insert Figure 2 about here.

Based on the topology we introduced earlier, we count the number of brokerage chains in our networks (interlocking directorate networks for years 2010 to 2018) and classify them based on the type of chain.

Aligned with the work of Jasny and Lubell (2015), we define a two-mode brokerage chain as a situation in which two companies are separated by a shortest path involving two directors and the brokering company. The number of ties between the two companies is four in this case. If the two companies are also otherwise connected through only one director and via two ties, we consider the chain a non-brokered one, and do not include it in the count. Figure (3) depicts the difference between brokered and non-brokered chains. The rationale here is that in the right-hand side structure, the companies can connect to each other via the shortest path between them, i.e., through a single director, and without needing to go through the longer path. By calculating and examining the brokerage chains in our networks, we can determine both the dominant brokerage roles of companies, and consequently sectors, for each year, as well as the diversity of associated directors.

s

Insert Figure 3 about here.

Therefore, this analysis is used to construct 16 firm level brokerage metrics (4 for each brokerage role) over the time period. These are then utilised in the panel data analysis to assess the interplay between gendered brokerage and firm performance. An accounting based measure of performance is utilised in this study, Return on Capital Employed (ROCE); an established performance metric used in the analysis of interlocking directorates and performance (Bhatt and Bhattacharya, 2015; Bischoff and Buchwald, 2018).

Additional company level data utilised in this analysis includes, number of employees, total assets, board size, and sector. Hawawini *et al.* (2003) argue that industry or sector characteristics matter more than firm specific attributes in determining performance, with the exception of dominant leaders in the industry. Number of employees and total assets allow for the control for firm size. Board size has frequently been investigated in relation to firm performance; with a selection of scholarly work suggesting that larger board have a negative impact on firm performance, as they result in poor communication and slow, ineffective decision making (Cheng, 2008; Nguyen *et al.*, 2016; Yermack, 1996). However, others argue that larger boards can offer positive performance benefits, as they are able to better undertake monitoring activities, since the board can offer a wider, more diverse range of opinions (Guest, 2009).

To test the hypotheses presented in this paper, a panel data regression analysis was undertaken, which was implemented in the "plm" R package (Croissant and Millo, 2008). In the panel data regression analysis, the dependent variable was the performance metrics, ROCE. We then specified a number of control variables; these included number of employees (EMP), firm size (as defined as the log of total assets) (ASSETS), board size (BOARD SIZE), and the sector each firm belongs

to (SECTOR). Resource dependency theory would argue that a larger board should perform better, given it will have greater opportunities to form links to critical resources (Bonn *et al.*, 2004), and potentially additional interlocking opportunities.

To test the impact of the gender brokerage roles on performance, we include the four director configurations for each GF role in a separate model. We take the lag of the brokerage role, examining the number of times a firm played a specific brokerage role in the previous year. We take the lag, as the benefits of network ties are unlikely to be instantaneous, rather it would take some time to have an effect. Additionally, using the lag of the network metrics helps alleviate potential endogeneity effects.

We therefore apply four models, taking the form:

$$ROCE_t = \alpha_0 + \alpha_1 EMP_t + \alpha_2 ASSETS_t + \alpha_3 SECTOR_t + \alpha_4 BOARD\ SIZE_t + \alpha_5 MALE - MALE\ ROLE_{t-1} + \alpha_6 FEMALE - FEMALE\ ROLE_{t-1} + \alpha_7 FEMALE - MALE\ ROLE_{t-1} + \alpha_8 MALE - FEMALE\ ROLE_{t-1} + \varepsilon$$

4. Results

Table (1) presents the descriptive statistics for the firm level attributes; this indicates high levels of variation in firm performance (ROCE). We observe less variation in firm size (as indicated by assets) and number of employees. The average board size is around 9 directors; there has been much debate regarding the ideal board size; in Spain the Olivencia code recommends boards should consist of between 5 and 15 directors (Campbell and Mínguez-Vera, 2008; Fernández- Fernández, 1999); there is no equivalent code for the UK case in relation to the ideal board size. We observe in this case, companies tend to follow this rule, with the average falling within these limits.

Insert Table 1 about here.

