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Board capital implications in early-stage firms

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Certificate of original authorship

I, Thi Ngoc Ha Bui, declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy in the Accounting Discipline Group at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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Abstract

Board functions is a key research area within the corporate governance literature. This thesis investigates how boards discharge their duties using a homogeneous sample of Australian early-stage mining exploration entities (MEEs). The setting is ideal for identifying firm-relevant board capital and examining how such board capital is applied to facilitate boards' duties at resource-constrained and high information-asymmetry firms. Findings in this thesis show that board members can strengthen their social capital by building director networks to obtain valuable information to advise management on strategic exploration investments. Such investments improve firms' future prospects, which in turn increase investor willingness to provide financial resources. This thesis also examines board human capital, particularly the expertise of directors who have sufficiently long experience in technical roles. These technical directors are found to facilitate both investment and financing advice. The advice is enhanced when directors participate in industry associations to extend their social connections. Finally, this thesis finds that well-connected boards are better monitors of financial reporting quality, as evidenced by a lower probability of MEEs receiving a modified audit opinion (MAO). However, the enhanced public exposure associated with high-centrality boards increases specialist auditors' reputational risk, resulting in an increased likelihood of MAO being issued.

Chapter 1: Introduction

1. Background and motivation

A public company's board of directors performs two main functions – a monitoring role and an advisory role (Jensen, 1993; Adams and Ferreira, 2007; Armstrong et al., 2010). While there is extensive research examining the monitoring role in the form of board oversight, research on the board's advisory role remains limited due to the absence of meaningful measures of advising quality (Coles et al., 2020). This is partly explained by the use of heterogeneous samples of industries in prior studies which makes it difficult to identify and measure context-specific advice. To provide superior advice to management, a board needs to possess expertise and firm-specific skills (Armstrong et al., 2010). Resource dependence theory considers a board as the provider of resources to their firm (Pfeffer and Salancik, 1978), which can be in the form of social capital and human capital.

Social capital is the embedded information and resources inherent in the social relationships between individuals or groups (Nahapiet & Ghoshal, 1998). By having connections with directors of industry peer firms, the board obtains industry and technical knowledge which is relevant to strategic decision-making. Board networks also serve as a conduit for information dissemination, facilitating mutual understanding and mitigating information asymmetry between the firm and outside stakeholders. While Larcker et al. (2013) suggest that board network resources are most valuable for firms which are in need of the resources such as young and high-growth firms, the current corporate governance literature has yet thoroughly examined the associations between board networks and board functions, particularly its advisory role in the aforementioned contexts. In addition, by measuring board social capital using the number of additional directorships, prior studies have documented its negative impacts on board governance and firm performance (Fich and Shivdasani, 2006; Hauser, 2018). The adverse effects are due to director's overcommitment and thus insufficient time spent discharging their board responsibilities. Consequently, it

remains an empirical question as to *whether* and *how* board social capital facilitates advice at firms which exhibit significant demand for such a function.

Additionally, the connections formed with other boards' members increase directors' knowledge about industry trends and practices (Intintoli et al., 2018), and provide reputational incentives to ensure effective monitoring of their own firms' accounting quality (Larson, 1992). From the auditors' perspective, they may either feel obligated to reciprocate for the potential referral by well-connected directors of firms where they are currently providing auditing services, or exert more effort to protect their reputation due to the increased public scrutiny resulting from working with directors who are highly connected.

Human capital can be obtained and improved not only through networking but also from formal education and professional experience. The extant literature on directors' human capital is rich yet offers inconclusive findings. In terms of educational backgrounds, Fich (2005) finds that the market does not necessarily view directors with MBA or law degrees favourably, while Fedaseyeu et al. (2018) find that directors with higher educational attainment perform more board duties and hence receive higher remuneration. Similarly, studies on directors' experience and expertise do not offer consistent insights due to the presence of diversity that could have contrasting impacts on how directors perform their duties. Further, due to the predominant focus on cross-sectional studies that investigate functional expertise common across industries, such as accounting, finance and business knowledge, there are limited studies that examine the impact of industry-specific technical expertise.

This thesis, therefore, utilises a sample of small early-stage mining exploration entities (MEEs) to investigate the research questions for three main reasons. Firstly, from an economic perspective, the mining industry plays a significant role in the Australian

economy. According to the Minerals Council of Australia (2020), the mining sector has contributed the most to the Australian GDP growth since 2008-2009. It was the largest contributor (10.4%) of Australia's GDP between 2019 and 2020 (S&P Global Market Intelligence, 2021) and accounted for more than 60% of national exports (Australian Bureau of Statistics, 2020).

Data collection for this thesis shows mining is the largest Australian Securities Exchange (ASX) industry sector constituting approximately 30% of all listed companies. Close to 80% of listed mining companies are MEEs. These are typically junior explorers in the early exploration stage of their mining life cycle and barely generate any operating revenue. They make a significant contribution to the sector by engaging in exploration activities which help to *"maintain [Australia's] position as an internationally competitive resource investment destination [and] secure the long-term future of the resources sector"* (Industry, 2021). Their importance is recognised by the introduction of a special incentive, Junior Minerals Exploration Incentive (*JMEI*), in 2018, allowing these firms to convert tax losses into credits, which could be passed onto investors of issued equity in the form of a franking credit or refundable tax offset. The scheme helps increase investment in junior explorers and support their exploration activities. The incentive has been extended until 2025 for an additional $100 million.

Secondly, the industry focused setting has experimental benefits to draw insights that are meaningful and relevant to MEEs' unique characteristics. These entities demand significant social and human capital at the board level because they are in an early development phase and lack managerial resources for their exploration activities. Consequently, board capital will play an important and complementary role. In addition, raising capital is difficult due to high project failure rates, loss making status and moral hazard (Ferguson et al., 2011). As such, building connections with other directors in the

mining industry is an efficient and economical way that the MEE boards can help reduce information asymmetry and enhance investor awareness. Board members are paid fees to perform their duties. In the case of MEEs, such duties include significant advisory efforts, particularly around two principal activities: exploration and fund raising.

Finally, the use of a single industry offers an empirical advantage as it helps alleviate challenges of commingling in studies that examined a broad spectrum of industry sectors. In other words, the focus on a homogeneous set of entities allows the thesis to identify industry relevant insights which could be unobservable and hence omitted by cross-industry studies and to disentangle specific types of expertise represented on MEE boards. Consequently, a homogeneous sample of MEEs provides an interesting setting to examine the importance of board capital.

2. Research objectives and key findings

The thesis aims to investigate MEEs' board capital and the following specific questions:

i. Question 1: *Whether* and *how* board social capital is associated with MEEs' exploration investment and financing outcomes?

To answer this question, the thesis employs social network analysis to measure board social capital in four centrality dimensions – degree centrality, betweenness centrality, closeness centrality and eigenvector centrality. A common factor which explains variations between these key network attributes is also used to derive a composite centrality measure. The thesis shows board centrality, after controlling for the managing director (MD)'s centrality, is positively associated with future investment in exploration and evaluation assets. The thesis also demonstrates that such investment, which indicates MEEs' prospectivity, serves as a mediating factor that helps strengthen investors' confidence in these firms' future growth, resulting in a higher level of equity raisings in MEEs.

ii. Question 2: *Whether* and *how* board human capital is associated with MEEs' exploration investment and financing outcomes?

This question focuses on the internal human capital of the board, measured by board members' education, expertise and the diversity of these attributes. Key findings suggest that, after controlling for the MD's educational level, boards with higher academic qualifications are associated with greater investment in exploration assets. In terms of expertise represented on the board, the thesis shows that both financial experts and technical mining experts facilitate capital raisings. Additionally, directors with mining expertise provide MEEs with technical advice on assessing exploration investment opportunities. Further, directors with general-industry expertise are found to provide useful advice on exploration investment only. These directors do not appear to offer significant benefits when it comes to financing decisions and they are not favourably regarded by the capital markets.

With respect to diversity, this thesis documents an overall positive effect of education diversity on MEEs' investment and financing outcomes. Further, there is no evidence of a negative effect of expertise diversity as reported in other studies.

The positive impacts of board human capital documented in this thesis are facilitated through memberships of mining associations which enhance information sharing and interactions between board members and industry peers. As a result, information asymmetry is mitigated and more capital is raised from the equity market.

iii. Question 3: *Whether* board social capital is associated with audit outcomes?

This question aims to address the relation between MEE board social capital and its financial reporting quality, proxied by the likelihood of receiving a modified audit opinion (MAO). This thesis finds that MEEs with well-connected boards are less likely to receive an MAO. Board connections provide directors with valuable industry information as well as strong

reputational and reciprocal incentives to be vigilant monitors of MEEs' financial reporting practices. However, board social capital appears to have unintended consequences. Specifically, engagements with high centrality boards are perceived as risker by specialist auditors due to the enhanced public exposure and scrutiny. Consequently, these specialists are more likely to issue an MAO at MEEs that have well-connected boards.

3. Key contributions

This thesis contributes to the corporate governance literature in a number of ways. First, the thesis complements prior research on the positive associations between boardroom networks and board advising duties by investigating four different qualities of board centrality (degree, betweenness, closeness and eigenvector centrality) instead of just focusing on the number of board seats (degree centrality equivalent). The thesis also provides practical insights for boards of young early-stage firms, such as MEEs, in fulfilling their advisory responsibilities. Specifically, MEE boards can leverage their connections with other boards in the industry to acquire information at a relatively low cost rather than pay for the services of industry consultants. Further, this thesis extends prior literature by suggesting mechanisms to facilitate superior board advice. MEE boards can improve their director networks to obtain relevant industry and technical information; this makes them better equipped to advise management on future investment in exploration projects. Such strategic investments are expected to generate potential future benefits, which in turn increase investors' confidence in MEEs' prospectivity. Consequently, investors are more willing to provide financial investment.

Second, the thesis adds to the literature of board human capital by investigating board's technical expertise beyond the more transferable areas of expertise such as accounting, finance or leadership. In particular, this thesis examines the expertise of directors who have spent 10 or more years working as a geologist, mining engineer or

metallurgist in the mining sector. This classification of technical industry expertise is more specific than that used in prior studies. As discussed above, board members with general-industry expertise who work in non-technical roles in the mining industry are found to be of less importance than those with technical expertise who are able to offer both investment and financial advice.

Third, this thesis provides a direct response to the call for more research on different types of demographic diversity in a single industry or smaller firms. Baker et al. (2020) find the literature to date has primarily examined gender diversity in multi-industry settings. This thesis focuses on a single sector and investigates the associations between directors' education, expertise and diversity of human capital and investing and financing outcomes.

Fourth, the research on MEE board human capital has practical implications. The thesis shows that boards with higher qualifications and education diversity are more likely to have their members joining industry associations. Such professional networks extend the breadth of human and social capital currently represented on their board. Specifically, industry knowledge and contacts obtained through networking opportunities at industry peak bodies are valuable inputs to assess investment opportunities and facilitate external financing. In addition, MEE boards can broaden their search for potential candidates beyond the mining sector if and when they are in need of directors with common functional expertise (accounting, finance, legal or business leadership). This is because directors having both *general* knowledge of the mining industry and functional knowledge do not necessarily offer more effective advice compared to those only possessing the latter.

Finally, this thesis contributes to the growing audit literature using social network analysis by examining the effect of the networks of audit clients' boards on audit outcomes in an industry-focused setting. Additionally, the thesis extends research on client competencies, proxied by their board social capital, in enhancing financial reporting quality.

This thesis also demonstrates that a specialist auditor's perceived risk can vary depending on the client's board centrality.

4. Limitations

Findings in this thesis should be interpreted with caution due to several limitations. First, there are potential omitted variables necessary to estimate the associations between board capital and MEEs' investment and financing decisions due to the availability of data. For example, data on mineral resources and reserves may be useful to understand MEEs' project quality, availability of financing options, and their need for technical advice on exploration investments. To mitigate endogeneity issues resulting from omitted variables, this thesis employs a firm-fixed effects model, which controls for omitted time-invariant variables assuming that the estimated mineral resources and reserves are stable over time. However, if the observations do vary, fixed effects regression models are not useful to address this source of endogeneity concern. Therefore, the thesis makes a further attempt to exploit a quasi-experimental approach, by which an MEE experiences a shock to its board social capital when one of its directors loses a board seat at another entity due to mergers and acquisitions, to confirm the robustness of the key findings. The advantage of this research design is that it utilises a random event (mergers and acquisitions) to explain the exogeneous variations of the board's capital.

The second limitation relates to examining board social capital using boardroom network alone. While this approach is essential to measure comprehensive attributes of boardroom network beyond board interlocks, it precludes the consideration of other social networks of board members. The thesis partially addresses this issue in Chapter 3 where board social networks other than the boardroom connections formed through professional memberships in industry peak bodies, such as the Australian Institute of Company Directors (AICD) and the Australasian Institute of Mining and Metallurgy (AusIMM), are considered.

A common type of social connections that this thesis is unable to obtain is university connections. Though Australian listed entities may voluntarily disclose information about the universities where their directors obtained tertiary qualifications, they seldom disclose the year of graduation, impeding the ability to construct networks of university alumni for robustness analyses.

Finally, this thesis focuses on a sample of Australian early-stage exploration entities which may limit the generalisability of the documented findings to other countries or industries. However, the implications of these findings can be replicated by future research investigating entities of similar operating nature in other industries or markets. Additionally, the focus on a homogeneous setting offers empirical advantages as discussed in section 1.

5. Thesis structure

The remainder of this thesis is structured as follows. Chapter 2 provides detailed analyses of both individual qualities and a composite measure of board centrality to investigate if board social capital facilitates superior advice and if it does, how such impact is mediated. Chapter 3 studies board human capital including educational background, professional expertise, and diversity of education and expertise. In addition to investigating the links between board human capital and MEEs' investment and financing outcomes, this chapter also highlights the channel through which the positive effects of directors' education and expertise are realised. Finally, Chapter 4 examines the association between board social capital and audit outcome, measured as the likelihood of MEEs receiving an MAO. This chapter also considers the moderating effect of audit specialisation on the link between board centrality and audit quality.

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Chapter 2: Board social capital and advisory qualities

1. Introduction

A public company's board of directors performs two main functions – a monitoring role and an advisory role (Jensen, 1993; Adams and Ferreira, 2007; Linck et al., 2008; Armstrong et al., 2010; Brickley and Zimmerman, 2010; Masulis et al., 2012). While there has been significant attention to the monitoring role of boards, the advisory role of boards has received less attention in the literature (Coles et al., 2008; Faleye et al., 2013). Further, given the dual function of the board, there is an ongoing debate of whether a trade-off between these roles exists. For example, Adams and Ferreira (2007) and Harris and Raviv (2008) argue there is a trade-off due to information frictions between executives/insiders and outside directors. In contrast, Brickley and Zimmerman (2010, p. 239) suggest that monitoring and advisory roles *"are being performed simultaneously and are complementary"*. These arguments focus on the balance between board functions. Consequently, implications of prior studies may not extend to situations where differential demands exist, such as where there are limited agency concerns associated with free cash flow (Jensen, 1986), an initial public offering (IPO) setting (Field et al., 2013), or young firms (Fahlenbrach et al., 2010; Vandenbroucke et al., 2016) – all examples of firms exhibiting a greater advisory demand.

In the literature on board social capital, Intintoli et al. (2021) discuss that the impacts of the boardroom network on its advisory capability have not been thoroughly examined. Further, Larcker et al. (2013) suggest that board connections are most beneficial for firms with the greatest need for network resources, which are typically young or facing adverse circumstances, and that:

> "*[t]here may be other ways of identifying resource-starved firms that are likely to benefit especially from information and resource exchange and we believe these to be interesting questions for future research*" (p. 237).

This chapter is motivated by the lack of research on the advisory role performed by the board of directors, especially in the context where this function is most needed. Therefore, this chapter aims to examine specific ways in which the boards of small early-stage mining exploration entities (MEEs) can leverage their social capital to fulfil their advisory duties.

Board centrality, the common attribute of board social capital, is beneficial to MEEs in two main ways. First, externally acquired human capital through boardroom network – including industry trends and practices, macroeconomic policies and technical knowledge – complements MEEs' scarce internal human resources. A high-centrality board has better access to relevant industry and technical information, and hence is more equipped to provide management with insightful advice regarding an MEE's exploration portfolio which is anticipated to generate future economic benefits. Second, raising funds to advance exploration projects against the backdrop of high information asymmetry, high project failure rates, and non-revenue generating positions (Ferguson et al., 2011), is a challenging task for MEEs. Having a board made up of highly connected directors mitigates investor concerns because such directors can leverage their networks to transmit information about MEEs' operations, particularly complex non-financial information which requires technical understanding as well as time to evaluate. Taken together, boards of well-connected directors help management with exploration decisions to create geological prospectivity; further, they also play an important role in decreasing the overall information asymmetry between MEEs and the market, which is expected to bolster investor confidence and willingness to invest.

Using a sample of 4,444 firm-year observations comprising 776 unique capitalising MEEs over the 2004 to 2016 period, this chapter finds that greater board centrality facilitates more investment in exploration and evaluation assets. This chapter also shows this investment is the mediating factor indicating MEEs' viability and prospectivity, which enhances investor confidence in these firms. Consequently, a positive association between board centrality and MEEs' equity finance is observed.

This chapter contributes to the current literature in two ways. First, this chapter complements prior studies on the positive association between board centrality and its advisory duties. Field et al. (2013) find that busy directors are not detrimental but beneficial to IPOs and young S&P 1500 firms as they have experience needed to navigate situations new to the firms. Further, the authors infer that those directors who hold three or more board seats bring in more valuable connections. However, Field et al. (2013) do not directly analyse directors' boardroom network nor the consequences of their advisory activity. Similarly, Brown et al. (2019) find evidence supporting the notion that board connections provide an effective information channel which helps boards with their strategic advice; however, they only measure one aspect of network centrality which is degree centrality. This chapter most resembles the study by Intintoli et al. (2021) who provide a composite measure of board centrality based on four key centrality measures (degree, closeness, betweenness and eigenvector centrality) as well as different proxies for advisory outcomes. However, this chapter is different to Intintoli et al. (2021) in that it focuses on a sample of early-stage MEEs which have limited resources to hire a large number of board members, executives and management consultants. The industry-focused approach is ideal to examine advisory duties as board advice needs to be context-specific to be effective; this also allows advisory quality to be meaningfully captured. In the case of MEE boards, information acquisition and consulting services are generally too costly for firms to afford. As a result, this chapter

extends prior literature by suggesting a practical and economical solution for boards to increase the quality of its advice. Specifically, leveraging formal and (extended) director connections to acquire additional resources is an inexpensive solution for boards of financially constrained firms, such as MEEs, to effectively perform their advisory role.

Second, this chapter extends prior literature on board centrality by recognising their differential impacts on young firms. Larcker et al. (2013) show the association between board centrality and stock returns is most pronounced among high-growth firms as well as those facing challenging conditions. Similarly, Field et al. (2013) find that director busyness, which reflects directors' connections and experience, has positive impacts on operating performance of young S&P 1500 firms. In addition, Chen and Guay (2020) document that shareholders tend to show more support for busy directors who bring in expertise to the boards of early-stage firms. This chapter adds to this strand of research by investigating specific channels through which the boards of young firms, specifically MEEs, can add value to their focal companies. First, MEE boards can leverage their networks to obtain additional human capital, such as relevant technical and industry information, that enables them to advise management on their high-risk exploration decisions. Second, the boards can make use of their connections and share information to raise awareness of and build confidence in their firms' exploration activities. More effective investment in exploration, coupled with less information asymmetry, would enhance investor confidence and the level of investment in MEEs.

2. Literature review

2.1. Board's primary functions

The board of directors performs two primary roles – monitoring and advising. A board's monitoring role includes vigilantly scrutinising management to guard against harmful

behaviour (Linck et al., 2008). For its advisory role (or more broadly service role), the board serves as a source of "*advice and counsel*" (Adams et al., 2010) and assists management with strategic decisions and actions (Linck et al., 2008).

Extensive studies have examined the effectiveness of board oversight with a significant focus on the independent quality of the board. Weisbach (1988) argues that the board has responsibilities to evaluate executives' performance and terminate the employment of these managers if their performance fails to meet expectations. Additionally, studies show CEOs are more likely to be replaced for poor performance at outsider-dominated boards. Using the introduction of the NYSE and NASDAQ listing rules for board and committee independence as exogeneous shocks, Guo and Masulis (2015) find the sensitivity of CEO turnover to firm performance is higher at firms that adopt independent board and nomination committee as per the new exchange listing rules. Relatedly, Coles et al. (2014) find that the turnover-performance sensitivity diminishes when the proportion of co-opted directors in the board who were appointed by the CEO increases. Their results echo a prior study by Core et al. (1999) who find that co-opted directors are less independent of the CEO and less effective monitors, resulting in a higher level of CEO compensation.

Another important board monitoring responsibility is to ensure the integrity of a firm's financial reporting. However, empirical studies show mixed results. Klein (2002) finds earnings management is negatively correlated with board and audit committee independence, suggesting that board independence facilitates more effective monitoring of accounting processes. On the other hand, Larcker et al. (2007) report that their corporate governance measures (14 factors extracted from the principal component analysis of 39 individual corporate governance characteristics) show mixed association with abnormal accruals and little association with the likelihood of restatements. Making use of the NYSE

and NASDAQ's regulatory requirement on audit committee independence, Chen et al. (2015) do not find a significant reduction in earnings management following the enactment of the reform at non-compliant firms relative to other firms. However, non-compliant firms with better information acquisition experienced improvements in financial reporting quality.

On the other hand, the literature has paid less attention to the board's advisory services (Adams and Ferreira, 2007).[1] One potential explanation is that there lacks a "*simple and intuitive*" proxy to capture the advising capability of the board (Coles et al., 2020). Consequently, Coles et al. (2020) propose to use outside directors' connections as a measure of the quality of advice. Further, as firm complexity increases, the sensitivity of firm value measured by Tobin's Q and the advisory role of the board increases. This suggests that more complex firms benefit from having directors with advisory expertise on the board. Similarly, in an effort to capture the advising capacity of the board, Faleye et al. (2013) examine the presence of independent directors who serve on at least one advisory committee but do not serve on any of the monitoring committees. The authors define monitoring committees as those relating to audit, compensation, and nominating or governance committees, and define advisory committees as those relating to finance, investment, strategy, acquisitions, science and technology, and executive committees. Based on this classification, the authors find that advisory directors are associated with greater acquisition performance, higher innovation, and greater firm value.

[1] Empirical evidence from Coles et al. (2008) contributes to this limited area of research by showing that complex firms have greater demands for advisory services from the board. Similarly, Masulis et al. (2012) identify foreign independent directors as effective advisory directors given that they offer valuable advice and assistance to their US firms due to their networks of local contacts.

When both monitoring and advisory roles are considered, the focus is on how they operate, and whether they are complementary or contrary to each other. The strand of research which supports the latter view suggests that inside directors and executives may be discouraged to provide private information to the board due to the fear of increased interference and monitoring (Raheja, 2005 and Harris and Raviv, 2008). Consequently, Adams and Ferreira (2007) suggest that boards may face a trade-off between two roles and that reducing the level of monitoring intensity may improve management's trust and willingness to share information needed for strategic advice. Using archival data, Faleye et al. (2011) find that higher board monitoring impedes the ability to advise, as evidenced by poorer acquisition performance and corporate innovation.

However, Brickley and Zimmerman (2010) challenge the trade-off theory by arguing that monitoring and advisory roles are complementary as information gained from one role can assist directors to perform more effectively in the other role. Results from Kim et al. (2014) provide support for this argument by showing that outside director tenure has positive impacts on investment and acquisition outcomes, as well as CEO compensation monitoring. The underlying assumption is that if private information about the firm causes the board to trade off its two key functions, the issue can be resolved as outside director tenure increases. This is because the directors will obtain better understanding about their firms over their years of service.