The distribution of the sectors among all companies recorded in our data is presented in table (2), which indicates the proportion of total firms belonging to each sector. We observe that financial sector is the most prominent; this is not surprising, given that interlocks are most prevalent amongst financial firms (Mizruchi, 1996; Shropshire, 2010). Therefore, financial firms are more likely to be present in the main component of the FTSE 350 interlock network over the time period and are potentially more likely to be involved in brokerage chains.

Insert Table 2 about here.

Figure (4) presents the number of firms from each sector holding a specific two-mode GF brokerage role for 2010, 2014 and 2018. Many scholars have noted that the characteristics of an industry or sector, influence the social responsibility of the firm (McWilliams and Siegel, 2000). King *et al.* (2002) note that the visibility of a sector can influence a firm's corporate social responsibility behaviour, given that firms operating in these sectors will be visible, and more ethical behaviours may have reputational benefits.

In figure (4) we observe that a large number of firms in the finance, insurance, and real estate sector have consistently held brokerage positions, across the various roles. Firms with a coordinator role are chiefly from the finance sector, especially in 2010; in 2014 and 2018 firms from other sectors began to hold these positions, but the majority were still from the finance sector.

For coordinator chains, the majority are male – male, however, we observe an increase in female directors' involvement in these chains in 2018. For itinerant roles, there has been an increase in the number of female-female chains over time, going from only a handful in the wholesale & retail

trade sector to a wider variety of sectors in 2010. The number of chains involving female directors had overtaken the male dominated brokerage chains by 2018, perhaps reflecting the overall trends in the FTSE 350 of increasing female representation (Sarabi and Smith, 2021). Firms belonging to finance, manufacturing (both categories), transportation, communications, electric, gas & sanitary service sectors have consistently held representative/gatekeeper roles. Similar to the patterns observed for itinerant and coordinator roles, there has been an increase in participation of female director in creating the representative/gatekeeper brokerage chains. This potentially points towards the success of interest groups (such as the 30% club) in achieving an increase in females playing key roles in the UK corporate system since 2010. For liaison role, the number of female-female chains has drastically increased from 2014 to 2018, with these frequently observed in the financial and manufacturing sectors.

Insert Figure 4 about here.

The results of the panel data analysis are presented in table (3). The chain type refers to the brokerage chain of the two-mode GF role model for each specific model, for instance in the RepGate model the Male-Male role refers to the Male-Male Representative/Gatekeeper GF role.

When implementing the model estimation, a number of robustness checks were carried out. Firstly, to check the issue of multicollinearity, we calculated the variance inflation factor (VIF) for each model. Gujarati *et al.* (2012) note that an independent variable with a VIF higher than 10 would represent a serious multicollinearity issue. Across all four models, and for all of the independent variables, the VIF was in the acceptable range (less than 2). Therefore, we are confident that our independent variables are not suffering from a serious collinearity problem. A further robustness check that was implemented was for autocorrelation. In panel data or time series analysis, (as

undertaken in this paper), there is a presupposition of the stability of the series (Hawaj and Buallay, 2021). If the time series is non-stationary, then autocorrelation can occur (Gujarati *et al.*, 2012). In order to check if there is a problem of autocorrelation in the models, the Durbin–Watson (DW) test is employed. If the DW values are within the range of 1.5 – 2.5, then this indicates that there is no autocorrelation problem that would impact the results. For the models presented in table (4) the DW values were all within the required range.

The results presented in table (3) indicate that larger firms, as defined by log of assets, are negatively associated with accounting performance (Return on Capital Employed). Board size is not significantly associated with this measure of performance. The sector classification parameters indicate whether firms belonging to the sector perform better than the baseline sector: mining and construction. These results indicate that firm belonging to the personal and supporting business service sector and to a lesser extent the wholesale and retail trade sector, perform better in terms of ROCE. The significant sector results confirm existing findings from the literature, that sector or industry groupings can impact a firm's performance levels (Moura-Leite *et al.*, 2012; Powell, 1996; Short *et al.*, 2007).

Insert Table 3 about here.