2.2. Demands for board advice at early-stage firms

While much attention in the current literature focuses on how boards balance both monitoring and advising roles, there is little research on specific contexts which have a high demand for one role but not the other, such as high advisory needs of small and early-stage

firms. Linck et al. (2008) suggest that a board of directors is structured in a way which reflects the firm's monitoring and advisory needs.

For small and early-stage firms, it is argued that their demand for board monitoring is relatively minor compared to their demand for board advising. On the one hand, there are less severe agency concerns due to a greater concentration of ownership (Machold et al., 2011; Brunninge et al., 2007) and resource constraints (Brunninge et al., 2007; Zahra et al., 2006), which mitigates appropriation for private benefit (Linck et al., 2008). Further, the scrutiny of the equity market acts as an alternative monitoring mechanism when these firms return to the market for additional funding (Jensen, 1986), which happens quite frequently due to their low cash reserves. On the other hand, young firms' strategic focus is exploring growth opportunities (Agarwal & Audretsch, 2001); this requires significant board expertise to support managerial resources and experience (Zahra et al., 2006; Machold et al., 2011).

While Coles et al. (2008) find that larger firms with complex operations require more advisory services, this chapter argues that small and young firms are equally in need of board advice and counsel. It is noteworthy that the two arguments are not necessarily contradictory but rather reflect a different research focus. Coles et al. (2008) investigate the organisational complexity with regard to operations, size and external financing options, while this chapter draws attention to the scarcity of resources, particularly human and financial resources, of firms that operate in a technical and high information-asymmetry environment. First, in the case of larger firms with complex, diversified operations and more financing options available, they are able to attract and retain a larger team of executives and key management personnel. However, small firms with financial constraints cannot necessarily afford a large management team or costly external consultants, leading to a greater reliance on the board's expertise for complementary and alternative inputs to strategic and technical decisions. Consequently, Machold et al. (2011) suggest that "*boards are viewed as cooperative teams*

that contribute to firms' value creation through their strategy involvement. Each board member brings specific and firm relevant knowledge to the team" (p. 370).

Second, at earlier stages in a firm's life cycle, the ability to raise capital is critical to sustain operations. Therefore, boards play an important role to *"increase the saliency of resource acquisition and stability"* (Lynall et al., 2003, p. 423). Taken together, a board of directors provides both human and capital resources much needed by small and young firms to survive and grow. Findings in Field et al. (2013) lend support for the greater resource demand of early-stage firms. The authors find that young S&P 1500 firms greatly benefit from having busy directors who can provide valuable advice and network resources. The benefits of busy directors can outweigh the potential costs of any limitations in the time they have available. Consequently, shareholders remain supportive of busy directors' elections (Chen and Guay, 2020). Larcker et al. (2013) also posit that "*resource-starved firms"* who are young and have strong growth potential are in greater need of board network resources, and find that those having high centrality boards outperform those who do not.

3. Hypotheses development

There is a growing number of accounting and finance studies that apply social network analysis (SNA) to examine the connections between individuals in the corporate setting, among which the relationships formed by boards of directors is one of the most studied. Specifically, prior research investigates how the embedded information and resources inherent in the network of relationships between board members affects corporate decisions. Through external connections, boards obtain relevant technical and industry knowledge, business contacts, and other social capital embedded in the networks. Given small and young firms need human and social capital for survival and growth, they offer an ideal setting to investigate how boards can effectively perform their advisory services by leveraging their

formal boardroom networks. Specifically, this chapter focuses on early-stage MEEs which operate in a highly cyclical industry, exhibit high information asymmetry, suffer high project failure rates, and are primarily non-cash generators (Ferguson, Clinch, & Kean, 2011)

3.1. Theory

3.1.1. Human capital obtained through boardroom connections

Human capital includes *"directors' expertise, experience, knowledge, reputation and skills"* (Hillman and Dalziel, 2003). The more specific the human capital used in performing a task is, the more economic value it offers (Dimov and Shepherd, 2005). In the context of MEEs, a significant portion of firm risk stems from the fact that their operations are susceptible to macroeconomic and industry conditions beyond management control. This includes risks of adverse commodity price fluctuations (Rajgopal & Shevlin, 2002), changes in government taxes and royalties, and stricter environmental policies (Featherstone, 2012).[2] The significant level of upfront investment required for exploration, low success rate (Trench, 2013), coupled with such inherently high risks, increase management's risk aversion due to concerns of developing a bad reputation for making poor decisions (Hirshleifer and Thakor, 1992). Therefore, having up-to-date knowledge of industry dynamics, regulations and good practices at the board level is important to complement managerial knowledge and to alleviate the managers' concerns. Prior studies have documented the importance of industry knowledge in facilitating effective board advice. Dass et al. (2014) argue that directors from related upstream and downstream industries have a positive impact on performance and firm value by reducing information gaps and providing relevant knowledge about industry trends

[2] Featherstone (2012) provides a long list of risks faced by young mining companies, including: falling commodity prices; rising costs; federal and state government taxes and royalties; increasing disclosure requirements; environmental, social and governance risks; tax changes; and global economic uncertainty.

and conditions. Similarly, Faleye et al. (2018) find that directors with industry experience facilitate better advice, measured by an increase in the numbers of patents for a given level of R&D spending.

One way to obtain valuable industry information is through building networks with industry peers via additional directorships as explained by resource dependence theory (Hillman and Dalziel, 2003). Carpenter and Westphal (2001) document that director ties to strategically related firms provide information which enhances their capability to advise on corporate decisions. Using a sample of firms where their directors lost board seats at other target firms, and hence board connections, following successful mergers and acquisitions, Brown et al. (2019) document that the effectiveness of board advice decreases the most for firms who lost connections to the most connected targets. The findings suggest that board networks provide access to valuable information resources to facilitate strategic advice and counsel. Similarly, Intintoli et al. (2021) examine how the connectedness of inside and outside directors makes them effective advisors. For outside directors especially, they are able to obtain information about industry trends and regulatory changes which are pertinent to their firm investment activities including R&D and acquisitions. Additionally, as director connections offer such an inexpensive and useful source of industry information, firms tend to adopt similar corporate policies despite criticisms of potentially spreading poor corporate behaviours (Haunschild and Beckman, 1998).[3] Further, Chuluun et al. (2017) argue that high

[3] Examples of the negative consequences include the spread of poison pills (Davis, 1991), options backdating (Bizjak et al., 2009), and earnings management (Chiu et al., 2013). In Australia, poison pills are generally not a common tactic used by target firms due to strict regulatory scrutiny (Allens Arthur Robinson, 2006). Similarly, the *ASX Listing Rules* require securities issued to directors to be approved by shareholders. Hence, the practice of backdating options to a date with a low exercise price is uncommon. Lastly, MEEs are generally loss-making firms because they are in an early exploration phase. Consequently, earnings management may have limited implication in this setting.

centrality boards have access to not only a greater volume of information but also a more diverse range of information which is beneficial to assess project potential and identify risk areas in their innovation activities. Consequently, directors with a high level of centrality are more equipped to offer superior advice to the firm, for which they receive higher compensation as evidenced in Ferris et al. (2020). These authors further demonstrate that the benefits of boardroom networks are most prominent among firms who have high growth opportunities and low free cash flows, leading to premium remuneration paid for well-connected advisory directors.

In addition, MEEs have small boards, often "*three-member boards, comprising a geologist or engineer, the company promoter, and a lawyer or accountant*" (Featherstone, 2012). It is suggested that if the boards of directors do not possess sufficient functional knowledge already, they need to obtain access to external networks which improve information acquisition and consequently facilitate problem solving (Ancona & Caldwell, 1988 cited in Forbes and Milliken, 1999). Thus, apart from the expertise currently available on the board, connections with members of other boards facilitates information exchange and enhances the breadth and depth of knowledge of the board, which is useful in providing strategic advice to top management. The need to supplement human resources at the board level is especially important for MEEs for two main reasons.

First, as suggested by McCann (1991), management of small firms such as MEEs tends to place greater reliance on their internal boards for advice than external counsel. For MEEs, this is because they are financially constrained, in the early exploration phase, and are unlikely to be generating any operating revenue (Chen et al., 2018; Bui et al., 2021). In instances where management is highly dependent on the boards' human capital for credible counselling, it is arguably sensible for the management to share their private knowledge with

boards. However, to the extent that hesitation may remain due to the fear of increased board oversight and scrutiny (Adams and Ferreira, 2007), obtaining information from an external network offers the board a practical solution to help reduce the tension between management and the board. In other words, board members may use their boardroom network as an alternative source of industry-relevant information rather than put pressure on the management to supply information.

Second, MEEs are not only constrained financially but also in terms of human capital at the management level. Consequently, MEE boards need to play a more active role in acquiring additional industry information and supporting managers to identify and exploit growth opportunities (Fahlenbrach et al., 2010). Observations by Trench (2013) suggest the extensive involvement of boards in assisting top management at young mining firms:

> *"[…] directors' willingness to get their hands dirty, to join forces with management in doing the heavy lifting when and where appropriate. At small companies, in particular, the availability of human resources is tight. Non-executive directors signing up to the boardroom decathlon as coaches to management need to be willing to take to the field, not merely offer advice and encouragement from the stands."* (p.17).

Taken together, industry and technical information acquired through boardroom network benefits board advisory duties as it serves as a credible and supplementary source of information which allows boards to offer insightful advice to management.

3.1.2. Social capital derived from boardroom connections

Social capital refers to *"the sum of actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual*

or social unit. Social capital thus comprises both the network and the assets that may be mobilized through that network" (Nahapiet & Ghoshal, 1998). Board social capital benefits MEEs as it provides a positive signal to the market, mitigating the perception of new firms lacking resources and legitimacy (Kor and Misangyi, 2008). Well-connected directors are likely to have a better reputation and thus are more motivated to sustain honest behaviours. Such directors "*provide confirmation to the rest of the world of the value and worth of the organization*" (Pfeffer and Salancik, 1978, p. 145) and "signal" that the firm is *"on the right path"* (Fahlenbrach et al., 2010, p. 15).

Board social capital also offers an effective channel to disseminate information. Prior literature suggests that board networks serve as a conduit for information flow (Haunschild and Beckman, 1998; Hillman and Dalziel, 2003). Hochberg et al. (2007) find that venture capital networks improve fund performance which is realised by improving deal flow, facilitating information and resource dissemination, and expanding customer and strategic alliance partners. Similarly, Omer et al. (2014) document the positive benefits of director network on performance. They argue that high centrality directors are able to obtain external information faster and access a larger pool of information to meet advisory responsibilities, which outweighs any disadvantages associated with their time constraints and the potential adoption of poor corporate practices from other firms. In the IPO context, Feng et al. (2019) argue and find that high centrality boards matter. More specifically, IPO boards made up of highly connected directors are able to facilitate information exchange with prospective investors, which helps reduce information asymmetry and valuation uncertainty. Consequently, investors would place less discount on IPO firms with well-connected directors, resulting in a higher market valuation. Another common corporate activity is mergers and acquisitions where the benefits of director networks are well-documented. Cai and Sivilir (2012) show that board connections between acquirers and target firms improve

information flow and communication, allowing acquirers to enjoy a lower takeover premium and enhancing the overall value for both acquirer shareholders and target shareholders at the deal announcement.

In terms of financing costs, Chuluun et al. (2014) provide evidence that board connectedness is positively associated with media coverage and ties to financial institutions. Further, highly connected boards facilitate information flow to investors. Greater visibility to investors, more ties to capital market, and reduced information risk lower the cost of debt. Relatedly, Luong et al. (2021) find that executives' and directors' social connections with Wall Street brokerages help decrease firms' cost of equity. Analysts obtain private and soft information valuable for their analyses and forecasts through the communication and interaction with firms' management and directors. Such analyses are then communicated to institutional investors; this helps reduce information asymmetry about firm value, resulting in lower risk premiums.

In the case of MEEs, the role of board centrality in facilitating information transmission is even more important. First, MEEs face inherent information asymmetry due to their early-stage and risky operations, and the use of highly technical non-financial information such as metal purity, drilling intercepts, geochemical composition, and proximity of the discovery to mine, which suggests that it may take more time for investors to evaluate the information (Ferguson and Crockett, 2003). Second, MEEs are in the early-stage of their development life cycle, generate minimal revenue, and have limited cash reserves (Ferguson et al., 2011; Chen et al., 2018). The continuation of exploration projects is highly dependent upon the ability to raise capital through the equity market as there is limited access to debt finance (Ferguson and Lam, 2021). However, high information asymmetry hinders the firms' ability to raise capital (Myers and Majluf, 1984). Boards of

well-connected directors can help mitigate information asymmetry by spreading information about MEEs' operations, particularly complex technical project-related information, across the boardroom network as well as the networks of potential investors. The latter is formed as a result of high centrality directors having a greater influence in the fundraising process and experience of interacting with industry investors (Ferguson and Scott, 2011).

In summary, the boards' social capital facilitates information exchange by connecting directors with key stakeholders to increase awareness of MEEs' activities and reduce the high information asymmetry between these firms and the market.

3.2. Hypotheses

Prior studies commonly used investment in research and development (R&D) as a proxy for outcomes of board advising (Kim et al., 2014; Chuluun et al., 2017; Faleye et al., 2018; Brown et al., 2019).[4] In the case of MEEs whose main operating activity is exploration and evaluation, this chapter follows Bui et al. (2021) and uses exploration and evaluation (E&E) assets as a proxy, the nature of which is similar to R&D spending. Under the *AASB 6 Exploration for and Evaluation of Mineral Resources*, MEEs have the choice of either expensing or deferring their E&E expenditure to match the revenue to be generated in future periods. While conservative MEEs choose to directly expense their E&E expenditure to the profit and loss statement, the vast majority of firms capitalise.[5] MEEs are allowed to

[4] Kim et al. (2014) measure advising outcomes using the sum of investment in R&D, capital expenditure, and acquisitions. Due to the size and early development life cycle, MEEs are not in a position to acquire another firm. As such, this chapter does not use acquisitions to proxy for board advice.

[5] Wu et al. (2010) report about 85% of their sample firms capitalise exploration costs. In this study, about 90% of MEE firms are capitalisers.

capitalise E&E expenditure provided that certain criteria are met.[6] It is expected that boards of well-connected directors who acquire relevant technical and industry knowledge by serving on boards of other firms in this sector provide more effective advice to management in making strategic decisions regarding their exploration portfolio. Such boards foster investments in exploration and evaluation activities which are anticipated to create geological prospectivity and ultimately, economic benefits. Therefore, a positive association between board centrality and capitalised E&E expenditure is expected. Hypothesis 1 is proposed as follows:

H1: *Board centrality is positively associated with future capitalised E&E expenditure.*

Additionally, board centrality provides an effective channel to transmit information throughout the network, resulting in an increase in investors' understanding about MEEs and their willingness to invest (Myers and Majluf, 1984). Therefore, it is expected that boards of highly connected directors increase the level of equity capital raised by MEEs. Hypothesis 2 is proposed as follows:

H2: *Board centrality is positively associated with future equity proceeds.*

As discussed in H1 above, high centrality boards are expected to demonstrate their active involvement in providing technical advice to management, and facilitate a greater level of investments in E&E assets in expectation of future economic payoffs. Therefore, it

[6] The criteria are: (a) the rights to tenure of the area of interest are current; and (b) at least one of the following conditions is also met: (i) the exploration and evaluation expenditures are expected to be recouped through successful development and exploitation of the area of interest, or alternatively, by its sale; and (ii) exploration and evaluation activities in the area of interest have not, at the end of the reporting period, reached a stage which permits a reasonable assessment of the existence or otherwise of economically recoverable reserves, and active and significant operations in, or in relation to, the area of interest are continuing (AASB 6, paragraph 7.2).

is envisaged that investor confidence in the viability of MEEs' exploration projects is strengthened. The underlying premise of this argument is based on a strand of research on the value relevance of intangible assets. Aboody and Lev (1998) find that capitalisation of software assets implies future success, as evidenced by a positive association between the capitalised value and future earnings. In addition, Wyatt (2005) suggests that the recognition of intangible assets is reflective of managerial insights into the firms' underlying economics. In the context of the Australian resource industry, Chen et al. (2018) argue that capitalised exploration investments are informative of MEEs' future prospects. In sum, greater board centrality fosters higher investments in exploration assets and indicates stronger evidence of prospectivity. This in turn bolsters investor confidence in MEEs' operations and hence a larger amount of equity investment is forthcoming. This mediating effect is proposed in the following Hypothesis 3:

H3: *The positive association between board centrality and future equity proceeds is mediated through greater investment in E&E assets.*

4. Research design

4.1. Empirical models and variables

The following models are employed to test the proposed hypotheses, with unique firms denoted by *i* and years by *t*. The variable definitions are presented in Appendix A.

Model for H1:

$$EE\_Investment_{i,t+1} = \theta_0 + \theta_1 Q5\_Centrality\_Board_{i,t} + \theta_2 Q5\_Centrality\_MD_{i,t} + \theta_3 MD\_Tenure_{i,t} + \theta_4 Board\_Size_{i,t} + \theta_5 Indep\_Ned_{i,t} + \theta_6 Busy\_Ned_{i,t} + \theta_7 MVE_{i,t} + \theta_8 RET_{i,t} + \theta_9 SD\_RET_{i,t} + \theta_{10} MTB_{i,t} + \boldsymbol{\varphi} + \epsilon_{i,t}, \quad (1)$$

Model for H2:

$$Equity_{i,t+1} = \theta_0 + \theta_1 Q5\_Centrality\_Board_{i,t} + \theta_2 Q5\_Centrality\_MD_{i,t} + \theta_3 MD\_Tenure_{i,t} + \theta_4 Board\_Size_{i,t} + \theta_5 Indep\_Ned_{i,t} + \theta_6 Busy\_Ned_{i,t} + \theta_7 MVE_{i,t} + \theta_8 RET_{i,t} + \theta_9 SD\_RET_{i,t} + \theta_{10} MTB_{i,t} + \boldsymbol{\varphi} + \epsilon_{i,t}, \quad (2)$$

Model for H3:

$$Equity_{i,t+1} = \theta_0 + \theta_1 Q5\_Centrality\_Board_{i,t} + \theta_2 Q5\_Centrality\_MD_{i,t} + \theta_3 EE\_Investment_{i,t+1} + \theta_4 MD\_Tenure_{i,t} + \theta_5 Board\_Size_{i,t} + \theta_6 Indep\_Ned_{i,t} + \theta_7 Busy\_Ned_{i,t} + \theta_8 MVE_{i,t} + \theta_9 RET_{i,t} + \theta_{10} SD\_RET_{i,t} + \theta_{11} MTB_{i,t} + \boldsymbol{\varphi} + \epsilon_{i,t}, \quad (3)$$

The mediating test under H3 follows a three-step analysis suggested by Baron and Kenny (1986). The first step is to demonstrate the association between board centrality and investments in E&E assets which is performed using Model (1). The second step requires estimation of the association between board centrality and future equity finance, which is demonstrated in Model (2). The last step is to incorporate investments in E&E assets in Model (2) to form a new model, Model (3). If a mediating effect is present, the coefficient on *Q5_Centrality_Board*$_t$ in Model (3) is expected to be smaller than that in Model (2) or becomes insignificant if full mediation is realised (Baron and Kenny, 1986).

In Model (1), the dependent variable, *EE_Investments*$_{t+1}$, can be *EE_Add*$_{t+1}$, *EE_Acq*$_{t+1}$, or *EE_Comb*$_{t+1}$, which are measured as the natural logarithm of the amount of exploration and evaluation (E&E) asset additions, acquisitions and combined additions and acquisitions one year after the current year *t*, respectively. In Models (2) and (3), *Equity*$_{t+1}$ is the natural logarithm of equity proceeds raised one year after the current year *t*.

The key explanatory variable for all models is *Q5_Centrality_Board*$_t$ which captures the social capital of all board members excluding the managing director (MD) for the current year *t*. Board centrality is measured in the same way as Intintoli et al. (2018) which is the average factor score of degree, betweenness, closeness, and eigenvector centrality of all individual members serving on the board excluding the MD.[7] For ease of interpretation, the composite board centrality is ranked in quintile annually with the highest (lowest) rank of 5 (1). Similarly, the composite MD centrality, *Q5_Centrality_MD,* is the quintile rank of the factor score based on the MD's four centrality measures.

Centrality is an important element of social network analysis which typically indicates *"power, influence, popularity and prestige"* (Scott & Carrington, 2014). The four most common aspects of centrality are degree centrality, betweenness centrality, closeness centrality, and eigenvector centrality (Larcker et al., 2013; Intintoli et al., 2018). These four key centrality measures are estimated as follows:

$$Degree_i = \frac{\sum_{i \neq j}^{n} A_{ij}}{n-1}$$

Degree centrality measures the number of connections that a director has with other directors. A_{ij} is an indicator variable equal to 1 if director *i* and director *j* serve on the same board, and *n* is the total number of directors. Degree centrality is normalised by dividing the raw degree by (n–1).

$$Betweenness_i = \frac{\sum_{i \notin \{j,k\}} \frac{g_{jk}(i)}{g_{jk}}}{\frac{(n-1)(n-2)}{2}}$$

[7] A factor score with eigenvalue greater than 1 is used as a composite measure of centrality.

Betweenness centrality measures the centrality quality which allows a director to play an intermediary role in transmitting information between a pair of two other directors. Here, $g_{jk}(i)$ denotes the total number of shortest paths between director *j* and director *k* which pass through director *i*, and g_{jk} denotes the total number of shortest paths between director *j* and director *k*. Betweenness centrality is normalised by dividing the raw betweenness by $\frac{(n-1)(n-2)}{2}$.

$$Closeness_i = \frac{n-1}{\sum_{i \neq j}^{n} s(i,j)}$$

Closeness centrality captures the distance between a director and their other connections. The closer the distance, the faster and hence less costly it would be to acquire information. Here, $s(i,j)$ denotes the number of steps in the shortest path for director *i* to reach director *j*. Closeness centrality is the inverse of the average distance between two directors and is normalised by multiplying the raw closeness by (n–1).

$$Eigen_i = \frac{\sum_{j}^{n} A_{ij} Eigen_j}{\lambda}$$

Eigenvector centrality measures the prestige of the connections that a director has. $Eigen_j$ is vector centrality of director *j* which director *i* is connected to, and λ is the proportionality factor.

Separating the board centrality from that of the MD is important as the MD's full-time commitment to day-to-day business operations suggests that their connections may exhibit different qualities compared to those of the board. Further, prior studies have found that MD/CEO network centrality affects corporate decisions. An empirical study by Faleye et al. (2014), which investigates the information acquired through CEOs' social networks,

finds that such networks provide the CEOs with helpful information that facilitates more corporate innovation, evidenced by greater R&D investments and a higher number of patents granted. Additionally, findings in Oh and Barker (2018) suggest that CEOs strategically imitate R&D policies of other firms they are connected to. Further, Ferris et al. (2017) argue that CEOs with greater social capital are associated with more risk-taking, which results in more volatility in stock returns and earnings through activities such as R&D expenditure, diversification, financial leverage and asset liquidity. Highly connected CEOs are able to pool individual risks that alter their risk tolerance. They are also more confident in executing corporate decisions owing to better information resources and more alternative career options. Intintoli et al. (2021) specifically examine the differential impacts of outside and inside director connectedness and find that while outsiders are more effective in assisting their firms with R&D investment decisions by providing relevant industry information gained from their networks, well-connected insiders play a stronger role in the firms' financing activities because of their firm-specific knowledge.

Board governance and MD characteristics are controlled for in all models. The effectiveness of board functions is dependent on their size (*Board_size*), measuring the number of directors serving on the board, and composition (*Indep_Ned*), which is the percentage of the board comprising independent non-executive directors (NEDs). Yermack (1996) finds that smaller boards add value to their firm while Coles et al. (2008) suggest that larger boards are beneficial, especially those with more NEDs who can offer advice to the MDs. Additionally, the presence of independent NEDs on the board ensures effective monitoring of management's decisions that align with business strategies and long-term shareholder value creation (Weisbach, 1988). Directors' busyness (*Busy_Ned*), measured as the percentage of the board having NEDs who serve on two or more boards of other industry

peer firms, is also included in all models.[8] While busy directors may be time constrained to effectively perform their monitoring role (Fich and Shivdasani, 2006), their busyness reflects the demand for their experience and expertise (Field et al., 2013). In terms of MDs' related attributes, their skills and firm-specific knowledge are relevant in making investment decisions and corporate policies. Therefore, *MD_tenure* is included in all models to proxy for the MDs' capability and human capital (Linck et al., 2008).

Finally, all models control for MEEs' economic characteristics comprising firm size (*MVE*), growth opportunity (*MTB*), stock performance (*RET*), and riskiness (*SD_RET*). Coles et al. (2008) suggest that larger firms display greater advising needs while Field et al. (2013) find that younger S&P 1500 firms benefit from the advice of busy directors who possess greater connections and experience. Further, Larcker et al. (2013) find firms experiencing high growth or adverse circumstances benefit from board centrality. Consequently, all models capture such events by including *MTB, RET* and *SD_RET*.

4.2. Sample and data

Table 1, Panel A presents the sample selection process. The initial sample of all Australian metals and mining firms obtained from Connect 4/Boardroom consists of 7,641 firm-year

[8] The measure of director busyness is different to and distinguished from the measure of director's degree centrality. A director is considered busy if they hold two or more directorships at other industry peer firms' boards. That is, busyness is measured based on the additional board-level roles, and hence captures additional workload and commitments. However, director's degree captures the number of connections that a director is linked to by sharing common board seats. Degree centrality is measured at a director-to-director level not a director-to-board level as is the case for busyness. Therefore, a director who has a higher degree centrality may not necessarily be a busy director if the high degree is due to the additional board(s) they serve on have a large number of members.

observations for 1,018 unique firms for the period 2004 to 2016.[9] Of the initial sample, 1,537 firm-year observations for MEEs with operating revenue greater than $1 million (i.e. large firms) and 178 firm-year observations for firms providing only mining services were excluded from the sample. In addition, 826 firm-year observations were excluded due to missing financial, market capitalisation or corporate governance data. Finally, 656 firm-year observations that were directly expensing their E&E expenditure to the profit and loss statement were excluded.[10] The final sample includes 4,444 firm-year observations made up of 776 unique capitalising MEEs.

[Insert Table 1 here]

Information on E&E assets was hand collected from notes to the financial statements. Financial data was sourced from Morningstar DatAnalysis Premium and Aspect Huntley databases, and monthly stock prices and market capitalisation were obtained from the SIRCA-SPPR database. Corporate governance data was obtained from Connect 4.

Panel B reports sample distribution by year. MEEs make up almost 80% of all Australian mining firms suggesting a significant portion of listed miners on the Australian Stock Exchange (ASX) are in an early exploration phase. Both the number of MEEs and all mining firms increase gradually over the sample period, with the highest numbers corresponding to the end of the mining boom between 2011–2015.

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[9] The sample period commenced in 2004, which corresponds to the first year when the corporate governance data is available through Connect 4.

[10] The differential motivation underlying the accounting choice for recording E&E expenditure leads to different disclosure and indications of probable future prospects. Consequently, this thesis only focuses on capitalising MEEs. These firms provide a clear breakdown of the capitalised E&E expenditures that indicate continuing effort in undertaking exploration activities which are expected to result in future economic benefits.

4.3. Descriptive statistics

Table 2, panel A compares economic and board governance characteristics of capitalising MEEs versus mining companies which have advanced past the exploration stage of the mining development cycle and earn revenue of greater than $1 million or entities providing mining services such as drilling and earthmoving (collectively, "non-MEEs"). It is noticeable that MEEs are smaller in size with a mean (median) market capitalisation of $38.75 million ($10.95 million) compared to $1.80 billion ($91.49 million) for non-MEEs. The difference is more evident when comparing total assets. The mean (median) non-MEEs have total assets worth $2.68 billion ($155.00 million) which is approximately 99 times (14 times) higher than that of MEEs with mean (median) total assets of $26.90 million ($10.93 million). In addition, MEE operations are riskier than non-MEEs given the significantly negative t-test of standard deviation of stock returns of –19.7476 ($p < 0.01$). The t-test, however, shows no significant difference between stock performance of MEEs and non-MEEs.

[Insert Table 2 here]

Capitalising MEEs' board attributes are different to those of non-MEEs. MEEs have a smaller board (4 members) compared to non-MEEs (5 members). Boards of MEEs also have a smaller number (proportion) of independent NEDs (median of one member, or 33% of total board) compared to non-MEEs (median of two members, or 40% of total board). Non-MEEs' larger board size and more independent NEDs are associated with their larger firm size, which is consistent with findings in Linck et al. (2008). Further, larger non-MEEs have more complex operations and hence may demand greater time commitment from NEDs, leading to a lower number of NEDs being classified as busy compared to MEEs. On average, only 9% of non-MEE boards are busy while 13% of capitalising MEE boards appear busy. Overall, MEEs and non-MEEs display starkly different characteristics which

suggest that it is important to distinguish these types of firms; such firm-level qualities may have fundamentally different impacts on corporate investments and financing.

Table 2, Panel B provides information about key components comprising MEEs' exploration and evaluation (E&E) assets. E&E assets' closing balance is $11.18 million, on average (median $5.62 million), which is equivalent to approximately 54% (median 60%) of total assets. This indicates that E&E assets are one of the most important accounts on MEEs balance sheet. E&E asset additions, which typically capture expenditures on mining activities, such as geological studies, drilling and sampling, are the most common component with an average value of $2.55 million (median $1.15 million). This component makes up 16% (median 11%) of MEEs' total assets. Another component that increases the closing balance of E&E assets is acquisitions. Specifically, the acquisition of mining tenements, mining projects or other E&E assets have an average value of $0.7 million, accounting for about 4% of total assets. While E&E asset acquisitions occur less frequently than E&E asset additions, the value of individual transactions of the former is typically larger than the latter. When combined, both capitalised components represent a significant portion of total assets, 20% on average (median 13%). Overall, E&E asset additions and acquisitions most frequently explain the increase in E&E assets closing balances.[11]

[11] All movements affecting the closing balance of E&E assets were hand collected. The closing balance was cross-checked with the data recorded in Aspect Financial or Morningstar DatAnalysis. For the purpose of this chapter, Table 2 panel B only discloses incremental components. The closing balance is decreased by impairments of previously capitalised E&E expenditures, the value of which is not trivial with the average value of $1.39 million, accounting for about 25% of the value of total assets. Another movement negatively affecting the closing balance of E&E assets is the transfer of E&E assets to development. However, this transaction occurs less frequently. E&E asset closing balance can be both increased and decreased by movements/transactions occurring during a given year. Therefore, to accurately capture the incremental investments in E&E assets and indications of potential future payoffs, this chapter investigates individual capitalised components not the aggregate closing amount.

The mapping of the boardroom connections of all mining firms for financial year 2016 using *Gephi* is presented below for illustration purpose only. The size and darkness of the nodes/circles are proportional to the degree centrality captured at the board-level. Using degree centrality measure, the highest centrality firms are Cradle Resources Ltd (ASX: CXX), followed by Image Resources NL (ASX: IMA).

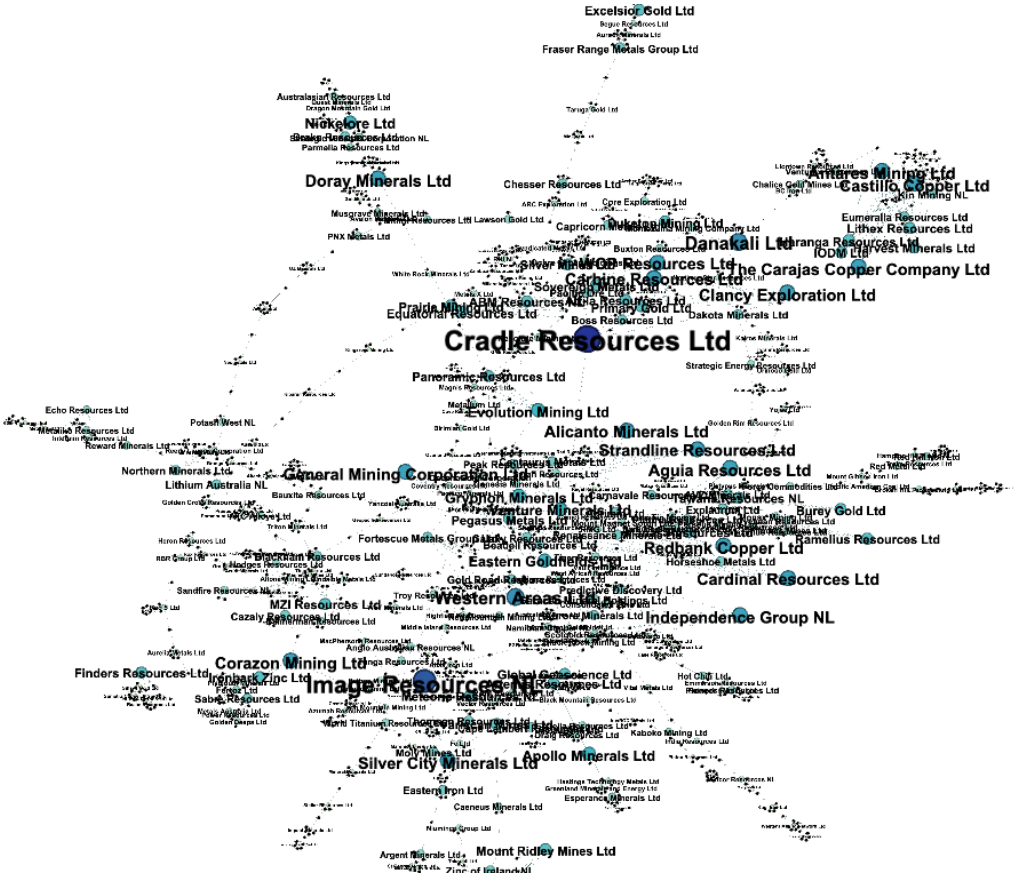

Figure 1: Mining board network in 2016

Table 3, Panel A compares raw centrality measures of capitalising MEEs and non-MEEs. Comparison was not performed for composite board and MD centrality measures

because of the nonintuitive nature resulting from the factor analysis.[12] In terms of key individual measures, MEE boards have less first-degree links (median degree of 6.33 for MEEs versus 7.50 for non-MEEs) and less prestigious connections (average eigenvector of 0.0012 for MEEs versus 0.0063 for non-MEEs). Directors on MEEs boards are also less closely tied compared to non-MEEs as evidenced by the significantly strong t-test results of 5.8603 ($p < 0.01$). These results are likely to be driven by non-MEEs' larger size, making their board of directors more visible; this presents them with greater opportunities to receive additional board appointments and establish broader connections, and be more closely positioned with other board members. However, MEE directors appear to have a more significant intermediary role compared to those of non-MEEs; there is a greater number of paths which pass through MEEs directors compared to non-MEEs (3,301 for median MEEs compared to 2,640 for median non-MEEs). Similar patterns can be found when comparing the MD centrality of MEEs and non-MEEs, except for betweenness centrality. [13]

[Insert Table 3 here]

Within MEEs, the differences between the centrality measures of non-MD board members and the MD are notable, which is expected given the different time and effort

[12] Based on the composite measure, in 2016, highest centrality MEE board was Cradle Resources Ltd (ASX: CXX), followed by Alicanto Minerals Ltd (ASX: AQI). The most well-connected MD was Jones Gregory of Variscan Mines Ltd (ASX: VAR) who also served as a non-executive director of four other mining boards, namely Eastern Iron Ltd (ASX: EFE), Moly Mines Ltd (ASX: MOL), Silver City Minerals Ltd (ASX: SCI) and Thomson Resources Ltd (ASX: TMZ).

[13] In 2016, based on individual measures, MEE boards with the highest level of degree, betweenness, closeness and eigenvector centrality were Castillo Copper Ltd (ASX: CCZ), Alicanto Minerals Ltd (ASX: AQI), AQI, and CZZ, respectively. MDs with the highest level of degree, betweenness, closeness, and eigenvector centrality were Gregory Jones of Variscan Mines Ltd (ASX: VAR), Bryan Dixon of Blackham Resources Ltd (ASX: BLK), Hamish Halliday of Venture Minerals Ltd (ASX: VMS), and Nicholas Lindsay of CCZ, respectively.

commitments required for each position. For example, on average non-MD board members have more connections (6 connections) than MDs (3 connections). NEDs are also on many more paths connecting a pair of two other directors compared to the MD.

In terms of time trends, Figure 2 shows that board degree centrality increased steadily until 2013 then declined gradually, while MD's degree centrality remained relatively stable between 2004 and 2016. It is also clear that while betweenness centrality followed an upward trend for both board members and MDs, closeness centrality decreased steadily over the sample period. The closeness centrality measure is the inverse of the average steps to connect one director with each of the other directors in their board networks. Therefore, by construction, a decrease in this measure suggests more steps are required to connect one director to another. This may be explained by the increase in the number of mining firms over the 2004 to 2016 period, leading to more steps to connect one director to another. For eigenvector centrality, the measure fluctuated considerably with a noticeable decline following the Global Financial Crisis in 2008.

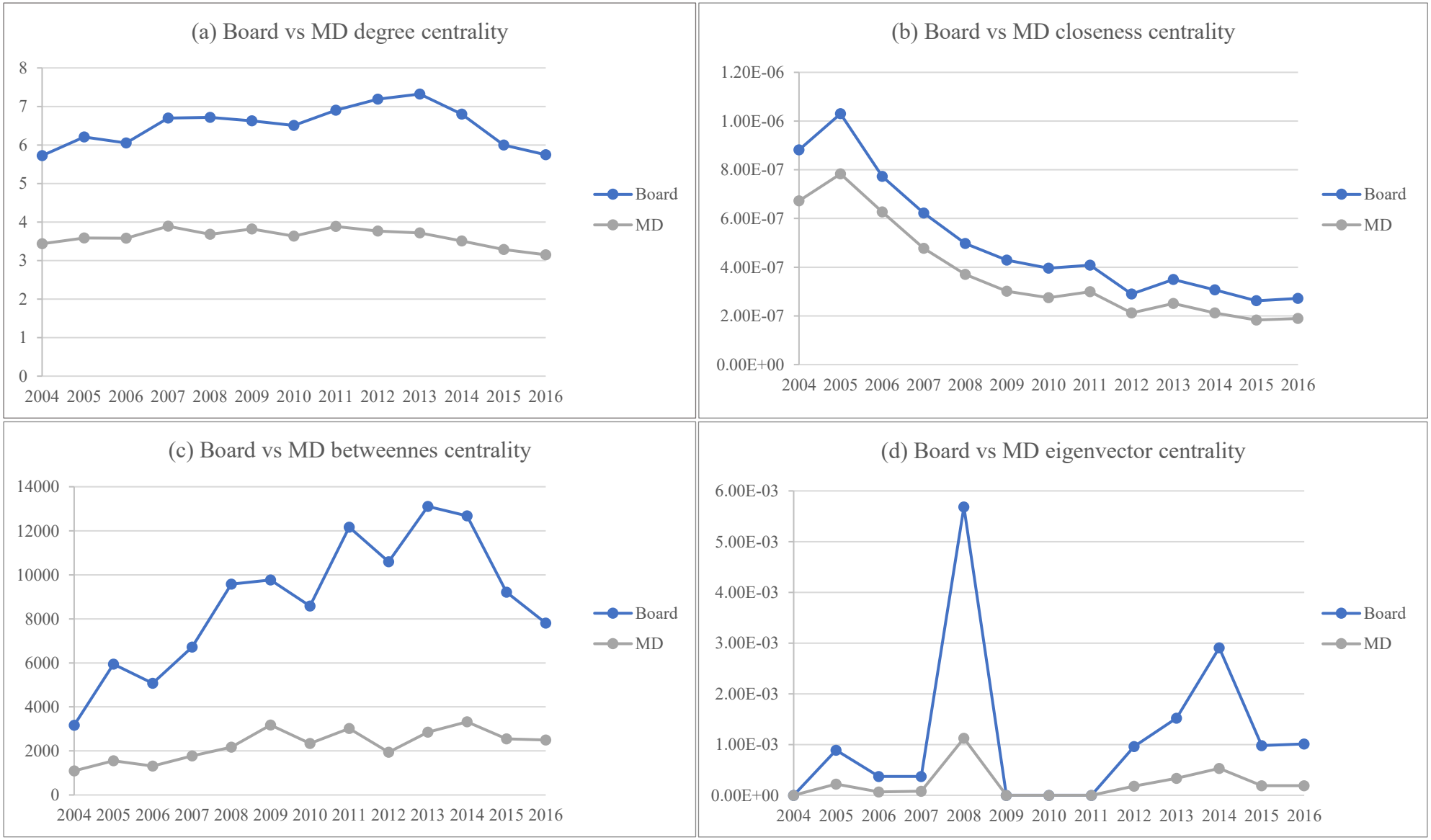

Figure 2: MEE board members versus MD centrality using four different measures

Table 3, Panel B reports the correlations between centrality measures of board members and MDs. It can be seen that board degree centrality is significantly correlated with betweenness centrality (r = 0.7974, p < 0.01) and closeness centrality (r = 0.7127, p < 0.01); so is the correlation between board betweenness centrality and closeness centrality (r = 0.8323, p < 0.01). Similarly, MD centrality measures are also highly correlated, but to a lesser extent compared to those of the board. As recommended by Intintoli et al. (2018), the high correlations between these individual centrality measures suggest the need to construct a composite measure for board centrality and MD centrality using factor analysis. The composite measures *Q5_Centrality_Board* and *Q5_Centrality_MD* adequately capture the underlying factors driving the variations among individual centrality measures, evidenced by the significant correlations between these two composite measures and their respective individual centrality measures.

Table 4 reports the Pearson's correlation matrix for all variables used to test the hypotheses. Overall, board centrality is significantly and positively correlated with future investments in E&E additions (r = 0.0372, p < 0.05) and acquisitions (r = 0.0615, p < 0.01), which is consistent with the prediction under H1. A positive and significant correlation between the MD's centrality and E&E additions is also observed (r = 0.0504, p < 0.01). Similarly, both the centrality of board members and MDs are positively and significantly correlated with future equity finance, as conjectured under H2 (r = 0.0600, p < 0.01 for board centrality and r = 0.1074, p < 0.01 for MD centrality).

[Insert Table 4 here]

There should be no significant concern with regard to multicollinearity as correlations among independent variables are fairly low. The highest correlations are observed between

$Busy\_Ned_t$ and $Q5\_Centrality\_board_t$ (r = 0.4887, p < 0.01), and between $Q5\_Centrality\_MD_t$ and $Boardsize_t$ (r = 0.3847, p < 0.01). [14]

5. Main results

5.1. Board centrality and investment advice

Table 5 presents the results of regressing combined E&E asset additions and acquisitions (EE_Comb_{t+1}) on board centrality and control variables. The variable of interest, $Q5\_Centrality\_board_t$, is positive and significant across all three estimations for year $t+1$ (coefficient = 0.1718, p < 0.05 in Column (1) without any fixed effects; coefficient = 0.2080, p < 0.01 in Column (2) controlling for year fixed effects; and coefficient = 0.1896, p < 0.05, in Column (3) controlling for both year and firm fixed effects). These results are consistent with H1 that predicts greater board centrality facilitates board advisory role by fostering higher investments in key exploration activities in anticipation of probable future economic payoffs. In terms of economic significance, MEEs in the highest quintile of board centrality invest in combined E&E assets approximately 129.79% (based on Column (2) results) and 113.49% (based on Column (3) results) more than those in the lowest quintile of centrality. [15]

[Insert Table 5 here]

[14] The low-to-moderate level of correlation between $Busy\_Ned_t$ and $Q5\_Centrality\_board_t$ demonstrates that these measures capture different attributes of directors, being busyness and social capital. Hence, it is important to distinguish these measures. This chapter also checks multicollinearity by estimating the variance inflation factor (VIF) with a mean of 2.3 for both the regression of $Q5\_Centrality\_board_t$ on a measure of investment advice and the regression of $Q5\_Centrality\_board_t$ on equity financing advice.

[15] Comparing MEE boards in the top quintile of the composite measure to those in the bottom quintile, the increase in combined E&E asset investment is 129.79% ($e^{0.2080*(5-1)} - 1$)) under Column (2) and 113.49% ($e^{0.1896*(5-1)} - 1$)) under Column (3). The economic magnitude of the associations between board degree, betweenness, closeness, and eigenvector centrality measures and E&E asset investments are calculated in the same manner.

To obtain a better understanding of which specific centrality measure explains the positive associations reported in Table 5, Table 6 separately examines the relations between E&E assets and individual board centrality measures. Results from Table 6, Column (1) show a significant and positive association between board's degree centrality and E&E assets (coefficient = 0.1767, $p < 0.01$). This suggests MEE boards ranking at the top quintile of degree centrality facilitate approximately 102.75% higher investment in combined E&E asset additions and acquisitions than those at the lowest quintile. Consistent findings are observed in Column (2) when both year and firm fixed effects are considered.

[Insert Table 6 here]

It is also evident from Table 6 that there are significantly positive associations between all other board centrality qualities and investments in E&E assets. In terms of board betweenness centrality, it can be inferred from Column (3) that MEEs with boards in the top quintile of betweenness centrality invest in combined E&E assets 96.84% more than those in the bottom quintile. Similarly, Column (5) suggests boards in the top quintile of closeness centrality foster 86.86% higher investment in combined E&E asset additions and asset acquisitions than those in the bottom quintile. Lastly, eigenvector centrality does not appear to have a significant impact on the investment of combined E&E assets. However, a closer look at the breakdown of this measure, which is made up of E&E asset additions and E&E asset acquisitions, reveals that board eigenvector centrality is significantly associated with the level of investment in E&E asset acquisitions. Untabulated results suggest that boards in the top quintile of eigenvector centrality facilitate 66.33% greater investment in E&E asset acquisitions than boards in the lowest quintile. As discussed in Section 4.3, acquisitions of E&E assets do not occur frequently but the level of investment in such transactions is typically significant. Because these transactions are more strategic and of higher value, the prestige of the connections of peer directors whom MEE directors are connected to plays an important role to

provide credible and insightful information that helps MEEs make strategic acquisition decisions.

In summary, findings in Table 5 and Table 6 provide strong evidence of the positive contributions of high centrality boards in rendering advice and counsel to management, particularly in relation to exploration investment. These results lend significant support to H1. The findings are consistent with those documented in Intintoli et al. (2021) who find positive associations between the connectedness of outside directors and R&D outcomes. These results also complement implications from Brown et al. (2018) that board connections are an effective mechanism to facilitate information flow, which is important for effective board advice.

5.2. Board centrality and equity finance

Table 7 presents the results for H2. As shown in Columns (1) and (2), board centrality is positively and significantly associated with the amount of equity proceeds raised in the following year (coefficient = 0.2387, $p < 0.01$ in Column (1) and coefficient = 0.2168, $p < 0.05$ in Column (2)), implying the MEE boardroom network serves as an information sharing channel which helps reduce information asymmetry and enhance investors' understanding about MEEs' activities.[16] In terms of economic significance, Column (2) suggests that comparing boards in the top quintile versus those in bottom quintile of the composite centrality, the amount of funds raised through issuance of equity instruments by MEEs with highest centrality boards increases by 138.02%. When firm fixed effects is controlled for in Column (3), the association between board centrality and future equity finance becomes insignificant.

[16] Untabulated analyses confirm that the association between board centrality and future equity raising also holds when using year *t+2* and *t+3*. By regressing board centrality on 2- and 3-year forward equity proceeds, concerns about reverse causality that MEEs with stronger prospectivity, resulting in a greater level of proceeds raised through the equity market, are able to attract more well-connected directors are mitigated (Cheng, 2008).