The majority of brokerage roles are non-significant, more specifically, the Representative-Gatekeeper, Itinerant, and Coordinator roles. However, after controlling for firm size, number of employees, and sector classification, the two-mode brokerage roles that have a significant impact on performance are the Liaison roles. In particular, there is a positive liaison effect on performance when there is heterogeneity in the directors creating the brokerage ties. Male-female and female-male chains have a significant and large, positive effect on performance. Whereas when a firm

plays a liaison role through same gender ties, there is a negative and (weakly) significant effect on performance. This highlights the need to examine gender patterns and provides support for hypothesis (1) presented in this study: heterogeneity in linkages has positive performance effects. This has mixed support for the second hypothesis, as male-female/female-male chains have a positive impact, indicating potential brokerage benefits of female directors on firm boards. Yet there is a negative female-female effect, suggesting that chains consisting of one gender are unlikely to bring new sources of advice and resources to a firm.

Figure (4) highlights that firms belonging to the finance, manufacturing (both categories) and transportation, communications, electric, gas & sanitary service sectors, hold more male-female and female-male liaison roles; and therefore, reap performance related benefit from these ties.

5. Alternative measure of firm performance

In order to check the robustness of the results presented in this paper, we employ the modelling approach to a further measure of firm performance, Return on Equity (ROE). A range of extant literature uses this profitability ratio as a measure of firm performance (including the works of Bennouri *et al.*, 2018; Lau, 2016; Mashayekhi and Bazaz, 2008). Table (4) presents the modelling results with ROE as the dependent variable. For the control variables, we observe that board size is non-significant, this result is in line with the findings of Zabri *et al.* (2016) in their analysis of top Malaysian firms. In this analysis, larger firms (according to assets) have a reduced ROE, as indicated by the negative and significant assets variable, this follows a similar pattern as the ROCE modelling results.

Insert Table 4 about here.

However, a clear point to note here is that the GF brokerage roles are mainly non-significant for the case of ROE, with the exception of the all-male itinerant brokerage chain, which is negative and (weakly) significant. This suggests that a firm acting as an external broker to a different sector through its male directors dampens firm performance, according to this profitability ratio. The other non-significant results suggest that the various brokerage roles do not offer a firm performance advantages in terms of ROE (both in terms of male and female chains). Detthamrong *et al.*, (2017) identify in their analysis of firms in Thailand, that the proportion of female directors on the board is not significantly associated with firm performance, as measured by ROE. The work of Watson (2007) notes in his examination of Australian firms, that network ties have a positive relationship between firm survival and growth, but not ROE. The results presented in table (4) are in line with Watson (2007). Bennouri *et al.* (2018) offers some explanation for the non-significant brokerage role results observed in table (4), and the difference between ROCE results and ROE results. They find that the effects of different types of director attributes (including gender) on different types of performance (including ROE) was not uniform. Further work could explore the impact of brokerage on other measures of firm performance, more specifically market-based measures of performance, to unpack the interplay between gender, intersectoral linkages, and firm performance.

6. Discussion & conclusion

In this paper, we proposed two hypotheses regarding the impact of gender intersectoral firm ties on performance. The first was that firms with linkages to firms belonging to different sector would benefit from such ties because of gaining access to different knowledge and resources. The second was that gendered brokerage, involving female directors would have a positive effect on firm performance. We tested these hypotheses through the use of metrics derived from social network analysis in a panel data regression, more specifically the use of two mode GF roles proposed by

(Jasny and Lubell, 2015). The results of the analysis provide support for the first hypothesis, where the only significant effects were for liaison roles, in which firms link to other firms belonging to different sectors (no intra sector linkages). When there was the presence of both male and female directors in these chains, there was a positive effect on performance, suggesting support for hypothesis 1. Furthermore, the roles with intra-sectoral ties were non-significant, indicating no significant relationship with this accounting-based measure of performance (ROCE). This provides support for the resource dependency theory hypothesis, that links to firms belonging to different sectors are more likely to bring new sources of knowledge, advice, and resources, with performance enhancing effects.