This is likely to be driven by firms' unique unobservable attributes such as leadership style and risk appetite which could also impact MEE's strategic decisions. An alternative explanation could be that while MEE directors do share their firms' information through their director networks to help increase investors' understanding and reduce information asymmetry, they are also conscious of their confidentiality obligations to not spreading commercially sensitive and proprietary information including those aforementioned unique firm attributes.

[Insert Table 7 here]

In addition, Table 8 Columns (1) and (3) suggest that the significant association between board centrality and future equity capital is driven by the number of connections (coefficient = 0.2388, $p < 0.01$ for degree centrality) which allow MEE boards to communicate with more peer directors and investors; and convenient positions connecting other directors to each other (coefficient = 0.3454, $p < 0.01$ for betweenness centrality) that afford boards the opportunities to be brokers of information. Specifically, boards ranked in the top quintile of degree centrality and betweenness centrality increase the amount of equity proceeds by 159.92% and 298.13% respectively, compared to those ranked at the bottom quintile. These findings imply that the number of relationships and the intermediary positions that MEE boards possess help them spread information about their entities to more individuals in the director networks and allow them to conveniently reach out to their peers for information sharing, which consequently improves awareness about MEEs and reduces information asymmetry. The distance (closeness) and prestige (eigenvector) qualities of board centrality appear to play less significant roles in MEEs' equity raising possibly because these reflect the timeliness of information exchange and reputation of other directors' connections which have less direct impacts on improving information flow and the ease of connecting other directors that alleviate the high information asymmetry problem facing MEEs.

[Insert Table 8 here]

Further, the coefficient on *Q5_Centrality_MD$_t$* is positive and significant across three Columns of Table 7, indicating the significant contribution of MD centrality to the success of equity financing. Coefficients on all four individual centrality measures in Table 8 are also significantly positive (coefficient = 0.2863, $p < 0.01$ for degree centrality; coefficient = 0.1015, $p < 0.1$ for betweenness centrality; coefficient = 0.3877, $p < 0.01$ for closeness centrality; and coefficient = 0.3332, $p < 0.01$ for eigenvector centrality). MEEs whose MD degree, betweenness, closeness and eigenvector centrality measures are among the top quintile raise 214.31%, 50.08%, 371.52%, and 279.16% more equity capital than those in the bottom quintile, respectively.

Findings in Tables 7 and 8 complement those in Intintoli et al. (2021) who find that the connectedness of both outside and inside directors helps reduce under-pricing when firms raise seasoned equity, with the latter playing a stronger role when their firms display significant information asymmetry due to their firm-specific knowledge.

5.3. Mediating effects of E&E asset investments

This section investigates the channel through which the association between board centrality and future equity finance is mediated. To demonstrate mediating effects, this chapter closely follows a three-step analysis recommended by Baron and Kenny (1986). Step one requires evidence of significant associations between board centrality and mediators, which are E&E asset additions, E&E acquisitions, or combined E&E assets. Analyses of such associations are discussed in Section 5.1 with results reported in Table 5. Results for the second step showing evidence of the relation between board centrality and equity finance is presented in Table 7 and discussed in Section 5.2. In the final step, both board centrality and mediating indicators are included as explanatory variables for future equity finance. The presence of mediating effects

is demonstrated when coefficient on *Q5_Centrality_Board*$_t$ is reduced or becomes insignificant. Results of the third and last step is reported in Columns (2) and (3) of Table 9.

For ease of comparison, Column (1) of Table 9 displays the same findings reported in Column (2) of Table 7. In Column (2), investments in E&E additions and acquisitions are included to examine whether the association between board centrality and future equity finance established in Column (1) is mediated through these channels. As can be seen from Column (2), the coefficient of 0.1706 on *Q5_Centrality_board*$_t$ is significant but smaller in magnitude compared to that in Column 1 (coefficient = 0.2168), representing a 21.31% difference. In Column (3) where individual E&E assets are replaced by the combined amount, the coefficient on *Q5_Centrality_board*$_t$ is also 16.37% lower. Overall, a significant mediating effect is demonstrated in Columns (2) and (3) with $p < 0.01$, confirming that E&E asset investment is the channel through which high board centrality improves investor confidence in MEEs' prospectivity, and hence the higher level of equity capital.

[Insert Table 9 here]

An alternative strategy to evaluate the mediating effect is measuring the 'distribution of the product' proposed by Mackinnon et al. (2004); Preacher et al. (2007) argue this approach to be more accurate as it measures the significance of and confidence interval for the product of two indirect effects. These are (i) the effect between key determinant (*Q5_Centrality_board*$_t$ in this case) and mediator (*EE_Comb*$_{t+1}$), $\hat{a}$, measured in Model (1), and (ii) the effect between the mediator and the dependent variable (*Equity*$_{t+1}$), $\hat{b}$, which is determined in Model (3). Using a program called "RMediation" in R, the mediated effect $\hat{a}\hat{b}$ through combined E&E additions and acquisitions being 0.0355 (standard deviation of 0.0121) has an asymmetric confidence interval of 0.0163 to 0.0559, which does not contain 0, suggesting a significant mediation association. In conclusion, both causal steps suggested by Baron and Kenny (1986) and

distribution of the product by Mackinnon et al. (2004) provide evidence of the significant mediating effects of E&E asset investments.

6. Additional tests

This section discusses the findings of several additional tests which extend key results reported in Section 5.

6.1. Joint test of board busyness and centrality on advisory qualities

Results from Tables 5 to 8 suggest high centrality boards provide their focal firms with additional human and social capital which facilitates the provision of superior advice to management. However, centrality measures are not free from endogeneity. Further, there is evidence from the main findings that busy directors are negatively associated with the provision of advice and counsel. Hauser (2018) shows that firms with directors who lost their board seats due to M&As experience increased profitability, suggesting that director busyness is detrimental to firm performance. However, Brown et al. (2019) argue that the M&A shocks not only decrease director busyness but also their connections, which have contrasting effects on board duties and firm operating performance. Brown et al. (2019), using the same quasi-natural experiment as Hauser (2018), suggest that while their findings show improvements in firm performance and board advising following the decrease in director busyness, such consequences are smallest for firms losing the most connections. The results imply that gains from reductions in director workloads are offset by loss due to reduced access to relevant information and resources. Therefore, this section follows Hauser (2018) and Brown et al. (2019) and investigates the joint effects of board busyness and centrality on its advice by using M&As to identify exogenous shocks. The estimation is specified as follows:

$$\Delta\_EE\_Add \textbf{ or } \Delta\_EE\_Acq \textbf{ or } \Delta\_EE\_Comb$$
$$= \theta_0 + \theta_1 Treated_{i,t} + \theta_2 \Delta\_MD\_Tenure_{i,t} + \theta_3 \Delta\_Board\_Size_{i,t} + \theta_4 \Delta\_Indep\_Ned_{i,t}$$
$$+ \theta_5 \Delta\_Busy\_Ned_{i,t} + \theta_6 \Delta\_MVE_{i,t} + \theta_7 \Delta\_RET_{i,t} + \theta_8 \Delta\_SD\_RET_{i,t} + \theta_9 \Delta\_MTB_{i,t} + \boldsymbol{\varphi}$$
$$+ \epsilon_{i,t}, \qquad (4)$$

$$\Delta\_Equity = \theta_0 + \theta_1 Treated_{i,t} + \theta_2 \Delta\_MD\_Tenure_{i,t} + \theta_3 \Delta\_Board\_Size_{i,t} + \theta_4 \Delta\_Indep\_Ned_{i,t}$$
$$+ \theta_5 \Delta\_Busy\_Ned_{i,t} + \theta_6 \Delta\_MVE_{i,t} + \theta_7 \Delta\_RET_{i,t} + \theta_8 \Delta\_SD\_RET_{i,t} + \theta_9 \Delta\_MTB_{i,t}$$
$$+ \boldsymbol{\varphi} + \epsilon_{i,t}, \qquad (5)$$

Where *Treated* denotes the number of cases in which a board has a member whose role was terminated following an M&A shock. *Treated* is further classified based on whether the board member is the MD (*Treated_MD*) or other board member (*Treated_Board*).

Table 10 presents the results for Model (4) which compares the advising outcomes of firms whose directors lost their positions (shocked directors) following successful M&As (treated firms) versus those not having shocked directors (control firms). Columns (1) to (3) present the result with the aggregate explanatory variable $Treated_t$, while Columns (4) to (6) separately investigate *Treated_MD* and *Treated_Board*. If following the M&As, shocked directors allocate more time and commitment to their role at treated firms, improvement in strategic advice is anticipated. However, the quality of advice may decline due to the directors losing access to relevant information and resources. Overall, the negative coefficient on *Treated* (–0.6040, $p < 0.1$) in Column (2) indicates that performance of treated firms' boards suffers following the M&As. Columns (4) to (6) also show no significant and positive coefficients for *Treated_Board* and *Treated_MD*. Therefore, it is inferred that, in the case of MEEs, the loss of industry and technical knowledge which is useful for strategic decisions in relation to acquisitions of exploration assets is more significant, which cancels out the benefits of reduced director busyness. This result also suggests the important role of the overall board centrality in

providing relevant capital needed by MEEs for growth, and that the potential negative effects of director busyness do not outweigh the benefits of resources provided by well-connected directors.

[Insert Table 10 here]

Similarly, Table 11 presents the findings for equity finance. There is also no evidence of any positive benefits arising from reduced directors' busyness as documented in Hauser (2018). In other words, there is no overwhelmingly negative impact of board busyness in the MEE setting.

[Insert Table 11 here]

Overall, it can be observed from the results in Table 10 and Table 11 that there is more evidence of negative impacts of losing valuable network resources necessary for directors to effectively perform their advisory duties. [17]

6.2. Board centrality and stock returns

To the extent that board centrality facilitates effective advice through greater investments in E&E assets, and bolsters investors' sentiment and willingness to invest in MEEs as documented in Section 5, it is anticipated that the aggregate benefits would be translated into stronger stock performance. The following model is used to estimate the association between board centrality and stock returns:

$$\Delta\_RET_{i,t} = \theta_0 + \theta_1 Board\_Connections_{i,t} + \theta_2 MVE_{i,t} + \theta_3 MTB_{i,t} + \theta_4 SD\_RET_{i,t} + \theta_5 \Delta\_RET_{i,t-1} + \boldsymbol{\varphi} + \epsilon_{i,t}, \quad (6)$$

[17] This chapter also follows Brown et al. (2019) to measure the economic consequences on MEEs' investment and financing outcomes following the loss of network resources at *treated* firms. However, the economic impact is not statistically significant. Therefore, the results from the analyses are not tabulated.

Where $Board\_Connection_t$ is the centrality of the entire board of directors including the MD ($Q5\_Centrality\_Board\_MD_t$), or separate centrality measures for board members other than the MD ($Q5\_Centrality\_Board_{t,}$) and for the MD ($Q5\_Centrality\_MD$); Δ_RET_t is the change in stock return between year $t+1$ and t; and Δ_RET_{t-1} is the change in stock return between year t and $t-1$.

Table 12 presents the results of the regression of stock returns on board centrality and control variables. Following Larcker et al. (2013), the dependent variable is the change in stock returns between the current and subsequent year. Column (1) reports findings of the aggregate measure of the entire board centrality inclusive of the MD, and Column (2) provides a breakdown of non-MD members centrality and MD centrality. $Q5\_Centrality\_Board\_MD_t$ is positive and significant (coefficient = 0.0255, $p < 0.1$), which suggests that overall board centrality is positively associated with stock performance. Further, Column (2) suggests that the association is driven by MD centrality (coefficient = 0.0292, $p < 0.05$ for $Q5\_Centrality\_MD_t$).

[Insert Table 12 here]

However, looking closer at individual centrality measures reported in Table 13, both the board centrality and MD centrality measures seem to have positive associations with stock prices. The coefficient of 0.0224 (p <0.1) on $Q5\_Bet\_board_t$ and 0.0331 (p <0.05) on $Q5\_Eig\_MD_t$ can be interpreted as MEEs whose board members have the highest ranked betweenness centrality and MDs have the highest eigenvector centrality outperform those ranked at the bottom quintile by 8.96% and 13.24% respectively. [18]

[Insert Table 13 here]

[18] The economic significant is calculated as (5–1) × 0.0224 for $Q5\_Bet\_board_t$ and (5–1) × 0.0331 for $Q5\_Eig\_MD_t$.

Taken together, findings in Table 12 and Table 13 suggest that board members other than the MD, who are likely to be less time constrained, can serve on more board seats and have more information passing through them, which provides them with valuable human and social capital that are viewed favourably by the market. MDs, on the other hand, have overall reputable links possibly resulting from their executive positions, which is also regarded positively by the market.

6.3. Moderating effects

Larcker et al. (2013) report the positive effects of board networks are most pronounced among firms which can most benefit from the resources provided by the network. More specifically, the authors show that network benefits are most prominent for young firms with high growth opportunities or those experiencing adverse circumstances such as low earnings or stock returns. Further, Ferris et al. (2020) suggest that young firms are willing to pay well-connected directors higher remuneration for their social capital. Similarly, this chapter proposes that the benefits of board centrality are most valuable for MEEs that need to raise additional equity capital but exhibit the lowest future prospectivity (those ranked in the bottom quintile of E&E additions, E&E acquisitions, or combined E&E assets). The results are presented in Table 14.

[Insert Table 14 here]

Column (1) of Table 14 shows that the negative effect of $Low\_EE\_Add_t$ on future fund raising is partially mitigated by board centrality. This is evidenced by the significant coefficient on the interaction term $Q5\_Centrality\_Board \times Low\_EE\_Add_t$ (coefficient = 0.4525, $p < 0.01$) which drives the significant result for the combined E&E assets $Q5\_Centrality\_Board \times Low\_EE\_Comb_t$ in Column (3) (coefficient = 0.4329, $p < 0.01$)

Table 15 presents the analysis of whether board busyness is a moderating factor which dampens the association between board centrality and the quality of board advice on future investments and fund raising. This is a further attempt to the joint test of the impact of board

centrality and busyness performed under Section 6.1. If director busyness is detrimental as suggested by Fich and Shivdasani (2006) and Hauser (2018), the impact is argued to be more pronounced for those who are most busy – as such, the consequences of being busy cancel out the benefits of board social capital. Therefore, it is expected that the coefficient on the interaction term between board centrality and an indicator variable coded 1 if busy NEDs are in the top quintile ($Q5\_Centrality\_Board\ x\ Busy_t$) will be negative. However, it can be seen from Table 15 that the coefficients on the interaction term are not significantly negative, hence providing no evidence of overwhelmingly negative effects of director busyness in the MEEs setting. This result, coupled with those discussed in Section 6.1, complements empirical findings in Field et al. (2013) and Chen and Guay (2020) who support the notion that early-stage firms benefit more from advisory directors who gain experience and valuable industry contacts by serving on more public boards.

[Insert Table 15 here]

6.4. Robustness tests

A number of additional tests were conducted to assess the robustness of the main findings.

6.4.1. Alternative measures of E&E investments

The main findings use the natural log of the value of investment in E&E assets as the proxy for advisory outcomes. These measures reflect incremental spending on ongoing exploration activities which are anticipated to generate potential economic benefits through future development and sales. The main findings hold when E&E investments are scaled by opening total assets, as shown in Table 16.

[Insert Table 16 here]

The quality of board advice may also be proxied by investment efficiency. This chapter follows McNichols and Stubben (2008) and Bae et al. (2017) to measure investment efficiency ($INV\_Efficiency_t$) as the residual from the following model:

$$INV_{i,t} = \theta_0 + \theta_1 Tobin_{i,t-1} + \theta_2 Tobin_{i,t-1} \times Q2\_Tobin_{i,t-1} + \theta_3 Tobin_{i,t-1} \times Q3\_Tobin_{i,t-1} + \theta_4 Tobin_{i,t-1} \times Q4\_Tobin_{i,t-1} + \theta_5 CF_{i,t} + \theta_6 Growth_{i,t-1} + \theta_7 INV_{i,t-1} + \epsilon_{i,t},$$

Where INV_t is the net cash spending on operating and investing exploration and evaluation as well as mining tenements for current year, scaled by opening exploration and evaluation assets; INV_{t-1} is the prior year net cash spending; and $Tobin_{t-1}$ is Tobin's Q of the prior year; $Q2\_Tobin_{t-1}$, $Q3\_Tobin_{t-1}$, and $Q4\_Tobin_{t-1}$ are indicator variables coded 1 if $Tobin_{t-1}$ is in the second, third and fourth quartile of each year sample, where Tobin's Q is measured as $\frac{MVE+Total\ asset-BVE}{Total\ asse}$; CF_t is operating cash flows for current year, scaled by opening exploration and evaluation assets; and $Growth_{t-1}$ is the natural log of prior year change in total assets.

Table 17 displays the regression of investment efficiency, $INV\_Efficiency_t$, on board centrality and control variables as per the following model:

$$INV\_Efficiency_{i,t} = \theta_0 + \theta_1 Q5\_Centrality\_Board_{i,t} + \theta_2 Q5\_Centrality\_MD_{i,t} + \theta_3 MD\_Tenure_{i,t} + \theta_4 Board\_Size_{i,t} + \theta_5 Indep\_Ned_{i,t} + \theta_6 Busy\_Ned_{i,t} + \theta_7 MVE_{i,t} + \theta_8 RET_{i,t} + \theta_9 SD\_RET_{i,t} + \theta_{10} MTB_{i,t} + \boldsymbol{\varphi} + \epsilon_{i,t},$$

[Insert Table 17 here]

As can be seen in Column (1) of Table 17, where the dependent variable is measured as an absolute value of $INV\_Efficiency_t$, the coefficient on $Q5\_Centrality\_Board_t$ is negative and significant (coefficient = –0.0458, $p < 0.1$). This implies a high centrality board decreases overinvestment. Separating the sample into those over-investing ($INV\_Efficiency_t >= 0$) and those under-investing ($INV\_Efficiency_t < 0$), regression results suggest that board centrality

enhances investments at firms identified as underinvesting as presented in Column (3) (coefficient = 0.0295, $p < 0.1$).

6.4.2. Alternative measure of centrality

Finally, this chapter follows Larcker et al. (2013) to measure board centrality as the quintile of the average of four equally weighted individual centrality measures (*N_score*) as follows:

$$N\_score = Q5\left(\frac{1}{4}\{Q5\_Deg\_Board + Q5\_Bet\_Board + Q5\_Clo\_Board + Q5\_Eig\_Board\}\right)$$

Columns (1) to (3) of Table 18 present findings for investments in exploration assets while Column (4) displays results for equity finance. Consistent with the main findings, the *N_score* is significant and positive across all measures of advising outcomes, supporting the significant benefits brought about by board centrality.

[Insert Table 18 here]

7. Conclusion

In conclusion, this chapter provides evidence of the positive role of board social capital in assisting MEEs during their exploration phase. Specifically, boards of well-connected directors gain access to relevant industry and technical knowledge; this helps directors advise managers on strategic decisions in relation to exploration investments that are expected to increase MEEs' prospectivity and in turn enhance investor confidence in MEEs' future growth. Therefore, coupled with boardroom network serving as an information transfer mechanism that reduces information asymmetry between MEEs and the market, high centrality boards are found to be positively associated with the level of equity finance raised by MEEs.

It is worthwhile mentioning that in this chapter the human capital acquired through boardroom networks is argued to supplement the internal human resources in making strategic decisions. However, the human capital of board members, such as academic qualifications, expertise, and industry memberships and affiliations, were not considered when testing

hypotheses in this chapter. These qualities are particularly important for MEEs due to their financial resource constraints which limit their access to costly advice from external consultants. The next chapter of this thesis will attempt to address this limitation.

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Chapter 2 Tables

Table 1: Sample construction

Panel A: Sample selection		
	Firm-year observations	Unique firms
Board information of metals & mining firms, 2004−2016	7,641	1,018
Less:		
Large mining firms (firms with operating revenue greater than $1 million) & those offering mining services	−1,537	
Firms offering mining services	−178	
Observations with missing financial, market capitalisation or corporate governance data	−826	
Firms that directly expense their exploration and evaluation expenditure (Expensers)	−656	
Final sample of mining exploration entities (MEEs), 2004−2016	4,444	776

Panel B: Sample distribution by year						
	All mining firms		**MEEs only**		**Capitalising MEEs entering the final sample**	
Year	Observations	Percentage	Observations	Percentage	Observations	Percentage
2004	355	4.65	231	3.90	161	3.62
2005	382	5.00	264	4.45	200	4.50
2006	411	5.38	293	4.94	219	4.93
2007	479	6.27	352	5.94	256	5.76
2008	581	7.60	445	7.51	322	7.25
2009	614	8.04	480	8.10	377	8.48
2010	623	8.15	488	8.23	377	8.48
2011	668	8.74	536	9.04	402	9.05
2012	727	9.51	591	9.97	468	10.53
2013	738	9.66	601	10.14	459	10.33
2014	718	9.40	577	9.74	444	9.99
2015	691	9.04	556	9.38	403	9.07
2016	654	8.56	512	8.64	356	8.01
Total	**7,641**	**100.00**	**5,926**	**100.00**	**4,444**	**100.00**

Table 2: Descriptive statistics

Panel A: Economic and board characteristics

	Capitalising MEEs					Non-MEEs					T-test
Variables	Obs	Min	Mean	Median	Max	Obs	Min	Mean	Median	Max	
Firm-level variables											
MVE ($000)	4,444	654.00	38,748.00	10,950.00	664,432.00	1,537	846.00	1,803,443.00	91,486.00	141,000,000.00	11.7461***
MVE	4,444	13.39	16.33	16.21	20.31	1,537	13.65	18.42	18.33	25.67	42.6161***
Total_Asset ($000)	4,444	156.00	26,899.00	10,926.00	359,762.00	1,421	733.00	2,681,997.00	155,000.00	161,000,000.00	14.4286***
Equity ($000)	4,444	0.00	5364.00	1,507.00	85,397.00	1,404	0.00	31,136.00	1,874.00	1,659,351.00	15.5051***
RET	4,444	–0.90	0.16	–0.20	6.01	1,353	–0.95	0.17	–0.07	5.97	0.3972
SD_RET	4,444	0.32	0.91	0.82	2.73	1,429	0.19	0.67	0.59	2.11	–19.7476***
MTB	4,444	–6.35	2.11	1.18	24.37	1,404	–10.06	1.77	1.31	29.83	–3.4593***
Board and MD characteristics											
Board_Size	4,444	3.00	4.03	4.00	7.00	1,537	2.00	5.40	5.00	15.00	32.1917***
Indep_Ned (Number)	4,444	0.00	1.36	1.00	4.00	1,537	0.00	2.38	2.00	13.00	22.4355***
Indep_Ned (%)	4,444	0.00	0.34	0.33	1.00	1,537	0.00	0.40	0.40	1.00	0.6016***
Busy_Ned (Number)	4,444	0.00	0.50	0.00	3.00	1,537	0.00	0.43	0.00	3.00	–3.1762***
Busy_Ned (%)	4,444	0.00	0.13	0.00	0.67	1,537	0.00	0.09	0.00	0.60	–6.8764***
MD_Tenure	4,444	0.00	3.45	2.17	22.56	1,537	0.00	4.76	3.23	25.75	9.5993***

Panel A compares economic and governance statistics between capitalising MEEs and non-MEEs for the period 2004−2016. *MVE ($000)* and *MVE* are the value in thousands and in natural logarithm of market capitalisation, respectively. *Total_Asset ($000)* and *Equity ($000)* are the value in thousands of total assets and proceeds from equity financing, respectively. *RET* is annual buy-and-hold stock return adjusted for dividends and capital changes. *SD_RET* is the annualised standard deviation of monthly stock returns in the prior two years. *MTB* is market-to-book value of equity. *Board_Size* is the number of directors on the board. *Indep_Ned (Number)* and *Indep_Ned (%)* are the number and percentage of independent non-executive directors (NEDs) on the board, respectively. *Busy_Ned (Number)* and *Busy_Ned* (%) are the number and percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board, respectively. *MD_Tenure* is duration (in years) since the MD was appointed. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Panel B: Exploration & evaluation (E&E) assets

		Observations ($000)				Observations scaled by total assets			
Variables	Obs	Min	Mean	Median	Max	Min	Mean	Median	Max
EE_Add	4,444	0.00	2,553.57	1,147.71	23,447.00	0.00	0.16	0.11	0.99
EE_Acq	4,444	0.00	695.48	0.00	22,693.34	0.00	0.04	0.00	0.79
EE_Combined	4,444	0.00	3,361.88	1,380.20	34,392.00	0.00	0.20	0.13	1.21
EE_Bal	4,444	0.00	11,183.96	5,619.79	112,501.00	0.00	0.54	0.60	0.98

Panel B describes the key capitalised components of the E&E asset account for the period 2004−2016, with those on the left side of the table reported in thousands of dollars, and those on the right side of the table scaled by total assets. *EE_Add* is the amount of exploration and evaluation (E&E) asset additions; *EE_Acq* is the amount of E&E asset acquisitions comprising both tenements and other E&E assets; *EE_Combined* is the sum of *EE_Add* and *EE_Acq.* EE_*Bal* is the closing balance of the E&E assets account.

Table 3: Centrality measures

Panel A: Raw centrality measures

Variables	*Capitalising MEEs*					*Non-MEEs*					*T-test*
	Obs	Min	Mean	Median	Max	Obs	Min	Mean	Median	Max	
Centrality_Board	4,444	–0.87	–0.03	–0.12	1.84	1,537	–0.92	–0.05	–0.15	2.07	
Centrality_MD	4,444	–0.98	–0.07	–0.10	2.74	1,537	–1.14	–0.08	–0.09	2.98	
Deg_Board	4,444	2.00	6.59	6.33	15.00	1,537	2.00	7.70	7.50	19.26	12.5454***
Bet_Board	4,444	0.00	9,565.73	3,301.24	68,953.04	1,537	0.00	8,657.75	2,640.68	74,661.52	–2.1948**
Clo_Board	4,444	0.00	0.00	0.00	0.00	1,537	0.00	0.00	0.00	0.00	5.8603***
Eig_Board	4,444	0.00	0.00	0.00	0.07	1,537	0.00	0.01	0.00	1.00	5.4023***
Deg_MD	4,444	0.00	3.62	3.00	15.00	1,537	0.00	5.43	5.00	19.00	17.6924***
Bet_MD	4,444	0.00	2,437.00	0.00	56,875.32	1,537	0.00	2,877.22	0.00	52,396.18	1.7026*
Clo_MD	4,444	0.00	0.00	0.00	0.00	1,537	0.00	0.00	0.00	0.00	9.8877***
Eig_MD	4,444	0.00	0.0002	0.00	0.01	1,537	0.00	0.0033	0.00	1.00	4.0113***

Panel A compares various centrality measures between capitalising MEEs and non-MEEs for the period 2004−2016. *Centrality_Board* and *Centrality_MD* are the average factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the Managing Director (MD), and of the MD, respectively. *Deg_Board, Bet_Board, Clo_Board* and *Eig_Board* are average raw measures of degree, betweenness, closeness, and eigenvector centrality of individual board members excluding the MD, respectively. *Deg_MD, Bet_MD, Clo_MD* and *Eig_MD* are raw measures of degree, betweenness, closeness, and eigenvector centrality of the MD, respectively. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Panel B: Correlation between centrality measures

	Q5_Deg_ Board	*Q5_Bet_ Board*	*Q5_Clo_ Board*	*Q5_Eig_ Board*	*Q5_Deg_ MD*	*Q5_Bet_ MD*	*Q5_Clo_ MD*	*Q5_Eig_ MD*	*Q5_Centrality_ Board*	*Q5_Centrality_ MD*
Q5_Deg_Board	1									
Q5_Bet_Board	0.7974***	1								
Q5_Clo_Board	0.7127***	0.8323***	1							
Q5_Eig_Board	0.5134***	0.5327***	0.5868***	1						
Q5_Deg_MD	0.3270***	0.1662***	0.2297***	0.1469***	1					
Q5_Bet_MD	0.2740***	0.2058***	0.2421***	0.1677***	0.6437***	1				
Q5_Clo_MD	0.4739***	0.4500***	0.5466***	0.3213***	0.7525***	0.4881***	1			
Q5_Eig_MD	0.3995***	0.3583***	0.4156***	0.6314***	0.5667***	0.3923***	0.7112***	1		
Q5_Centrality_Board	0.9228***	0.9066***	0.8170***	0.5594***	0.2756***	0.2628***	0.4879***	0.4085***	1	
Q5_Centrality_MD	0.4126***	0.2975***	0.3625***	0.2196***	0.9412***	0.6267***	0.8700***	0.6498***	0.3898***	1

This table presents the correlation between individual centrality measures and the composite measures for the period 2004−2016. $Q5\_Deg\_Board_t$, $Q5\_Bet\_Board_t$, $Q5\_Clo\_Board_t$ and $Q5\_Eig\_Board_t$ are quintile rank of the average degree, betweenness, closeness and eigenvector centrality of individual board members excluding the MD, respectively. Similarly, $Q5\_Deg\_MD_t$, $Q5\_Bet\_MD_t$, $Q5\_Clo\_MD_t$ and $Q5\_Eig\_MD_t$ are the quintile rank of the MD's degree, betweenness, closeness and eigenvector centrality, respectively. $Q5\_Centrality\_Board_t$ and $Q5\_Centrality\_MD_t$ are the quintile rank of the average factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 4: Pearson's correlation matrix

	EE_Add_{t+1}	EE_Acq_{t+1}	EE_Comb_{t+1}	$Equity_{t+1}$	$Q5\_Centrality\_Board_t$	$Q5\_Centrality\_MD_t$	MD_Tenure_t
EE_Add_{t+1}	1						
EE_Acq_{t+1}	–0.0636***	1					
EE_Comb_{t+1}	0.8764***	0.2300***	1				
$Equity_{t+1}$	0.1512***	0.0574***	0.1747***	1			
$Q5\_Centrality\_Board_t$	0.0372**	0.0615***	0.0504***	0.0600***	1		
$Q5\_Centrality\_MD_t$	0.0504***	0.0108	0.0659***	0.1074***	0.3898***	1	
MD_Tenure_t	0.0541***	–0.0555***	0.0574***	0.0261*	–0.0676***	0.3174***	1
$Board\_Size_t$	0.1073***	–0.0331**	0.1023***	0.0526***	0.2541***	0.3847***	0.0109
$Indep\_Ned_t$	–0.0203	0.0233	–0.0005	0.0033	0.0881***	0.0403***	0.0088
$Busy\_Ned_t$	–0.0272*	–0.0102	–0.0310**	–0.0447***	0.4887***	0.0531***	–0.0226
MVE_t	0.1729***	0.0038	0.1887***	0.1651***	0.1543***	0.2286***	0.0752***
RET_t	0.0753***	0.0374**	0.0963***	0.1673***	0.0337**	0.0147	–0.0033
SD_RET_t	0.0117	0.0136	0.0187	0.0833***	–0.0149	–0.0592***	–0.0551***
MTB_t	–0.0562***	0.0066	–0.0345**	0.1566***	0.0183	–0.0095	–0.0024

Continued	$Board\_Size_t$	$Indep\_Ned_t$	$Busy\_Ned_t$	MVE_t	RET_t	SD_RET_t	MTB_t
$Board\_Size_t$	1						
$Indep\_Ned_t$	0.0717***	1					
$Busy\_Ned_t$	–0.0646***	0.0613***	1				
MVE_t	0.3820***	0.0623***	–0.0380**	1			
RET_t	0.0020	–0.0332**	–0.0219	0.3803***	1		
SD_RET_t	–0.1106***	–0.0241	0.0118	–0.0541***	0.2682***	1	
MTB_t	–0.0255*	–0.0079	0.0286*	0.2957***	0.3661***	0.1171***	1

This table presents the correlation for all variables used for testing H1 to H3 from 2004–2016. EE_Add_{t+1}, EE_Acq_{t+1}, EE_Comb_{t+1} are the natural logarithm of the amount of E&E asset additions, E&E asset acquisitions (comprising both tenements and other E&E assets), and combined E&E asset additions and acquisitions in the following year, respectively. $Equity_{t+1}$ is the natural logarithm of equity proceeds raised in the following year. $Q5\_Centrality\_Board_t$ and $Q5\_Centrality\_MD_t$ are the quintile rank of the average factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively. MD_Tenure_t is duration (in years) since the MD was appointed. $Board\_Size_t$ is the number of directors sitting on the board for the current year. $Indep\_Ned_t$ is the percentage of independent non-executive directors (NEDs) on the board for the current year. $Busy\_Ned_t$ is percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. MVE_t is the natural logarithm of market capitalisation for the current year. RET_t is the annual buy-and-hold stock return adjusted for dividends

and capital changes for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns in the prior two years. *MTB* is the market-to-book value of equity. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5: Association between board centrality and investment advice

		EE_Comb_{t+1}	
Variables	**(1)**	**(2)**	**(3)**
Q5_Centrality_Board$_t$	0.1718**	0.2080***	0.1896**
	(0.0671)	(0.0667)	(0.0762)
Q5_Centrality_MD$_t$	-0.0648	-0.0476	0.0432
	(0.0624)	(0.0616)	(0.0712)
MD_Tenure$_t$	0.0628***	0.0662***	0.0456*
	(0.0163)	(0.0165)	(0.0258)
Board_Size$_t$	0.1252	0.117	-0.1597*
	(0.0813)	(0.0810)	(0.0951)
Indep_Ned$_t$	-0.2603	0.0421	0.0644
	(0.2934)	(0.2904)	(0.3168)
Busy_Ned$_t$	-1.1080**	-1.3669***	-1.2652**
	(0.5275)	(0.5202)	(0.5594)
MVE$_t$	0.6836***	0.5073***	0.7466***
	(0.0735)	(0.0780)	(0.1051)
RET$_t$	0.2505***	0.2891***	0.1875**
	(0.0720)	(0.0768)	(0.0732)
SD_RET$_t$	0.3999**	0.5393***	0.0435
	(0.1917)	(0.1972)	(0.1872)
MTB$_t$	-0.1747***	-0.1776***	-0.0428
	(0.0314)	(0.0308)	(0.0321)
Constant	0.1147	2.6587**	1.3516
	(1.1458)	(1.2040)	(1.6032)
Observations	4444	4444	4444
Year fixed-effects	No	Yes	Yes
Firm fixed-effects	No	No	Yes
Adj. R-squared	5.07%	7.76%	45.18%

This table presents the association between composite board centrality measure and investment advice over the 2004 to 2016 period using the following model:

$$EE\_Comb_{i,t+1} = \theta_0 + \theta_1 Q5\_Centrality\_Board_{i,t} + \theta_2 Q5\_Centrality\_MD_{i,t} + \theta_3 MD\_Tenure_{i,t} + \theta_4 Board\_Size_{i,t} + \theta_5 Indep\_Ned_{i,t} + \theta_6 Busy\_Ned_{i,t} + \theta_7 MVE_{i,t} + \theta_8 RET_{i,t} + \theta_9 SD\_RET_{i,t} + \theta_{10} MTB_{i,t} + \boldsymbol{\varphi} + \epsilon_{i,t}, \quad (1)$$

$EE\_Comb_{t+1,}$ is natural logarithm of the combined E&E assets additions and acquisitions in the following year. *Q5_Centrality_Board*$_t$ *Q5_Centrality_MD*$_t$ are quintile rank of the average of factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively.

MD_Tenure$_t$ is duration (in years) since the MD takes office. *Board_Size*$_t$ is the number of directors sitting on the board for the current year. *Indep_Ned*$_t$ is percentage of independent non-executive directors (NEDs) on the board for the current year. *Busy_Ned*$_t$ is percentage of NEDs on the board who hold two or more board positions in industry peers other than the current board for the current year. *MVE*$_t$ is the natural logarithm of market capitalisation for the current year. *RET*$_t$ is annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. *SD_RET*$_t$ is the annualised standard deviation of monthly stock returns in the prior two years. *MTB*$_t$ is market to book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 6: Association between board centrality and investment advice – Individual measures

				EE_Comb$_{t+1}$				
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Q5_Deg_Board	0.1767***	0.1518**						
	(0.0670)	(0.0750)						
Q5_Deg_MD	-0.0500	0.0331						
	(0.0622)	(0.0704)						
Q5_Bet_Board			0.1693***	0.1874***				
			(0.0599)	(0.0683)				
Q5_Bet_MD			-0.0608	0.0423				
			(0.0471)	(0.0539)				
Q5_Clo_Board					0.1563**	0.2060***		
					(0.0688)	(0.0723)		
Q5_Clo_MD					-0.031	-0.0802		
					(0.0656)	(0.0762)		
Q5_Eig_Board							0.0325	0.0823
							(0.0690)	(0.0655)
Q5_Eig_MD							0.0453	0.0000
							(0.0632)	(0.0621)
Constant	2.7255**	1.4361	2.5619**	1.1781	2.5942**	1.1997	2.6561**	1.2459
	(1.2030)	(1.6022)	(1.2039)	(1.5997)	(1.2035)	(1.6051)	(1.2146)	(1.6046)
Observations	4444	4444	4444	4444	4444	4444	4444	4444
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	No	Yes	No	Yes	No	Yes	No	Yes
Adj. R-squared	7.71%	45.12%	7.74%	45.18%	7.69%	45.16%	7.61%	45.08%

This table presents the association between four board centrality measures and investment advice over the 2004 to 2016 period using the following model:

$$EE\_Comb_{i,t+1} = \theta_0 + \theta_1 Q5\_Centrality\_Board_{i,t} + \theta_2 Q5\_Centrality\_MD_{i,t} + \theta_3 MD\_Tenure_{i,t} + \theta_4 Board\_Size_{i,t} + \theta_5 Indep\_Ned_{i,t} + \theta_6 Busy\_Ned_{i,t} + \theta_7 MVE_{i,t} + \theta_8 RET_{i,t} + \theta_9 SD\_RET_{i,t} + \theta_{10} MTB_{i,t} + \boldsymbol{\varphi} + \epsilon_{i,t}, \quad (1)$$

$EE\_Comb_{t+1,}$ is natural logarithm of the combined E&E assets additions and acquisitions in the following year, respectively. $Q5\_Centrality\_Board_t$ comprises $Q5\_Deg\_Board_t$, $Q5\_Bet\_Board_t$, $Q5\_Clo\_Board_t$ and $Q5\_Eig\_Board_t$, which are quintile rank of the average degree, betweenness, closeness and eigenvector centrality of individual board members excluding the MD, respectively. $Q5\_Centrality\_MD_t$ comprises $Q5\_ Deg\_MD_t$, $Q5\_ Bet\_MD_t$, $Q5\_Clo\_MD_t$ and $Q5\_Eig\_MD_t$ which are quintile rank MD's degree, betweenness, closeness and eigenvector centrality. MD_Tenure_t is duration (in years) since the MD takes office. $Board\_Size_t$ is the number of directors sitting on the board for the current year. $Indep\_Ned_t$ is percentage of independent non-executive directors (NEDs) on the board for the current year. $Busy\_Ned_t$ is percentage of NEDs on the board who hold two or more board positions in industry peers other than the current board for the current year. MVE_t is the natural logarithm of market capitalisation for the current year. RET_t is annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns in the prior two years. MTB_t is market to book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 7: Association between board centrality and equity finance

		$Equity_{t+1}$	
Variables	**(1)**	**(2)**	**(3)**
Q5_Centrality_Board$_t$	0.2387***	0.2168**	0.033
	(0.0881)	(0.0871)	(0.1099)
Q5_Centrality_MD$_t$	0.3544***	0.3724***	0.2446**
	(0.0795)	(0.0785)	(0.1015)
MD_Tenure$_t$	-0.0015	-0.0213	0.015
	(0.0235)	(0.0232)	(0.0375)
Board_Size$_t$	-0.1375	-0.0548	-0.2263*
	(0.1085)	(0.1080)	(0.1362)
Indep_Ned$_t$	0.017	0.1451	0.4594
	(0.3523)	(0.3503)	(0.4319)
Busy_Ned$_t$	-2.6885***	-2.3750***	-0.838
	(0.6423)	(0.6407)	(0.8155)
MVE$_t$	0.4062***	0.3330***	0.2318*
	(0.0835)	(0.0869)	(0.1275)
RET$_t$	0.4283***	0.2174**	0.2007**
	(0.0825)	(0.0863)	(0.0942)
SD_RET$_t$	0.9177***	1.0621***	0.7047***
	(0.2265)	(0.2342)	(0.2598)
MTB$_t$	0.1839***	0.1695***	0.1753***
	(0.0254)	(0.0253)	(0.0311)
Constant	2.4509*	3.2448**	8.9023***
	(1.2908)	(1.3450)	(1.9247)
Observations	4444	4444	4444
Year fixed-effects	No	Yes	Yes
Firm fixed-effects	No	No	Yes
Adj. R-squared	5.98%	9.63%	23.61%

This table presents the association between composite board centrality and MEEs' future fund raisings over the 2004 and 2016 period using the following model:

$$Equity_{i,t+1} = \theta_0 + \theta_1 Q5\_Centrality\_Board_{i,t} + \theta_2 Q5\_Centrality\_MD_{i,t} + \theta_3 MD\_Tenure_{i,t} + \theta_4 Board\_Size_{i,t} + \theta_5 Indep\_Ned_{i,t} + \theta_6 Busy\_Ned_{i,t} + \theta_7 MVE_{i,t} + \theta_8 RET_{i,t} + \theta_9 SD\_RET_{i,t} + \theta_{10} MTB_{i,t} + \boldsymbol{\varphi} + \epsilon_{i,t}, \quad (2)$$

Equity$_{t+1}$ is natural logarithm of equity proceeds raised in year following year. *Q5_Centrality_Board*$_t$ *Q5_Centrality_MD*$_t$ are quintile rank of the average of factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively.

MD_Tenure$_t$ is duration (in years) since the MD takes office. *Board_Size*$_t$ is the number of directors sitting on the board for the current year. *Indep_Ned*$_t$ is percentage of independent non-executive directors (NEDs) on the board for the current year. *Busy_Ned*$_t$ is percentage of NEDs on the board who hold two or more board positions in industry peers other than the current board for the current year. *MVE*$_t$ is the natural logarithm of market capitalisation for the current year. *RET*$_t$ is annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. *SD_RET*$_t$ is the annualised standard deviation of monthly stock returns in the prior two years. *MTB*$_t$ is market to book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 8: Association between board centrality and equity finance – Individual measures

				Equity$_{t+1}$				
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Q5_Deg_Board	0.2388***	-0.0048						
	(0.0863)	(0.1062)						
Q5_Deg_MD	0.2863***	0.1898*						
	(0.0791)	(0.1011)						
Q5_Bet_Board			0.3454***	0.1265				
			(0.0784)	(0.0991)				
Q5_Bet_MD			0.1015*	0.0709				
			(0.0567)	(0.0751)				
Q5_Clo_Board					0.1392	0.1367		
					(0.0895)	(0.1117)		
Q5_Clo_MD					0.3877***	0.1877*		
					(0.0833)	(0.1101)		
Q5_Eig_Board							-0.1006	-0.0416
							(0.0846)	(0.0935)
Q5_Eig_MD							0.3332***	0.1229
							(0.0790)	(0.0901)
Constant	3.1667**	8.9305***	2.5388*	8.6448***	3.1333**	8.7464***	3.1365**	8.9220***
	(1.3454)	(1.9247)	(1.3414)	(1.9335)	(1.3462)	(1.9238)	(1.3561)	(1.9311)
Observations	4444	4444	4444	4444	4444	4444	4444	4444
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	No	Yes	No	Yes	No	Yes	No	Yes
Adj. R-squared	9.32%	23.53%	9.24%	23.51%	9.68%	23.65%	9.15%	23.50%

This table presents the association between four board centrality measures and MEEs' future fund raisings over the 2004 and 2016 period using the following model:

$$Equity_{i,t+1} = \theta_0 + \theta_1 Q5\_Centrality\_Board_{i,t} + \theta_2 Q5\_Centrality\_MD_{i,t} + \theta_3 MD\_Tenure_{i,t} + \theta_4 Board\_Size_{i,t} + \theta_5 Indep\_Ned_{i,t} + \theta_6 Busy\_Ned_{i,t} + \theta_7 MVE_{i,t} + \theta_8 RET_{i,t} + \theta_9 SD\_RET_{i,t} + \theta_{10} MTB_{i,t} + \boldsymbol{\varphi} + \boldsymbol{\omega} + \epsilon_{i,t}, \quad (2)$$

Equity$_{t+1}$ is natural logarithm of equity proceeds raised in year following year. *Q5_Centrality_Board$_t$* comprises *Q5_Deg_Board$_t$*, *Q5_Bet_Board$_t$*, *Q5_Clo_Board$_t$* and *Q5_Eig_Board$_t$*, which are quintile rank of the average degree, betweenness, closeness and eigenvector centrality of individual board members excluding the MD, respectively.