However, there is mixed support for the second hypothesis, as indicated by the brokerage chain results in the liaison model given in table (3). In the case of brokerage chains involving both male and female directors, linking to firms belonging to different sector has a positive impact on firm performance. Directors of the same gender linking to firms belonging to different sectors has a negative and weakly significant impact on performance. Haynes and Hillman (2010) note that heterogeneity in boards is key for firm development, and firm with heterogeneous boards are more likely to pursue new strategies. Our findings are in line with Haynes and Hillman (2010), where heterogeneity in brokerage chains, in terms of both industry and gender, is associated with a positive impact on firm performance. This highlights that when examining the impact of firm ties via the interlock network on performance, the characteristics of the directors, especially their gender, should not be neglected as this significantly shapes the benefits a firm reaps from these network ties. This work highlights that when examining the business case for appointing female directors to a firm, it is not only their individual characteristics that contribute to the business case, but also their network ties and potential to provide firm brokerage opportunities. This is particularly

important when considering the institutional environment of the UK, or any country which employs a voluntary approach, as the business case is often used by interest groups and other campaigners to encourage gender equality on corporate boards.

However, this pattern was only observed for the case of ROCE, and not for the profitability ratio, ROE. For ROE, there was no support for the second hypothesis, where many of the GF brokerage roles had a non-significant (or weakly significant) relationship with ROE. Future work could seek to examine if gendered brokerage has the same impact on other measures of firm performance, more specifically market-based measures of performance. A further avenue for future research would be to explore various other attributes of the directors and how their work history may shape the impact of brokerage on firm performance, rather than focusing solely on directors' gender.

Finally, the results from the ROCE models highlights a need to better understand when heterogeneity in gendered brokerage chains gives rise to an increased firm performance. This suggests there is a need to further examine heterogenous brokerage chains (male-female and female-male liaison chains) in more detail, to identify who the directors and firms are in these key positions.

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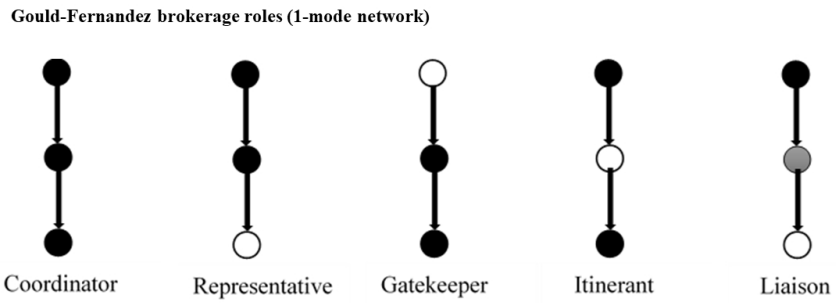

Figure 1 Gould-Fernandez brokerage role (1-mode network)

338x190mm (96 x 96 DPI)

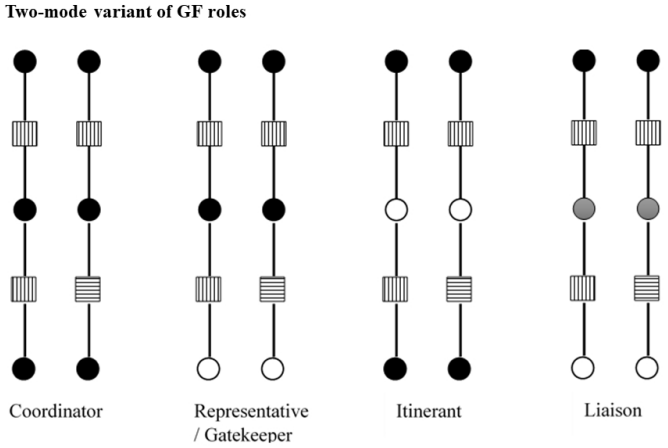

Figure 2 Two-mode variant of GF roles

338x190mm (96 x 96 DPI)

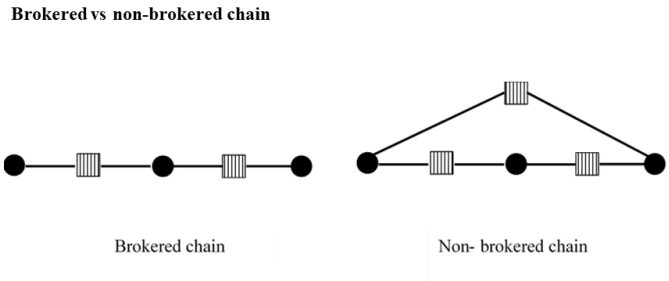

Figure 3 Brokered vs non-brokered chain

338x190mm (96 x 96 DPI)