Similarly, $Q5\_Centrality\_MD_t$ comprises individual $Q5\_Deg\_MD_t$, $Q5\_Bet\_MD_t$, $Q5\_Clo\_MD_t$ and $Q5\_Eig\_MD_t$ which are quintile rank of the MD's degree, betweenness, closeness and eigenvector centrality, respectively. MD_Tenure_t is duration (in years) since the MD takes office. $Board\_Size_t$ is the number of directors sitting on the board for the current year. $Indep\_Ned_t$ is percentage of independent non-executive directors (NEDs) on the board for the current year. $Busy\_Ned_t$ is percentage of NEDs on the board who hold two or more board positions in industry peers other than the current board for the current year. MVE_t is the natural logarithm of market capitalisation for the current year. RET_t is annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns in the prior two years. MTB_t is market to book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses

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Table 9: Mediating effect of exploration asset investments

Variables		*Equity*$_{t+1}$	
	(1)	(2)	(3)
Q5_Centrality_Board$_t$	0.2168**	0.1706**	0.1813**
	(0.0859)	(0.0854)	(0.0851)
Q5_Centrality_MD$_t$	0.3724***	0.3837***	0.3805***
	(0.0767)	(0.0760)	(0.0759)
EE_Add$_{t+1}$		0.1445***	
		(0.0168)	
EE_Acq$_{t+1}$		0.0674***	
		(0.0183)	
EE_Comb$_{t+1}$			0.1706***
			(0.0182)
Constant	5.1185***	4.6303***	4.5785***
	(1.3793)	(1.3446)	(1.3432)
Mediating effect		0.0462***	0.0355***
[p-value]		[0.001]	[0.004]
% of total effect mediated		21.31%	16.37%
Observations	4,444	4,444	4,444
Controls	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes
Adj. R-squared	9.63%	11.27%	11.37%

This table presents the mediating analysis of investments in E&E assets on the association between board centrality and MEEs' future fundraisings between 2004–2016. The mediating test involves 3 steps with the first two steps performed in Models (1) and (2). The final step is estimated using Model 3 as follows:

$$Equity_{i,t+1} = \theta_0 + \theta_1 Q5\_Centrality\_Board_{i,t} + \theta_2 Q5\_Centrality\_MD_{i,t} + \theta_3 EE\_Investment_{i,t+1} + \theta_4 MD\_Tenure_{i,t} + \theta_5 Board\_Size_{i,t} + \theta_6 Indep\_Ned_{i,t} + \theta_7 Busy\_Ned_{i,t} + \theta_8 MVE_{i,t} + \theta_9 RET_{i,t} + \theta_{10} SD\_RET_{i,t} + \theta_{11} MTB_{i,t} + \boldsymbol{\varphi} + \epsilon_{i,t}, \quad (3)$$

Equity$_{t+1}$ is the natural logarithm of equity proceeds raised in the following year. *Q5_Centrality_Board*$_t$ and *Q5_Centrality_MD*$_t$ are the quintile rank of the average factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively, for the current year. In Column (2), *EE_Investment*$_{t+1}$ includes both *EE_Add*$_{t+1}$ and EE_*Acq*$_{t+1}$ which, are the natural logarithm of the amount of E&E asset additions and E&E asset acquisitions (comprising both tenements and other E&E assets) in the following year, respectively. In Column (3), *EE_Investment*$_{t+1}$ is replaced with *EE_Comb*$_{t+1,}$ which is the combined E&E asset additions and acquisitions in the following year. *MD_Tenure*$_t$ is the duration (in years) since the MD was appointed. *Board_Size*$_t$ is the number of directors sitting on the board for the current year. *Indep_Ned*$_t$ is percentage of independent non-executive directors (NEDs) on the board for the current year. *Busy_Ned*$_t$ is percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. *MVE*$_t$ is the natural logarithm of market capitalisation for the current year. *RET*$_t$ is the annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. *SD_RET*$_t$ is the annualised standard deviation of monthly stock returns in the prior two years. *MTB*$_t$ is the market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 10: Joint effect of board busyness and centrality on investment advice

Variable	*Δ_EE_Add* (1)	*Δ_EE_Acq* (2)	*Δ_EE_Comb* (3)	*Δ_EE_Add* (4)	*Δ_EE_Acq* (5)	*Δ_EE_Comb* (6)
Treated	–0.0163	–0.6040*	–0.3253			
	(0.2455)	(0.3570)	(0.2773)			
Treated_Board				0.0429	–0.6125	–0.2992
				(0.2695)	(0.3855)	(0.2937)
Treated_MD				–0.4746	–0.5386	–0.5278
				(0.8880)	(1.3634)	(0.9073)
Δ_MD_Tenure	0.0309	–0.0609*	0.0168	0.0306	–0.0609*	0.0167
	(0.0294)	(0.0343)	(0.0293)	(0.0295)	(0.0344)	(0.0293)
Δ_Board_Size	0.1869**	0.3167***	0.2884***	0.1874**	0.3167***	0.2886***
	(0.0842)	(0.1161)	(0.0875)	(0.0842)	(0.1162)	(0.0875)
Δ_Indep_Ned	–0.3692	–0.6313*	–0.3725	–0.3732	–0.6307*	–0.3743
	(0.2812)	(0.3683)	(0.2907)	(0.2817)	(0.3689)	(0.2911)
Δ_Busy_Ned	0.3510	–1.0860*	–0.1679	0.3547	–1.0865*	–0.1662
	(0.5142)	(0.6508)	(0.5181)	(0.5144)	(0.6512)	(0.5187)
Δ_MVE	0.9335***	0.4131***	0.9945***	0.9340***	0.4130***	0.9947***
	(0.1013)	(0.1262)	(0.1018)	(0.1013)	(0.1262)	(0.1018)
Δ_RET	–0.2877***	0.0746	–0.2377***	–0.2880***	0.0747	–0.2378***
	(0.0703)	(0.0923)	(0.0717)	(0.0703)	(0.0923)	(0.0717)
Δ_SD_RET	0.0388	0.5477**	0.2636	0.0374	0.5479**	0.2630
	(0.1647)	(0.2213)	(0.1663)	(0.1649)	(0.2214)	(0.1663)
Δ_MTB	–0.0589**	–0.1339***	–0.1371***	–0.0589**	–0.1339***	–0.1371***
	(0.0293)	(0.0270)	(0.0312)	(0.0293)	(0.0270)	(0.0312)
Constant	–0.6632***	–0.3890***	–0.7753***	–0.6629***	–0.3890***	–0.7752***
	(0.0832)	(0.1107)	(0.0873)	(0.0832)	(0.1107)	(0.0874)
Observations	3,595	3,595	3,595	3,595	3,595	3,595
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	5.36%	1.73%	7.23%	5.34%	1.71%	7.21%

This table presents the joint test of board busyness and centrality on board investment advice by exploiting a quasi-natural experiment over the 2004–2016 period using the following model:

$$\Delta\_EE\_Add \textbf{ or } \Delta\_EE\_Acq \textbf{ or } \Delta\_EE\_Comb = \theta_0 + \theta_1 Treated_{i,t} + \theta_2 \Delta\_MD\_Tenure_{i,t} + \theta_3 \Delta\_Board\_Size_{i,t} + \theta_4 \Delta\_Indep\_Ned_{i,t} + \theta_5 \Delta\_Busy\_Ned_{i,t} + \theta_6 \Delta\_MVE_{i,t} + \theta_7 \Delta\_RET_{i,t} + \theta_8 \Delta\_SD\_RET_{i,t} + \theta_9 \Delta\_MTB_{i,t} + \boldsymbol{\varphi} + \epsilon_{i,t}, \quad (4)$$

Treated is the number of cases in which the board has a director whose role at the target firm was terminated following an M&A shock (shocked director). In Columns (4) to (6), *Treated* is separated into *Treated_Board* and *Treated_MD* which are the number of cases in which the board has a member who is not the MD and who is the MD, whose role at the target firm was terminated following an M&A shock, respectively. Shocked directors must maintain their role at the board of treated firms in year t+1 where t is the financial year target firms were delisted from the stock exchange following successful M&As, causing directors to lose their board seats (Hauser, 2018). All other dependent and independent variables are in change form which captures the changes over time using the t–1 to t+1 window. *EE_Add, EE_Acq* or *EE_Comb* are the natural logarithm of the amount of E&E asset additions, E&E asset acquisitions (comprising both tenements and other E&E assets), and combined E&E asset additions and acquisitions, respectively. *MD_Tenure* is the duration (in years) since the MD was appointed. *Board_Size* is the number of directors sitting on the board. *Indep_Ned* is the percentage of independent non-executive directors (NEDs) on the board. *Busy_Ned* is the percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board. *MVE* is the natural logarithm of market capitalisation. *RET* is the annual buy-and-hold stock return adjusted for dividends and capital changes. *SD_RET* is the annualised standard deviation of monthly stock returns. *MTB* is the market-to-book value of equity. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 11: Joint effect of board busyness and centrality on equity finance

Variables	*Δ_Equity* (1)	*Δ_Equity* (2)
Treated	–0.0685	
	(0.3802)	
Treated_Board		–0.3063
		(0.4148)
Treated_MD		1.7737
		(1.3309)
Δ_MD_Tenure	–0.0112	–0.0098
	(0.0448)	(0.0447)
Δ_Board_Size	–0.0645	–0.0664
	(0.1249)	(0.1250)
Δ_Indep_Ned	–0.3629	–0.347
	(0.4271)	(0.4269)
Δ_Busy_Ned	0.4627	0.4477
	(0.7603)	(0.7615)
Δ_MVE	2.2333***	2.2314***
	(0.1332)	(0.1333)
Δ_RET	–0.1432	–0.1421
	(0.0917)	(0.0917)
Δ_SD_RET	0.6827***	0.6882***
	(0.2420)	(0.2424)
Δ_MTB	–0.0246	–0.0246
	(0.0291)	(0.0291)
Constant	–0.2031	–0.2044
	(0.1344)	(0.1344)
Observations	3,608	3,608
Year fixed-effects	Yes	Yes
Adj. R-squared	13.97%	13.99%

This table presents the joint test of board busyness and centrality on future fundraising by exploiting a quasi-natural experiment over the 2004–2016 period using the following model:

$$\Delta\_Equity = \theta_0 + \theta_1 Treated_{i,t} + \theta_2 \Delta\_MD\_Tenure_{i,t} + \theta_3 \Delta\_Board\_Size_{i,t} + \theta_4 \Delta\_Indep\_Ned_{i,t} + \theta_5 \Delta\_Busy\_Ned_{i,t} + \theta_6 \Delta\_MVE_{i,t} + \theta_7 \Delta\_RET_{i,t} + \theta_8 \Delta\_SD\_RET_{i,t} + \theta_9 \Delta\_MTB_{i,t} + \boldsymbol{\varphi} + \epsilon_{i,t}, \quad (5)$$

Treated is the number of cases in which the board has a director whose role at the target firm was terminated following an M&A shock (shocked director). In Column (2), *Treated* is separated into *Treated_Board* and *Treated_MD* which are the number of cases in which the board has a member who is not the MD and who is the MD, whose role at the target firm was terminated following an M&A shock, respectively. Shocked directors must maintain their role at the board of treated firms in year *t*+1 where *t* is the financial year target firms were delisted from the stock exchange following successful M&As, causing directors to lose their board seats (Hauser, 2018). All other dependent and independent variables are in change form, which captures the changes over time using the *t*–1 to *t*+1 window. *Equity* is the natural logarithm of equity proceeds. *MD_Tenure* is the duration (in years) since the MD was appointed. *Board_Size* is the number of directors sitting on the board. *Indep_Ned* is the percentage of independent non-executive directors (NEDs) on the board. *Busy_Ned* is the percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board. *MVE* is the natural logarithm of market capitalisation. *RET* is the annual buy-and-hold stock return adjusted for dividends and capital changes. *SD_RET* is the annualised standard deviation of monthly stock returns. *MTB* is the market-to-book value of equity. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 12: Association between board centrality and stock returns

Variables	Δ_RET (1)	Δ_RET (2)
$Q5\_Centrality\_Board\_MD_t$	0.0255*	
	(0.0132)	
$Q5\_Centrality\_Board_t$		0.0169
		(0.0142)
$Q5\_Centrality\_MD_t$		0.0292**
		(0.0144)
MVE_t	–0.3607***	–0.3677***
	(0.0160)	(0.0164)
MTB_t	–0.0380***	–0.0371***
	(0.0070)	(0.0070)
SD_RET_t	–0.7247***	–0.7202***
	(0.0510)	(0.0508)
Δ_RET_{t-1}	–0.4951***	–0.4947***
	(0.0168)	(0.0168)
Constant	6.5999***	6.6489***
	(0.2651)	(0.2669)
Observations	3,633	3,633
Year fixed-effects	Yes	Yes
Adj. R-squared	49.09%	49.14%

This table presents the association between board centrality and stock returns over the 2004–2016 period using the following model:

$$\Delta\_RET_{i,t} = \theta_0 + \theta_1 Board\_Connections_{i,t} + \theta_2 MVE_{i,t} + \theta_3 MTB_{i,t} + \theta_4 SD\_RET_{i,t} + \theta_5 \Delta\_RET_{i,t-1} + \boldsymbol{\varphi} + \epsilon_{i,t}, \quad (6)$$

Δ_RET is the change of stock return between year t and t+1. $Board\_Connections_t$ is $Q5\_Centrality\_Board\_MD_t$ in Column (1) or separately measured by $Q5\_Centrality\_Board_t$ and $Q5\_Centrality\_MD_t$ in Column (2). $Q5\_Centrality\_Board\_MD_t$ is the quintile rank of the average factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of the entire board including the MD for the current year. $Q5\_Centrality\_Board_t$ and $Q5\_Centrality\_MD_t$ are the quintile rank of average factor score of centrality measures of individual board members excluding the MD, and of the MD, respectively, for the current year. Δ_RET_{t-1} is the lagged Δ_RET_t. MVE_t is the natural logarithm of market capitalisation for the current year. MTB_t is the market-to-book value of equity for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns over the prior two years. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 13: Association between board centrality and stock returns – individual measures

Variables	Δ_RET			
	(1)	(2)	(3)	(4)
$Q5\_Deg\_Board_t$	0.0148			
	(0.0137)			
$Q5\_Deg\_MD_t$	0.0266*			
	(0.0141)			
$Q5\_Bet\_Board_t$		0.0224*		
		(0.0133)		
$Q5\_Bet\_MD_t$		0.0120		
		(0.0114)		
$Q5\_Clo\_Board_t$			0.0150	
			(0.0162)	
$Q5\_Clo\_MD_t$			0.0252	
			(0.0164)	
$Q5\_Eig\_Board_t$				–0.0084
				(0.0161)
$Q5\_Eig\_MD_t$				0.0331**
				(0.0148)
MVE_t	–0.3668***	–0.3602***	–0.3650***	–0.3625***
	(0.0163)	(0.0159)	(0.0164)	(0.0163)
MTB_t	–0.0371***	–0.0381***	–0.0376***	–0.0375***
	(0.0070)	(0.0070)	(0.0070)	(0.0070)
SD_RET_t	–0.7200***	–0.7255***	–0.7230***	–0.7214***
	(0.0509)	(0.0510)	(0.0507)	(0.0509)
Δ_RET_{t-1}	–0.4949***	–0.4948***	–0.4946***	–0.4941***
	(0.0168)	(0.0168)	(0.0168)	(0.0168)
Constant	6.6528***	6.5785***	6.6257***	6.6426***
	(0.2661)	(0.2649)	(0.2680)	(0.2684)
Observations	3,633	3,633	3,633	3,633
Year fixed-effects	Yes	Yes	Yes	Yes
Adj. R-squared	49.11%	49.09%	49.13%	49.10%

This table presents the association between individual board centrality measures and stock returns over the 2004–2016 period using the following model:

$$\Delta\_RET_{i,t} = \theta_0 + \theta_1 Board\_Connections_{i,t} + \theta_2 MVE_{i,t} + \theta_3 MTB_{i,t} + \theta_4 SD\_RET_{i,t} + \theta_5 \Delta\_RET_{i,t-1} + \boldsymbol{\varphi} + \epsilon_{i,t}, \quad (7)$$

Δ_RET is the change of stock return between year t and t+1. $Board\_Connections_t$ is separately measured by $Q5\_Deg\_Board_t$, $Q5\_Bet\_Board_t$, $Q5\_Clo\_Board_t$ and $Q5\_Eig\_Board_t$, which are the quintile rank of the average degree, betweenness, closeness and eigenvector centrality of individual board members excluding the MD, respectively and $Q5\_Deg\_MD_t$, $Q5\_Bet\_MD_t$, $Q5\_Clo\_MD_t$ and $Q5\_Eig\_MD_t$ which are the quintile rank of the MD's degree, betweenness, closeness and eigenvector centrality, respectively. Δ_RET_{t-1} is the lagged Δ_RET_t. MVE_t is the natural logarithm of market capitalisation for the current year. MTB_t is the market-to-book value of equity for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns over the prior two years. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 14: Moderating effect of board centrality

		Equity$_{t+1}$	
Variables	**(1)**	**(2)**	**(3)**
Q5_Centrality_Board$_t$ *x Low_EE_Add*$_t$	0.4525***		
	(0.1635)		
Q5_Centrality_Board$_t$ *x Low_EE_Acq*$_t$		0.0054	
		(0.1707)	
Q5_Centrality_Board$_t$ *x Low_EE_Comb*$_t$			0.4329***
			(0.1671)
Q5_Centrality_Board$_t$	0.1199	0.1957	0.1125
	(0.0914)	(0.1653)	(0.0909)
Low_EE_Add$_t$	–2.5111***		
	(0.5489)		
Low_EE_Acq$_t$		–0.7220	
		(0.5971)	
Low_EE_Comb$_t$			–3.0109***
			(0.5443)
Q5_Centrality_MD$_t$	0.3575***	0.3650***	0.3474***
	(0.0783)	(0.0785)	(0.0781)
Constant	4.5125***	3.9317***	5.5579***
	(1.3639)	(1.4549)	(1.3780)
Observations	4,444	4,444	4,444
Controls	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes
Adj. R-squared	10.29%	9.76%	10.91%

This table presents the moderating effect of board centrality using the following model:

$$Equity_{i,t+1} = \theta_0 + \theta_1 Centrality\_Board \times Low\_EE\_Investment_{i,t} + \theta_2 Q5\_Centrality\_Board_{i,t} + \theta_3 Low\_EE\_Investment_{i,t} + \theta_4 Q5\_Centrality\_MD_{i,t} + \theta_5 MD\_Tenure_{i,t} + \theta_6 Board\_Size_{i,t} + \theta_7 Indep\_Ned_{i,t} + \theta_8 Busy\_Ned_{i,t} + \theta_9 MVE_{i,t} + \theta_{10} RET_{i,t} + \theta_{11} SD\_RET_{i,t} + \theta_{12} MTB_{i,t} + \boldsymbol{\varphi} + \epsilon_{i,t}, \quad (9)$$

Equity$_{t+1}$ is natural logarithm of equity proceeds raised in the following year. *Q5_Centrality_Board*$_t$ and *Q5_Centrality_MD*$_t$ are the quintile rank of the average factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively. *Low_EE_Investments*$_t$ are *Low_EE_Add*$_t$, *Low_EE_Acq*$_t$ or *Low_EE_Comb*$_t$ which are indicator variables coded 1 if E&E asset additions, E&E asset acquisitions (comprising both tenements and other E&E assets), and combined E&E asset additions and acquisitions are in the lowest quintile of each year sample, respectively. *MD_Tenure*$_t$ is the duration (in years) since the MD was appointed. *Board_Size*$_t$ is the number of directors sitting on the board for the current year. *Indep_Ned*$_t$ is the percentage of independent non-executive directors (NEDs) on the board for the current year. *Busy_Ned*$_t$ is the percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. *MVE*$_t$ is the natural logarithm of market capitalisation for the current year. *RET*$_t$ is the annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. *SD_RET*$_t$ is the annualised standard deviation of monthly stock returns in the prior two years. *MTB*$_t$ is the market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 15: Moderating effect of board busyness

Variables	EE_Add_{t+1} (1)	EE_Acq_{t+1} (2)	EE_Comb_{t+1} (3)	$Equity_{t+1}$ (4)
$Q5\_Centrality\_BoardxBusy_t$	-0.1869	-0.0951	-0.0979	0.7363***
	(0.1939)	(0.1866)	(0.1775)	(0.2386)
$Q5\_Centrality\_Board_t$	0.1313*	0.2711***	0.1440**	0.0625
	(0.0704)	(0.0671)	(0.0635)	(0.0815)
$Q5\_Centrality\_MD_t$	-0.1027	0.0947	-0.0317	0.3796***
	(0.0659)	(0.0644)	(0.0610)	(0.0784)
$Busy_t$	0.4367	-0.083	0.1148	-3.8187***
	(0.7743)	(0.7582)	(0.7158)	(1.0016)
MD_Tenure_t	0.0685***	-0.0666***	0.0624***	-0.021
	(0.0184)	(0.0165)	(0.0164)	(0.0231)
$Board\_Size_t$	0.2387***	-0.3307***	0.1335	-0.0715
	(0.0916)	(0.0854)	(0.0825)	(0.1088)
$Indep\_Ned_t$	-0.4386	0.4957*	0.0147	0.1666
	(0.3096)	(0.2846)	(0.2908)	(0.3500)
MVE_t	0.5622***	-0.0541	0.5159***	0.3450***
	(0.0821)	(0.0661)	(0.0780)	(0.0868)
RET_t	0.2482***	0.1744**	0.2936***	0.2159**
	(0.0872)	(0.0863)	(0.0767)	(0.0861)
SD_RET_t	0.5420**	0.0101	0.5359***	1.0461***
	(0.2130)	(0.1966)	(0.1974)	(0.2338)
MTB_t	-0.2207***	-0.0135	-0.1802***	0.1731***
	(0.0322)	(0.0248)	(0.0309)	(0.0256)
Constant	1.138	3.3626***	2.4989**	3.3899**
	(1.2662)	(1.0284)	(1.2067)	(1.3484)
Observations	4444	4444	4444	4444
Year fixed-effects	Yes	Yes	Yes	Yes
Adj. R-squared	6.48%	1.08%	7.62%	9.76%

This table presents the impact of board busyness on the association between board centrality and board advising over the 2004–2016 period.

$$EE\_Investment_{i,t+1} \text{ or } Equity_{i,t+1} = \theta_0 + \theta_1 Q5\_Centrality\_Board \times Busy_{i,t} + \theta_2 Q5\_Centrality\_Board_{i,t} + \theta_3 Q5\_Centrality\_MD_{i,t} + \theta_4 Busy_{i,t} + \theta_5 MD\_Tenure_{i,t} + \theta_6 Board\_Size_{i,t} + \theta_7 Indep\_Ned_{i,t} + \theta_8 MVE_{i,t} + \theta_9 RET_{i,t} + \theta_{10} SD\_RET_{i,t} + \theta_{11} MTB_{i,t} + \boldsymbol{\varphi} + \boldsymbol{\omega} + \epsilon_{i,t}, \quad (9)$$

$EE\_Investments_{t+1}$ can be EE_Add_{t+1}, EE_Acq_{t+1} or EE_Comb_{t+1}, which are the natural logarithm of the amount of E&E asset additions, E&E asset acquisitions (comprising both tenements and other E&E assets), and combined E&E asset additions and acquisitions in the following year, respectively. $Equity_{t+1}$ is natural logarithm of equity proceeds raised in year following year.

$Q5\_Centrality\_Board_t$ and $Q5\_Centrality\_MD_t$ are quintile rank of the average of factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively, for the current year. $Q5\_Centrality\_BoardxBusy_t$ is the interaction term between $Q5\_Centrality\_Board_t$ and $Busy_t$. $Busy_t$ is a binary variable coded 1 if the measure of director busyness, which is the percentage of the board having NEDs who hold two or more board positions in industry peers other than the current board, is in the top quintile of each year sample, and 0 otherwise. MD_Tenure_t is duration (in years) since the MD takes office. $Board\_Size_t$ is the number of directors sitting on the board for the current year. $Indep\_Ned_t$ is percentage of independent non-executive directors (NEDs) on the board for the current year. MVE_t is the natural logarithm of market capitalisation for the current year. RET_t is annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns in the prior two years. MTB_t is market to book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 16: Association between board centrality and investment advice using scaled E&E

Variables	EE_Add_{t+1} (1)	EE_Acq_{t+1} (2)	EE_Comb_{t+1} (3)
$Q5\_Centrality\_Board_t$	0.0117**	0.0218***	0.0378***
	(0.0059)	(0.0080)	(0.0138)
$Q5\_Centrality\_MD_t$	0.0058	–0.0050	–0.0007
	(0.0051)	(0.0078)	(0.0126)
MD_Tenure_t	–0.0028*	–0.0054***	–0.0080**
	(0.0016)	(0.0012)	(0.0035)
$Board\_Size_t$	–0.0068	–0.0214***	–0.0283**
	(0.0058)	(0.0068)	(0.0122)
$Indep\_Ned_t$	0.0310	0.0840***	0.1093**
	(0.0230)	(0.0304)	(0.0485)
$Busy\_Ned_t$	–0.0278	–0.0817	–0.1296
	(0.0452)	(0.0508)	(0.0983)
MVE_t	–0.0308***	–0.0261***	–0.0657***
	(0.0058)	(0.0068)	(0.0132)
RET_t	0.0389***	0.0154*	0.0488***
	(0.0083)	(0.0090)	(0.0151)
SD_RET_t	0.0505***	–0.0253	0.0450
	(0.0178)	(0.0167)	(0.0338)
MTB_t	0.0156***	0.0118**	0.0319***
	(0.0044)	(0.0058)	(0.0114)
Constant	0.5995***	0.5412***	1.2711***
	(0.0896)	(0.1050)	(0.2000)
Observations	3,480	3,480	3,480
Year fixed-effects	Yes	Yes	Yes
Adj. R-squared	8.08%	2.21%	5.08%
Mean VIF	2.36	2.36	2.36

This table presents the association between the composite board centrality measure and investment advice over the 2004–2016 period using the following model:

$$EE\_Investment_{i,t+1} = \theta_0 + \theta_1 Q5\_Centrality\_Board_{i,t} + \theta_2 Q5\_Centrality\_MD_{i,t} + \theta_3 MD\_Tenure_{i,t} + \theta_4 Board\_Size_{i,t} + \theta_5 Indep\_Ned_{i,t} + \theta_6 Busy\_Ned_{i,t} + \theta_7 MVE_{i,t} + \theta_8 RET_{i,t} + \theta_9 SD\_RET_{i,t} + \theta_{10} MTB_{i,t} + \boldsymbol{\varphi} + \epsilon_{i,t}, \quad (1)$$

$EE\_Investments_{t+1}$ can be EE_Add_{t+1}, EE_Acq_{t+1} or EE_Comb_{t+1}, which are the amount in the following year of E&E asset additions, E&E asset acquisitions (comprising both tenements and other E&E assets), and combined E&E asset additions and acquisitions which are scaled by opening assets, respectively. $Q5\_Centrality\_Board_t$ and $Q5\_Centrality\_MD_t$ are the quintile rank of the average factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively. MD_Tenure_t is the duration (in years) since the MD was appointed. $Board\_Size_t$ is the number of directors sitting on the board for the current year. $Indep\_Ned_t$ is the percentage of independent non-executive directors (NEDs) on the board for the current year. $Busy\_Ned_t$ is percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. MVE_t is the natural logarithm of market capitalisation for the current year. RET_t is the annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns in the prior two years. MTB_t is the market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 17: Association between board centrality and investment efficiency

Variables	$\|INV\_Efficiency_t\|$ (1)	$INV\_Efficiency_t >= 0$ (2)	$INV\_Efficiency_t < 0$ (3)
$Q5\_Centrality\_Board_t$	–0.0458*	–0.0260	0.0295*
	(0.0259)	(0.0544)	(0.0166)
$Q5\_Centrality\_MD_t$	0.0310	0.0199	–0.0172
	(0.0246)	(0.0567)	(0.0155)
MD_Tenure_t	–0.0133*	–0.0263	0.0073*
	(0.0069)	(0.0170)	(0.0043)
$Board\_Size_t$	–0.0021	–0.0262	0.0229
	(0.0273)	(0.0664)	(0.0168)
$Indep\_Ned_t$	0.0354	0.0027	–0.0175
	(0.0989)	(0.2261)	(0.0612)
$Busy\_Ned_t$	0.7303***	0.6289	–0.4124***
	(0.2172)	(0.4222)	(0.1445)
MVE_t	0.1132***	0.2776***	–0.0594***
	(0.0278)	(0.0705)	(0.0177)
RET_t	–0.0231	–0.1026	0.0774**
	(0.0432)	(0.0721)	(0.0343)
SD_RET_t	–0.0573	–0.0785	0.0182
	(0.0654)	(0.1392)	(0.0461)
MTB_t	0.0645***	0.0962***	–0.0539***
	(0.0138)	(0.0320)	(0.0096)
Constant	–1.3145***	–3.6643***	0.5148*
	(0.4439)	(1.0771)	(0.2784)
Observations	2696	895	1801
Year fixed-effects	Yes	Yes	Yes
Adj. R-squared	5.13%	7.36%	8.44%

This table presents the association between the composite board centrality measure and MEE investment efficiency over the 2004–2016 period using the following model:

$$INV\_Efficiency_{i,t} = \theta_0 + \theta_1 Q5\_Centrality\_Board_{i,t} + \theta_2 Q5\_Centrality\_MD_{i,t} + \theta_3 MD\_Tenure_{i,t} + \theta_4 Board\_Size_{i,t} + \theta_5 Indep\_Ned_{i,t} + \theta_6 Busy\_Ned_{i,t} + \theta_7 MVE_{i,t} + \theta_8 RET_{i,t} + \theta_9 SD\_RET_{i,t} + \theta_{10} MTB_{i,t} + \boldsymbol{\varphi} + \epsilon_{i,t},$$

$INV\_Efficiency_t$ is the residual from the below model:

$$INV_{i,t} = \theta_0 + \theta_1 Tobin_{i,t-1} + \theta_2 Tobin_{i,t-1} \times Q2\_Tobin_{i,t-1} + \theta_3 Tobin_{i,t-1} \times Q3\_Tobin_{i,t-1} + \theta_4 Tobin_{i,t-1} \times Q4\_Tobin_{i,t-1} + \theta_5 CF_{i,t} + \theta_6 Growth_{i,t-1} + \theta_7 INV_{i,t-1} + \epsilon_{i,t},$$

INV_t is the net cash spending on operating and investing exploration and evaluation as well as mining tenements for the current year, scaled by opening exploration and evaluation assets. INV_{t-1} is the prior year net cash spending. $Tobin_{t-1}$ is Tobin's Q of the prior year. $Q2\_Tobin_{t-1}$, $Q3\_Tobin_{t-1}$, $Q4\_Tobin_{t-1}$ are indicator variables coded 1 if $Tobin_{t-1}$ is in the second, third and fourth quartile of each year sample, respectively. CF_t is the operating cash flow for current year, scaled by opening exploration and evaluation assets. $Growth_{t-1}$ is the natural log of prior year change in total assets. $Q5\_Centrality\_Board_t$ and $Q5\_Centrality\_MD_t$ are the quintile rank of the average factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively. MD_Tenure_t is the duration (in years) since the MD was appointed. $Board\_Size_t$ is the number of directors sitting on the board for the current year. $Indep\_Ned_t$ is the percentage of independent non-executive directors (NEDs) on the board for the current year. $Busy\_Ned_t$ is the percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. MVE_t is the natural logarithm of market capitalisation for the current year. RET_t is the annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns in the prior two years. MTB_t is the market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 18: Association between board centrality and board advising using the N_score

Variables	EE_Add_{t+1} (1)	EE_Acq_{t+1} (2)	EE_Comb_{t+1} (3)	$Equity_{t+1}$ (4)
N_score_t	0.1586**	0.3468***	0.1918***	0.2700***
	(0.0715)	(0.0712)	(0.0642)	(0.0842)
$Q5\_Centrality\_MD_t$	–0.2508**	0.1947	–0.1108	0.5601***
	(0.1230)	(0.1244)	(0.1137)	(0.1425)
MD_Tenure_t	0.0724***	–0.0644***	0.0662***	–0.0098
	(0.0181)	(0.0162)	(0.0163)	(0.0230)
$Board\_Size_t$	0.2468***	–0.3219***	0.1408*	0.0078
	(0.0880)	(0.0826)	(0.0796)	(0.1061)
$Indep\_Ned_t$	–0.4195	0.5244*	0.0402	0.1291
	(0.3093)	(0.2843)	(0.2904)	(0.3505)
$Busy\_Ned_t$	–0.9644*	–1.8487***	–1.2816**	–2.4239***
	(0.5453)	(0.5013)	(0.5085)	(0.6329)
MVE_t	0.5567***	–0.0647	0.5097***	0.3427***
	(0.0820)	(0.0661)	(0.0779)	(0.0868)
RET_t	0.2450***	0.1712**	0.2902***	0.2183**
	(0.0872)	(0.0862)	(0.0769)	(0.0862)
SD_RET_t	0.5439**	0.0215	0.5411***	1.0697***
	(0.2129)	(0.1965)	(0.1972)	(0.2348)
MTB_t	–0.2189***	–0.0111	–0.1782***	0.1681***
	(0.0322)	(0.0248)	(0.0308)	(0.0253)
Constant	1.535	3.4774***	3.0064**	5.4722***
	(1.3081)	(1.0802)	(1.2346)	(1.4009)
Observations	4,444	4,444	4,444	4,444
Year fixed-effects	Yes	Yes	Yes	Yes
Adj. R-squared	6.51%	6.51%	1.35%	7.76%
Mean VIF	2.31	2.31	2.31	2.31

This table presents the association between board centrality and investment and financing outcomes over the 2004–2016 period using the following model:

$$EE\_Investment_{i,t+1} \text{ or } Equity_{i,t+1} = \theta_0 + \theta_1 N\_score_{i,t} + \theta_2 Q5\_Centrality\_MD_{i,t} + \theta_3 MD\_Tenure_{i,t} + \theta_4 Board\_Size_{i,t} + \theta_5 Indep\_Ned_{i,t} + \theta_6 Busy\_Ned_{i,t} + \theta_7 MVE_{i,t} + \theta_8 RET_{i,t} + \theta_9 SD\_RET_{i,t} + \theta_{10} MTB_{i,t} + \boldsymbol{\varphi} + \epsilon_{i,t}, \quad (1)$$

$EE\_Investments_{t+1}$ can be EE_Add_{t+1}, EE_Acq_{t+1} or EE_Comb_{t+1}, which are the natural logarithm of the amount of E&E asset additions, E&E asset acquisitions (comprising both tenements and other E&E assets), and combined E&E asset additions and acquisitions in the following year, respectively. $Equity_{t+1}$ is the natural logarithm of equity proceeds raised in year following year.

The N_score_t is adopted from Larcker et al. (2013) as follows:

$$N\_score = Q5\left(\frac{1}{4}\{Q5\_Deg\_Board + Q5\_Bet\_Board + Q5\_Clo\_Board + Q5\_Eig\_Board\}\right)$$

$Q5\_Centrality\_MD_t$ is the quintile rank of the factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of the MD. MD_Tenure_t is duration (in years) since the MD was appointed. $Board\_Size_t$ is the number of directors sitting on the board for the current year. $Indep\_Ned_t$ is the percentage of independent non-executive directors (NEDs) on the board for the current year. $Busy\_Ned_t$ is the percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. MVE_t is the natural logarithm of market capitalisation for the current year. RET_t is the annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns in the prior two years. MTB_t is the

market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Appendix A: Variable definitions

Variable	Definition	Data source
Dependent variables:		
EE_Add_{t+1}	Natural logarithm of the amount of exploration and evaluation (E&E) asset additions in the following year.	Hand collected from annual reports
EE_Acq_{t+1}	Natural logarithm of the amount of E&E asset acquisitions (comprising both tenements and other E&E asset acquisitions) in the following year.	Hand collected from annual reports
EE_Comb_{t+1}	Natural logarithm of the amount of combined E&E asset additions and acquisitions in the following year.	Hand collected from annual reports
$Equity_{t+1}$	Natural logarithm of equity proceeds raised in the following year.	DatAnalysis
Explanatory variables:		
$Centrality\_Board_t$	Average of factor score of individual board members excluding the MD. Factor score is based on four key centrality measures (degree, betweenness, closeness, and eigenvector centrality) measured at individual director level for the current year.	Connect4/igraph
$Centrality\_MD_t$	Factor score of the MD. Factor score is based on the MD's centrality measures (degree, betweenness, closeness, and eigenvector centrality) for the current year.	Connect4/igraph
$Q5\_Deg\_Board_t$	Quintile rank of average degree of individual board members excluding the MD for the current year. Degree centrality is measured as follows: $Degree_i = \frac{\sum_{i \neq j}^{n} A_{ij}}{n-1}$ where A_{ij} is an indicator equal 1 if director i and director j serve on a same board. n is the total number of sample directors. Degree centrality is normalised by dividing raw degree by (n–1).	Connect4/igraph
$Q5\_Bet\_Board_t$	Quintile rank of average betweenness of individual board members excluding the MD for the current year. Betweenness centrality is measured as follows: $Betweenness_i = \frac{\sum_{i \notin \{j,k\}} \frac{g_{jk}(i)}{g_{jk}}}{\frac{(n-1)(n-2)}{2}}$	Connect4/igraph

Variable	Definition	Data source
	where $g_{jk}(i)$ denotes the total number of shortest paths between director j and director k which pass through director i, and g_{jk} denotes the total number of shortest paths between j and k. Betweenness centrality is normalised by dividing raw betweenness by $\frac{(n-1)(n-2)}{2}$.	
$Q5\_Clo\_Board_t$	Quintile rank of average closeness of individual board members excluding the MD for the current year. Closeness centrality is measured as follows: $Closeness_i = \frac{n-1}{\sum_{i \neq j}^{n} s(i,j)}$ where s(i,j) denotes the number of steps in the shortest path between director i and director j. Closeness centrality is the inverse of the average distance between two directors. Closeness centrality is normalised by multiplying raw closeness by (n–1).	Connect4/igraph
$Q5\_Eig\_Board_t$	Quintile rank of average eigenvector of individual board members excluding the MD for the current year. eigenvector centrality is measured as follows: $Eigen_i = \frac{\sum_j^n A_{ij} Eigen_j}{\lambda}$ where $Eigen_j$ is vector centrality of director j which director i is connected to by serving on a same board. λ is proportionality factor. Eigenvector centrality captures the connectivity of director i based on the connectivity of all other directors who director i is linked to.	Connect4/igraph
$Q5\_Deg\_MD_t$	Quintile rank of the MD's degree centrality for the current year.	Connect4/igraph
$Q5\_Bet\_MD_t$	Quintile rank of the MD's betweenness centrality for the current year.	Connect4/igraph
$Q5\_Clo\_MD_t$	Quintile rank of the MD's closeness centrality for the current year.	Connect4/igraph
$Q5\_Eig\_MD_t$	Quintile rank of the MD's eigenvector centrality for the current year.	Connect4/igraph
Board characteristics:		
$Board\_Size_t$	Number of directors sitting on the board for the current year.	Connect 4

Variable	Definition	Data source
$Busy\_Ned_t$	Percentage of non-executive directors (NEDs) on the board who hold two or more board positions in industry peers other than the current board for the current year.	Connect 4
$Indep\_Ned_t$	Percentage of NEDs on the board who are independent for the current year.	Connect 4
MD_Tenure_t	Duration (in years) since an MD was appointed.	Connect 4
Firm economic characteristics:		
MVE_t	Natural logarithm of market capitalisation for the current year.	Sirca – SPPR
RET_t	Annual buy-and-hold stock return adjusted for dividends and capital changes for the current year.	Sirca – SPPR
SD_RET_t	Annualised standard deviation of monthly stock returns over the 24-month period until financial year-end.	Sirca – SPPR
MTB_t	Market-to-book value of equity for the current year.	DatAnalysis

Chapter 3: Board human capital and advisory qualities

1. Introduction

Chapter 2 considers mining exploration entities' (MEEs') significant demand for advice from the board because (i) their operating environment is inherently susceptible to variable macroeconomic and industry conditions, and (ii) they lack financial and human resources. As demonstrated in Chapter 2, MEE boards can enhance the effectiveness of their advice by leveraging boardroom networks to acquire relevant human capital in terms of industry knowledge and to build connections with directors of industry peer firms which help reduce information asymmetry and facilitate equity raising.

This chapter continues to explore how the board's advisory role can be effectively performed by focusing on MEEs' internal human capital – specifically directors' qualifications, expertise, professional memberships, and the diversity of such characteristics. Empirical evidence on the association between board of directors' educational backgrounds and corporate value has been inconclusive. Fich (2005) finds that directors with MBA or law degrees are not perceived favourably by the markets. Similarly, Kim and Lim (2010) do not document a positive relation between directors' educational level and firm value. In contrast, Fedaseyeu et al. (2018) show that directors' educational level increases board human capital for which they are paid higher remuneration.

Relatedly, there are also studies on directors' experience and expertise. Guner et al. (2008), Litov et al. (2014), and Drobetz et al. (2018) suggest that directors with financial, legal and industry expertise, respectively, have a positive impact on firm value. In contrast, Fahlenbrach et al. (2010) do not find directors with prior CEO experience affect operating performance. Kang et al.'s (2018) results imply that directors with CEO experience or industry experience alone do not drive firm performance; however, those with combined industry and CEO experience help enhance firm performance through higher quality innovations.

The inconclusive findings of prior studies could be due to variations in the level and quality of qualifications (King et al., 2016) and diversity of skills (Adams et al., 2018). The presence of diverse qualifications and expertise may either increase the pool of information and resources which benefit decision-making or cause conflicts and make communication difficult (Williams and O'Reilly, 1998). Therefore, research on a single aspect of directors' education or expertise may suffer confounding effects. Consequently, recent literature on board human capital has increasingly focused on the breadth and diversity of qualifications and experience.

However, diversity studies also fail to provide consistent findings. In terms of education, Cumming and Leung (2021) report that diversity in education has a positive impact on innovation in female-dominated industries but such impact is reversed in male-dominated industries. Further, Fang and Hope (2021) suggest that variations in academic backgrounds of sell-side analysts increase forecast accuracy. For directors' experience and expertise, Adams et al. (2018) find that diversity in directors' skills is detrimental to firm value. However, Gray and Nowland (2017) find no significant association between directors' expertise and firm value.

Studies using a wide range of industries pose a number of challenges to examining the effects of directors' education and expertise. In a heterogeneous setting, it is difficult to identify specific qualifications and expertise needed to ensure alignment with business operations and effective board functioning. Studies using heterogenous settings can only focus on functional experience and expertise that are essential across different business

sectors such as accounting, finance and law.[19] Therefore, the purpose of this chapter is to understand the specific human capital required at a board level to advise early-stage MEEs.

This chapter examines associations between directors' human capital, in terms of education, expertise and diversity, and the outcomes of board advice using a sample of 5,158 firm-year observations over the 2004 – 2018 period. Findings in this chapter suggest positive relations between directors' academic qualifications and MEEs' future investment in exploration assets, after controlling for the managing director's (MD) educational level. It is also shown that directors with financial expertise play a positive role when MEEs require access to the equity market for additional capital. In addition, directors with technical expertise in mining assist MEEs to both assess investment opportunities and raise equity finance. By distinguishing between different human capital of directors, this chapter indicates that while directors with administrative or corporate-related roles in the mining industry – general-industry experts – support MEEs' strategic investing decisions, they do so to a lesser extent than the directors with technical mining expertise. Further, general-industry expert directors do not appear to be significantly associated with the level of future equity finance raised. This chapter further shows that diversity in education is significantly and positively associated with both future asset investment and equity finance, suggesting that the benefits of diverse cognitive knowledge outweigh potential communication challenges.

This chapter is expected to contribute to the corporate governance literature in two ways. First, it extends the literature on board human capital by investigating both functional expertise (which is common across industry sectors) and technical expertise (which is specific to firms' operating activities). Prior studies on functional expertise are extensive, spanning

[19] Industry expertise is an exception. However, research papers on industry expert directors tend to focus on past career in the same industry as the focal firm, without considering the granularity of past roles/tasks.

across domains such as accounting (Defond et al., 2005; Kim and Lim 2010), finance (Guner et al., 2008), legal (Krishnan et al., 2011 and Litov et al., 2014), and leadership expertise (Fich 2005 and Fahlenbrach et al., 2010). For multiple types of expertise, the research setting is commonly based on cross-sectional (i.e. heterogenous) samples as observed in Anderson et al. (2011), Adams et al. (2018), and Fedaseyeu et al. (2018). This chapter adds to a small number of studies which focus on a particular industry. For industry-specific research, prior literature has predominantly explored the banking sector. For example, Minto et al. (2014) study the financial expertise of directors in the US banking sector. Similarly, Gilani et al. (2021) examine the link between financial expert directors and the capital ratio of US banks. Also using a sample of US banks, Liu and Sun (2021) investigate whether directors with legal expertise affect banks' risk-taking behaviour. In the context of early-stage MEEs, this chapter considers the expertise of board members who have extensive technical work experience as geologists, mining engineers and metallurgists in the mining sector. This classification of technical mining expertise is more specific and narrower than prior literature's classification of industry experts. In other words, only those deeply involved in technical roles/tasks are considered mining experts. Directors with administrative or corporate-related roles only are considered general-industry experts.

Granularity in industry expertise aside, this chapter also ensures the expertise data used adequately captures both the depth of knowledge and skills of directors, which requires a minimum of 10 years of employment in a single area of work. In the prior literature, apart from accounting and financial expertise classified based on the Sarbanes-Oxley Act (SOX) requirements or formal credentials from professional accounting bodies, other types of expertise are generally, and often subjectively, determined based on experience.[20]

[20] Definitions of expertise used in prior studies are summarised in Appendix A to Chapter 3.

Consequently, experience and expertise are often used interchangeably although they are distinctive terms. Skovholt et al. (2016, p. 17) provide an explanation for this practice:

> *"Skepticism seems warranted when authors and researchers inadvertently or even consciously equate experience with expertise. While there appears to be some correlation between these two constructs, experience and expertise are certainly distinct".*

Although the definitions of expert/expertise vary, Ericsson and Lehmann (1996, as cited in Skovholt et al., 2016) suggest that *"it is generally assumed that experts possess a unique combination of the innate talents and the motivation necessary for the rigorous training and practice required to achieve excellence".* It seems that current research on directors' expertise neglects, to some extent, the depth of experience and excellence by focusing only on whether directors have had exposure to and experience in a certain area. This chapter classifies an expert director based on their employment history of 10 years or more in one specific area. The choice of 10 years as a threshold to classify a director as an expert is based on the following discussion of expertise by Feldhusen (2005 p. 68):

> *"[e]xpertise is high-level mastery of the declarative and procedural knowledge of a field. The declarative knowledge base has been estimated to be 100,000 or more units of information and well-honed convergent and creative cognitive skills (Glaser, 1984). Further, it is estimated that on average it takes about 10 years of study and/or practice to achieve such an immense knowledge base".*

In the corporate finance literature, Huang (2014) classifies CEOs' industry expertise as "widely experienced" based on a tenure of 10 years or more. The author argues that such criterion is consistent with prior literature of CEO turnover and longevity by citing the mean (median) CEO tenure recorded for the period 1992–2004 in ExecuComp of 10 years (8 years). Further, anecdotal evidence shows that one common selection criterion of a "fellow" member,

who is regarded as a leader in the field by professional institutions, is based on work experience of between 10 to 15 years.[21] [22]

Second, this chapter adds to the board diversity literature by considering demographic diversity in a sample of small early-stage firms. An extensive meta-analysis of 579 studies of board diversity from 1999 to 2019 by Baker et al. (2020) finds that current research lacks focus on a single industry, smaller firms, and types of demographic diversity other than gender diversity. This chapter directly addresses some of the limitations reported and found in the current literature on board diversity. Further, by taking an industry-focused view, this chapter identifies specific corporate decisions which require advice drawing on directors' qualifications and expertise. Consequently, any association found between the diversity of such attributes and board advice is subject to less significant endogeneity concerns than research indirectly inferring effectiveness of board advice through non-task specific outcomes (Li and Wahid, 2018).

Finally, this chapter also suggests a channel through which MEEs can benefit from the diversity of their board human capital. Education diversity increases the likelihood of directors joining mining professional bodies, which not only strengthens the depth of director knowledge and skills, but also extends their social networks. These skills and networks are essential to advise managers making investment and financing decisions.

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[21] Among other requirements, a fellow member of the Australasian Institute of Mining and Metallurgy, the Geological Society of Australia, or the Governance Institute of Australia, must have at least 10 years' experience in the relevant field. At the Australia Institute of Company Directors, a member with experience of six consecutive years or 10 years within a 12-year period may be eligible as a fellow. Other peak bodies apply a 15-year requirement, such as the Financial Services Institute of Australasia, Chartered Accountants, the Institution of Engineers Australia, and the Australian Institute of Geoscientists.

[22] Due to the need to hand collect additional data, the thesis was unable to perform robustness tests for other tenure thresholds to determine expertise.

2. Literature review

Hillman and Dalziel (2003) define *"directors' expertise, experience, knowledge, reputation and skills"* as the human capital represented on the board of directors. Prior studies on corporate governance, both theoretical and empirical, agree on the roles of the board in monitoring and advising management (Jensen, 1993; Adams and Ferreira, 2007; Harris and Raviv, 2008; Linck et al., 2008; Coles et al., 2008; Armstrong et al., 2010; and Brickley and Zimmerman, 2010). While the monitoring role requires the board to have skills, knowledge and sufficient independence, the advisory role requires expertise and firm-specific knowledge (Armstrong et al., 2010).