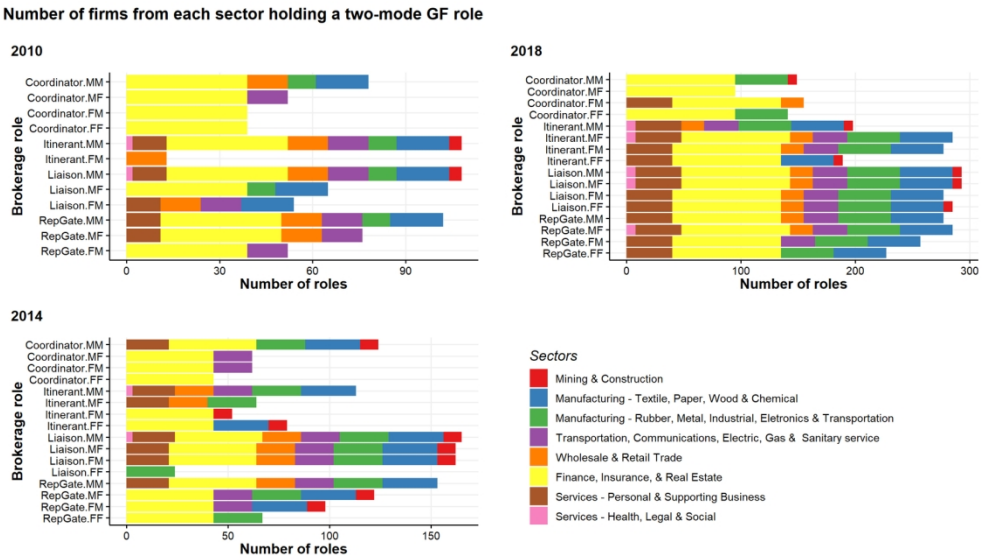

Figure 4 Number of firms from each sector holding a two-mode GF role

304x177mm (150 x 150 DPI)

TABLE 1

Table 1 Firm level descriptive statistics

Variable	N	Mean	Std. dev.	Min.	Max.
Return on Capital Employed (ROCE)	2,169	15.928	27.715	-114.74	799.75
Board Size	2,169	9.368	2.508	4	20
Assets (log)	2,169	15.432	1.775	10.879	21.606
Number of Employees (log)	2,169	9.006	1.863	1.386	13.382

TABLE 2

Table 2 Proportion of firms belonging to each sector

Sector	Proportion
Mining & Construction	6.64
Manufacturing – Textile, Paper, Wood &	13.28
Manufacturing – Rubber, Metal, Industrial, Electronics & Transportation	9.13
Transportation, Communications, Electric, Gas & Sanitary Services	10.79
Wholesale & Retail Trade	10.79
Finance, Insurance & Real Estate	33.20
Services – Personal & Supporting Business	11.20
Services – Health, Legal & Social	4.98

TABLE 3

Table 3 Model estimates (ROCE)

	RepGate	Itinerant	Coordinator	Liaison
Number of Employees (log)	-0.5831	-0.5698	-0.5915	-0.5405
	(0.4463)	(0.4459)	(0.4467)	(0.4419)
Total Assets (Log)	-1.8736***	-1.8423***	-1.8452***	-1.9019***
	(0.5121)	(0.5119)	(0.5117)	(0.5058)
Board Size	0.0065	0.0274	0.0154	-0.0133
	(0.2904)	(0.2892)	(0.2890)	(0.2865)
Sector: Manufacturing – Textile, Paper, Wood & Chemical	5.9351	6.1312	5.9899	4.8247
	(3.1582)	(3.1557)	(3.1534)	(3.1341)
Sector: Manufacturing – Rubber, Metal, Industrial, Electronics & Transportation	0.4892	0.7745	0.4399	-0.2524
	(3.4093)	(3.3916)	(3.3898)	(3.3563)
Sector: Transportation, Communications, Electric, Gas & Sanitary Services	2.5915	2.9512	2.6413	2.9823
	(3.2668)	(3.2586)	(3.2512)	(3.2197)
Sector: Wholesale & Retail Trade	6.7522*	7.0215*	6.8259*	7.0829*
	(3.3432)	(3.3474)	(3.3421)	(3.3085)
Sector: Finance, Insurance & Real Estate	2.9116	2.9616	2.7179	3.5362
	(2.8270)	(2.8175)	(2.8347)	(2.7862)
Sector: Services – Personal & Supporting Business	10.0990**	10.3501**	10.1663**	10.2913**
	(3.2847)	(3.2845)	(3.2816)	(3.2589)
Sector: Services – Health, Legal & Social	-1.7968	-1.6110	-1.7405	-1.0787
	(3.9861)	(3.9886)	(3.9859)	(3.9422)
Female-Male Role (lag 1)	-0.1885	-5.2031	-0.0020	6.5136***
	(1.9614)	(5.2846)	(1.7761)	(1.7024)
Male-Female Role (lag 1)	-0.0222	-2.9774	0.5789	10.2540***
	(2.3787)	(9.7228)	(2.8994)	(2.0068)
Male-Male Role (lag 1)	0.1266	-2.5189	1.3056	-2.0586**
	(0.9185)	(2.6232)	(1.7218)	(0.7954)
Female-Female Role (lag 1)	2.3184	3.8080	2.3322	-10.2182*
	(4.8957)	(7.9217)	(4.8031)	(4.0921)
R^2	0.0337	0.0346	0.0340	0.0560
Adj. R^2	0.0230	0.0240	0.0233	0.0456
Num. obs.	1928	1928	1928	1928

***p < 0.001; **p < 0.01; *p < 0.05

TABLE 4

Table 4 Model estimates (ROE)

	RepGate	Itinerant	Coordinator	Liaison
Number of Employees (log)	1.6658*	1.6675*	1.6428*	1.6728*
	(0.7088)	(0.7083)	(0.7100)	(0.7098)
Total Assets (Log)	-3.2117***	-3.1506***	-3.1919***	-3.1245***
	(0.8133)	(0.8130)	(0.8132)	(0.8124)
Board Size	0.6529	0.6681	0.6695	0.7359
	(0.4613)	(0.4593)	(0.4594)	(0.4603)
Sector: Manufacturing – Textile, Paper, Wood & Chemical	24.9378***	25.3509***	24.9050***	25.4404***
	(5.0160)	(5.0122)	(5.0115)	(5.0342)
Sector: Manufacturing – Rubber, Metal, Industrial, Electronics & Transportation	8.7472	8.6918	8.4463	9.0859
	(5.4149)	(5.3868)	(5.3872)	(5.3912)
Sector: Transportation, Communications, Electric, Gas & Sanitary Services	18.5488***	19.4510***	18.8222***	19.3797***
	(5.1885)	(5.1756)	(5.1670)	(5.1718)
Sector: Wholesale & Retail Trade	16.2487**	16.5417**	16.3552**	16.7613**
	(5.3099)	(5.3166)	(5.3114)	(5.3144)
Sector: Finance, Insurance & Real Estate	8.7299	8.6829	8.6646	8.7782*
	(4.4899)	(4.4750)	(4.5050)	(4.4754)
Sector: Services – Personal & Supporting Business	12.1726*	12.7491*	12.3305*	13.1966*
	(5.2169)	(5.2168)	(5.2153)	(5.2347)
Sector: Services – Health, Legal & Social	7.3704	7.8716	7.4223	7.6373
	(6.3310)	(6.3351)	(6.3346)	(6.3323)
Female-Male Role (lag 1)	4.4348	-0.1146	-0.6768	-0.5304
	(3.1151)	(8.3935)	(2.8226)	(2.7346)
Male-Female Role (lag 1)	-0.4948	-1.6826	1.5154	-0.9577
	(3.7780)	(15.4426)	(4.6078)	(3.2235)
Male-Male Role (lag 1)	-0.9525	-8.3024*	0.9877	-2.0742
	(1.4589)	(4.1664)	(2.7364)	(1.2777)
Female-Female Role (lag 1)	-1.5981	1.7493	2.9123	-2.1090
	(7.7755)	(12.5819)	(7.6332)	(6.5730)
R^2	0.0385	0.0394	0.0376	0.0392
Adj. R^2	0.0279	0.0288	0.0270	0.0286
Num. obs.	1928	1928	1928	1928

***p < 0.001; **p < 0.01; *p < 0.05