2.1. Education

Education is commonly adopted as a proxy for an individual's skills and cognitive ability. Hitt and Tyler (1991) document that managers' 'type' of education, based on major areas of study including accounting, engineering, finance and management, plays a role in a firm's strategic decisions. The findings suggest that educational backgrounds reflect an individual's values and cognition which moderate the relationship between objective criteria used to evaluate strategic alternatives and acquisition decisions. Examining directors' educational 'levels' of attainment, Fedaseyeu et al. (2018) find that directors with higher educational levels perform more board functions, such as serving as the board chair and/or chair or a member of the board's subcommittees. Consequently, these directors receive higher compensation. However, evidence from Malmendier and Tate (2005) suggests that the type of the CEOs' education may have opposite effects on corporate decisions. Specifically, CEOs with financial education identified by a university degree in accounting, finance, business, MBA, or economics, are found to reduce the sensitivity of cash flow and capital expenditure. On the other hand, CEOs with education in engineering, physics, operations research,

chemistry, mathematics, biology, pharmacy, and other applied sciences increase the cashflow-investment association.

Despite its perceived importance, a directors' education (level or type) does not seem to have a significant impact on firm value. Fich (2005) finds no positive market reactions to appointments of directors who hold a CEO position at another firm who have an MBA or a law degree. This result is consistent with the interpretation that there are specific skills obtained by directors with CEO experience that are more favourably received by the market than formal academic qualifications. Similarly, Kim and Lim (2010) fail to find evidence of the association between the educational level of outside directors and firm value among Korean listed companies.

There are industry-specific studies on the impact of directors' education and firm performance. Nguyen et al. (2014) examine executive educational characteristics in the banking sector, including the prestige of educational institutions attended and the attainment of an MBA. The authors argue that Ivy League institutions are prestigious and graduates from these universities tend to perform better than other executives. Ivy League executives are also more likely to have access to elite groups of successful individuals. For those executives attaining an MBA degree, they are believed to possess extensive social networks formed during their MBA study which could add value to the banks' financial activities. Empirical findings show that executive directors who attended Ivy League institutions contribute positively to shareholder value while there is no evidence that those holding MBA degrees have significant economic impacts. In contrast, King et al. (2016) provide evidence that CEOs with MBAs outperform their peers by enabling them to either: (i) change the bank business models through increasing fee-based operations and investments in real estate and mortgages; or (ii) change their banks' asset composition. The authors, however, do not find the same

impact for CEOs holding undergraduate or doctoral degrees. Using a sample of Taiwanese electronics firms, Chen (2014) finds that directors' educational levels have a significantly positive impact on their firm R&D investments, which is consistent with the argument that advanced education reflects directors' knowledge and skills to process information, acquire requisite knowledge, and assess the viability of research projects.

2.2. Expertise

In addition to educational backgrounds, expertise is an important attribute of director human capital. Forbes and Milliken (1999) suggest that functional knowledge and skills possessed by a board of directors *"span the traditional domains of business, including accounting, finance, and marketing, as well as those domains that pertain to the firm's relationship with its environment, such as law".* Consequently, empirical studies examine these specific types of business experience and expertise. Similar to studies on director education, this strand of research quite often provides inconclusive findings.

Defond et al. (2005) find that the market reacts positively to audit committee appointments of directors who are a *"public accountant, auditor, principal or chief financial officer, controller, or principal or chief accounting officer"*, but not to those with broader (non-accounting) financial skills. The authors suggest that directors with accounting-based financial skills help improve the financial reporting quality and complement their firms' governance practices, which are both viewed favourably by the market. These findings are confirmed by Krishnan et al. (2011) who also document a positive link between audit committee members with accounting-only expertise and financial reporting quality, after controlling for legal-only expertise. However, Kim and Lim (2010) report a significantly negative association between directors with accounting experience and their firm value. The authors indicate that such negative effect could be due to the affiliated positions of those non-

executive directors who worked as partners at accounting firms that provide accounting-related services to the focal firms where they are board members.

Other studies include the accounting expertise of directors under the broader category of a financial expert. Guner et al. (2008) examine the link between board members with financial expertise and corporate financing and investment policies. Chief Financial Officers (CFOs), accountants, treasurers and Vice Presidents for finance are considered "finance executives". The authors also categorise directors with financial expertise based on their employment history, distinguishing between commercial bank executives, investment bank executives, executives of a non-bank financial institution, ''finance'' professors (including finance, economics, accounting, and business), consultants, lawyers, executives of a non-financial firm, and noncorporate workers. Based on these categories, Guner et al. (2008) document that directors with financial expertise are significantly associated with their firms' corporate decisions. In particular, directors who are commercial bankers are associated with a reduction in the sensitivity of investment to cashflow in firms that are financially unconstrained; the authors attribute this to the affiliation between these banker directors and their banks which provided loans to the focal firms. For investment banker directors, the paper finds that they are related to greater debt issues and poorer acquisitions. The misaligned incentives of banker directors with firms' shareholders lead the authors to suggest that firms need to be mindful of the potential trade-off between monitoring and advising roles of financial expert directors on the board. Minto et al. (2014) investigate the association between directors with financial expertise and the banks' performance. They find that prior to the Global Financial Crisis in 2007–2008, independent financial-expert directors encouraged more risk-taking activities which benefited shareholders. The positive outcomes were realised due to the directors' ability to identify risks and recognise government guarantees applicable to banks, which made them good advisers to management in pursuing risk-taking activities to

increase shareholder wealth. However, during the crisis, such risk-taking advice was detrimental to stock performance of US banks. Gilani et al. (2021) also base their analysis of financial expert directors on a sample of US banks. The authors argue and show that boards of US banks with financial experts are better at identifying bank risks, which lead to a higher target capital ratio and more timely adjustment of the ratio when banks are undercapitalised.

In terms of legal experience, Litov et al. (2014) assert that lawyer-directors provide valuable advice by assisting their board with legal and regulatory issues, which reduces the negative impacts of litigations on firm performance. Specifically, lawyer-directors are found to better advise on securities law, class action, and accounting malpractice litigations. Directors with legal expertise may also facilitate more effective oversight. Krishnan et al. (2011) examine the legal expertise of audit committee members. They argue that legal experts sitting on the audit committee are more sensitive to litigation risks arising from financial reporting, and are more familiar with the legal implications of commercial transactions such as mergers and acquisitions, disposal of assets, and loan agreements. Their findings support the positive role of directors with legal expertise by showing a significantly positive association between the presence of legal experts (defined as those having a law degree and/or experience as a lawyer at a law firm or as a legal counsel) on the audit committee and the quality of financial reporting, after controlling for accounting expertise. The authors, however, do not find the same impacts for audit committee members having *both* legal and accounting expertise. Looking at independent directors of US banks, Liu and Sun (2021) find directors with legal expertise are more effective in constraining executives' risk-taking behaviours. However, such effects do not translate into improved performance. In fact, they report a negative relation between the proportion of directors' legal expertise and banks' Tobin's Q.

For business and leadership experience, findings in Fich (2005) support the advisory and "certification" roles of directors with CEO experience for young firms seeking to exploit growth potential, as evidenced by higher market reactions to appointments of CEO-directors than for non-CEO directors. CEO directors are also found to be associated with positive changes to long-term performance. In contrast, the market appears to not support CEOs taking an additional non-executive role in another firm demonstrated by negative stock price reactions at the CEOs' firms. This could be due to concerns of insufficient commitment to the firm where they serve as the CEO. Fahlenbrach et al. (2010) continue to examine the impacts of CEO-directors using a more comprehensive sample over the 1989–2002 period. The authors, however, find that CEO-directors do not influence the appointing firms' operating performance nor decision-making in terms of penalising CEOs for poor performance, acquisition outcomes, or setting CEO compensation. They posit that while CEO-directors are highly sought after, their reputational costs are high. As such, they are more likely to join prestigious boards with similar corporate policies and governance to their focal firms.

In contrast to research on common types of business expertise, studies examining directors possessing industry experience and expertise provide consistent evidence of positive impacts. Dass et al. (2014) argue that directors from related upstream and downstream industries help their firms mitigate information gaps by providing relevant knowledge, expertise and connections which consequently improve firm value (measured by Tobin's Q) and financial performance (measured by return on assets). Similarly, Faleye et al. (2018), who investigate directors' past employment in the same industry as the firms where they serve as directors, show that industry-expert directors provide more effective advice by enhancing the quality of research and development (R&D) investment as evidenced by an increase in the number of patents received and cited for the same level of R&D spending. The authors also show non-executive directors with industry expertise increase firm value for those investing

in R&D. Likewise, Drobetz et al. (2018) find that industry expert directors are positively associated with firm value by providing senior management with strategies and actions on corporate investments, monitoring cash spending, and during crisis times. While also investigating the industry expertise of independent directors, Kang et al. (2018) focus only on those with past CEO experience. The authors hypothesise that directors with CEO experience in the same industry facilitate value-enhancing activities through higher R&D investments and quality innovations as they have both general knowledge of company management and specific knowledge of industry dynamics. Their empirical findings show the positive impacts are more pronounced for young and small firms which have a higher demand for advice and guidance.

Examining multiple types of expertise (of academics, accountants, bankers, consultants, doctors, engineers, executives, lawyers, other CEOs, politicians and scientists) on the boards of Australian publicly-listed firms for the financial year 2007, Gray and Nowland (2017) do not find a significant association between expert directors and firm value. When separating expertise into two subcategories, they find those with business expertise comprising lawyers, consultants, accountants, bankers and CEOs have no impact on firm value; however, those who are executives, scientists, engineers, politicians, academics and doctors are significantly and negatively associated with firm value. Consequently, the authors suggest that boards comprising types of expertise beyond commercial related functions may adversely affect firm value and performance. Fedaseyeu et al. (2018) investigate whether director qualifications are associated with their board functions and compensation. These qualifications include six types of expertise (legal/consulting, academic, accounting/finance, management, political, military) and three levels of education (undergraduate, advanced and MBA degrees). The authors find evidence supporting the “expertise” hypothesis that expert directors are paid higher compensation. Directors with a higher level of qualification are more

likely to be qualified to perform additional board functions. In other words, expertise reflects the role directors perform on the board. In particular, directors with accounting, finance or CEO experience are more likely to serve as the chair of the board, committee chair or committee member. In addition, the authors find that lawyers and academics are more likely to join board's sub-committees. Consequently, as directors perform more board functions, they are entitled to higher remuneration.

2.3. Diversity

Adams et al. (2018) examine director skills disclosed by US firms following the 2009 amendment to Regulation S-K and show that diversity of skills hinders firm performance due to the lack of commonality. They suggest in addition to directors' experience, the diversity of experience helps explain the association between director experience and firm performance. In addition, the authors argue that in searching for a new nominee, the board faces a "multi-dimensional" problem such that not all criteria are optimised. Consequently, not all boards achieve the optimal composition of skills.

Empirical studies on the economic consequences of qualification diversity on the board provide mixed findings due to the presence of both costs and benefits that arise from greater heterogeneity. In contrast to the negative impacts documented in Adams et al. (2018), Anderson et al. (2011) find there is a positive relation between the heterogeneity of board members and firm performance. The authors examine diversity of various board's demographic characteristics which comprise educational level (bachelor, master and above) and type (MBA, technical, law, and liberal arts), functional expertise (law, consulting, accounting, and investment banking), age, gender, ethnicity, board tenure, and external directorships. Similarly, Fang and Hope (2021) find that diversity of experience, educational background and gender in analyst teams improves forecast accuracy given the teams are

equipped with a broader range of information, perspectives and different approaches to evaluation tasks.

Board diversity can be beneficial for several reasons. First, boards with directors of diverse backgrounds and experience will have to critically evaluate alternative options and potential solutions brought forward during board meetings, resulting in more effective problem solving and decision-making (Watson and Michaelsen, 1988). Milliken and Vollrath (1991) also find that a diverse board facilitates better information acquisition and effective interpretation of opportunities and threats; this helps generate alternative strategies and better choices of strategy for execution. Baranchuk and Dybvig (2009) also support the benefits of greater diversity in the boardroom by arguing that adding new directors to the board, and thus increasing board diversity, can mitigate the negative association between board size and firm performance because of the additional valuable information brought in by the new directors. Alternatively, the benefits of board diversity can be explained by resource dependence theory which views the board of directors as a means to gain access to additional information and resources (Pfeffer and Salancik, 1978). Therefore, a more diverse board can provide firms with a wider range of information, knowledge and experience necessary to advise management on growth strategies. The more dependent a firm is on the environment in which it operates, the more important the board is in providing access to information and resources beyond the boundary of the firm.

The opposite of board diversity is groupthink, which explains circumstances where:

> *"As a group of decision makers becomes excessively close-knit and develops a strong sense of "one-of-us-ness", it becomes imperceptibly prone to cognitive process that, as a result of internal group pressure, becomes impatient of appraising alternative*

strategies. Strong group cohesion can contribute to erroneous decisions and a policy fiasco. Its focus was concurrence seeking" (Eaton 2001, p. 183).

In addition, Jensen (1993) argues that a strong focus on politeness and courtesy comes at the cost of truth and frankness in boardrooms, which may cause failure in the internal control system used by the board of directors. Bernile et al. (2018) believe that board homogeneity may facilitate idiosyncratic decisions which result in more volatility in operating outcomes. The authors propose that board diversity is beneficial given that it moderates risky corporate policies. Their findings provide consistent support for this conjecture and further demonstrate that board diversity fosters more efficient investments in innovation and ultimately better firm performance.

However, the benefits of diverse perspectives and broader information and skills may be attenuated by inevitable challenges. Forbes and Milliken (1999) suggest that a board made up of directors from diverse educational, functional and industry backgrounds is likely to encounter cognitive conflicts due to different perceptions and approaches to the same board issues. Additionally, diverse boards may exhibit communication and coordination difficulties due to the lack of understanding about each other's capability and the use of different language and terminology. This may lead to poor communication and consequently low group cohesion (Williams and O'Reilly, 1998). Therefore, both costs and benefits may arise from diverse boards. Giannetti and Zhao (2019) examine board ancestral diversity while controlling for gender and experience diversity in a sample of S&P 1500 companies from 1996 to 2014. The study shows that diverse boards are associated with greater stock returns while also experiencing greater disagreements and higher director turnover. When the costs of board diversity are sufficiently larger than the benefits, the net economic impact on firm performance could be negative as documented in Adams et al. (2018).

3. Hypotheses development

From the literature review, it is apparent that prior studies on directors' education and expertise tend to examine a broad spectrum of industries, making it difficult to control for contextual factors driving the demand for directors' human capital that determines their roles and performance. Further, by using a cross-sectional setting, prior research on board human capital mainly focuses on common skills required across all business domains, such as accounting, finance and business leadership, but not the technical and industry-specific knowledge and expertise. There are few studies that examine the technical expertise of directors; further, their classification of technical expertise is loosely defined. Malmendier and Tate (2005) classify CEOs as having technical education (experience) if they have degrees (professional careers) in engineering or the natural sciences. Cumming and Leung (2021) categorise directors as scientific experts if they have a professional qualification in engineering, pharmacy, or medical science. Further, while there are studies examining directors with industry knowledge and expertise, the emphasis is generally on whether the directors have *exposure* to a relevant industry. Consequently, insights into the value of industry-specific knowledge and expertise remain limited. Even in an industry-focused research, evidence on expertise beyond the banking industry is scarce. Therefore, this chapter uses the early-stage MEE setting to examine: (1) whether firm-specific qualifications and expertise help directors better perform their advisory role, and (2) whether diversity of such human capital is associated with board advice.

3.1. Board education and expertise

As mining explorers, MEEs' key operating activities are exploration and evaluation (E&E) (Bui et al., 2021), the continuation of which is highly dependent on their ability to access the equity market for capital (Ferguson and Lam, 2021). Therefore, exploration investments and equity financing are the main activities MEE boards are likely to focus their advisory efforts

on. While not every aspect of directors' academic qualifications and professional expertise is expected to benefit MEEs' investing and financing outcomes, some positive impacts are anticipated for two reasons. First, MEEs are in their early development stages, generating minimal revenue from operating activities, and financially constrained. Consequently, management relies more on the board for advice than costly external consultants to continue their exploration activities in anticipation of future economic payoffs (McCann, 1991). Further, due to limited human resources at the management level, MEE boards need to be more actively involved in their firms' operations (Trench, 2013). This is reflected in MEEs' significant demand for board knowledge and expertise (Linck et al., 2008), which can be satisfied through either the formal education or professional careers of board members. Therefore, board human capital is expected to have a strong economic impact on activities on which MEEs require board advice the most.

Second, expertise classification in this chapter accounts for not only the depth of professional experience and knowledge, but also the breadth by considering employment history rather than the broader classification commonly adopted in prior studies of board human capital. Stronger and more context-specific experience is expected to be beneficial when MEE boards conduct their advisory duties. For investments in E&E assets, mining experts are likely to contribute technical knowledge to determine whether investment in certain exploration activities is warranted. In terms of fundraising, directors with financial expertise, who have extensive experience and valuable contacts with bankers and brokers in the financial markets, are expected to help MEE management to identify potential investors willing to provide financial capital to fund exploration activities and projects. Therefore, Hypothesis 1 is stated as follows:

H1a: *There are positive associations between director education and future E&E assets and equity finance.*

H1b: *There are positive associations between director expertise and future E&E assets and equity finance.*

H1c: *There are positive associations between director education and expertise and future E&E assets and equity finance.*

3.2. Diversity of education and expertise

Due to their tight financial budgets and nature of early-stage operations, MEEs often have a board size at or near the legal minimum of three members (Trench, 2013). As suggested by Forbes and Milliken (1999), optimally, a board of directors needs to possess both functional and technical education and expertise to effectively perform its functions. In the MEE context, an ideal board would comprise directors with both general business expertise (such as accounting and finance) and industry-specific knowledge (such as geological and mining expertise). Coupled with their small board size, early-stage MEE boards are thus likely to exhibit a high level of diversity in qualifications and expertise.

Dahlin et al. (2005) show that diverse educational backgrounds among team members enhance the range and depth of information used. In addition, Anderson et al. (2011) document a positive effect of board diversity on performance. Such benefits are greater as firms' operations become more complex but deteriorate as operating complexity decreases. In contrast, findings from Adams et al. (2018) suggest that diverse boards lack common ground which negatively impacts firm performance. Given the "double-edged consequences" (Forbes and Milliken 1999) of education and expertise diversity, the association between board diversity and board advice is stated in the null form as follows:

H2a: *There is no association between the diversity of director education and expertise and future E&E assets.*

H2b: *There is no association between the diversity of director education and expertise and future equity financing.*

4. Research design

4.1. Empirical models and variables

To test proposed hypotheses, the following models are estimated. *i* denotes unique firms and *t* denotes year. Both models include firm fixed-effects (φ) to mitigate endogeneity concerns due to potential omissions of relevant firm characteristics, and year fixed-effects (ω) to control for industry level shocks which vary early. Appendix B presents the variable definitions.

Model for H1a, H1b & H1c:

$$EE\_Comb_{i,t+1} \text{ or } Equity_{i,t+1}$$
$$= \theta_0 + \sum_j \theta_1^j Q\_board_{j,i,t} + \sum_k \theta_2^k E\_board_{k,i,t} + \sum_j \theta_3^j Q\_MD_{j,i,t}$$
$$+ \sum_k \theta_4^k E\_MD_{k,i,t} + \theta_5 Board\_Size_{i,t} + \theta_6 Indep\_Ned_{i,t} + \theta_7 Busy\_Ned_{i,t}$$
$$+ \theta_8 MVE_{i,t} + \theta_9 RET_{i,t} + \theta_{10} SD\_RET_{i,t} + \theta_{11} MTB_{i,t} + \boldsymbol{\varphi} + \boldsymbol{\omega}$$
$$+ \epsilon_{i,t}, \qquad (1)$$

Model for H2a & H2b:

$$EE\_Comb_{i,t+1} \text{ or } Equity_{i,t+1}$$
$$= \theta_0 + \theta_1 D\_degree\_board_{i,t} + \theta_2 D\_expertise\_board_{i,t}$$
$$+ \theta_3 Board\_Size_{i,t} + \theta_4 Indep\_Ned_{i,t} + \theta_5 Busy\_Ned_{i,t} + \theta_6 MVE_{i,t}$$
$$+ \theta_7 RET_{i,t} + \theta_8 SD\_RET_{i,t} + \theta_9 MTB_{i,t} + \boldsymbol{\varphi} + \boldsymbol{\omega}$$
$$+ \epsilon_{i,t}, \qquad (2A)$$

$$EE\_Comb_{i,t+1} \text{ or } Equity_{i,t+1}$$

$$= \theta_0 + \theta_1 D\_degree\_fullboard_{i,t} + \theta_2 D\_expertise\_fullboard_{i,t}$$

$$+ \theta_3 Board\_Size_{i,t} + \theta_4 Indep\_Ned_{i,t} + \theta_5 Busy\_Ned_{i,t} + \theta_6 MVE_{i,t}$$

$$+ \theta_7 RET_{i,t} + \theta_8 SD\_RET_{i,t} + \theta_9 MTB_{i,t} + \boldsymbol{\varphi} + \boldsymbol{\omega}$$

$$+ \epsilon_{i,t}, \qquad (2B)$$

In all models, the dependent variables can be EE_Comb_{t+1} or $Equity_{t+1}$. EE_Comb_{t+1} is measured as the natural logarithm of the amount of combined E&E asset additions and acquisitions one year after the current year *t*. $Equity_{t+1}$ is the natural logarithm of equity proceeds raised one year after the current year *t*.

Key explanatory variables for Model (1) capture the education and expertise of all board members excluding the managing director (MD) for the current period, which are measured in two ways. First, the measures, *Q_board* and *E_board,* represent the proportion of board members excluding the MDs on the board who have an academic degree and a certain type of expertise, respectively. Academic qualifications are indicators corresponding to each of the educational levels: bachelor, honours, masters and PhD degrees. Similarly, expertise is measured as an indicator based on experience of at least 10 years or more in the areas of finance, accounting, legal, leadership, technical mining, engineer, general industry expertise, local expertise, and other business and commercial knowledge.[23] Examples of biographies and other relevant information used to classify each type of expertise are provided in Appendix C for reference.

[23] For leadership expertise, the classification is based on whether a director have held an executive role at a publicly listed entity rather than the tenure of their leadership. For local expertise, the classification also relies on whether a director is the citizen of the country where the MEE has an operation.

Second, education and expertise are measured based on an index where separate degree levels are replaced by a single variable, *edu_index_board*, and separate areas of expertise are replaced by *expert_index_board*. The variables *edu_index_board* and *expertise_index_board* are the average of the total number of degree levels and expertise obtained by board members excluding the MD, respectively. A composite index, *edu_expert_index_board*, is also constructed as the average of the sum of both educational levels and expertise for board members excluding the MD.

The key explanatory variables of interest in Models (2A) and (2B) measure the Blau diversity of education and expertise among board members excluding the MD (Models (2A)), and among the entire board including the MD for the current year (Models (2B)). Blau diversity is measured as: $1 - \sum p_{j \text{ or } k}^2$ where p is the proportion of a certain type of degree or expertise out of a total number of types of degree or expertise represented among board members excluding the MD (Model (2A)) or among the entire board (Model (2B)). Additionally, academic qualification diversity and expertise diversity are separately ranked by quintile each year and summed to derive indexed measures: *diversity_index* is the sum of quintile ranked diversity of degree and expertise for the full board, while *diversity_index_board* is the sum of quintile ranked diversity degree and expertise diversity of board members excluding the MD.

This chapter aims to capture the education and expertise of board members which are expected to compliment those of the MD. As such, the MD's academic qualifications and expertise are separately measured. Further, prior literature documents that MD/CEO's educational backgrounds and expertise are associated with corporate decisions and performance. For example, Chevalier and Ellison (1999) find that managers graduating from institutions with a higher average SAT score generate higher stock returns. Evidence from King et al. (2017) suggests that only bank CEOs with an MBA are significantly associated

with a return on assets but not those with undergraduate education or PhD degrees. In terms of expertise, Huang (2014) finds that CEOs who have expertise in one division of a diversified firm are more likely to divest non-specialised divisions with which they have no prior experience. Further, subsequent to such divestiture, firms realise positive stock returns. With respect to financial expertise, Custódio and Metzger (2014) find CEOs with financial expertise are able to increase cash holdings even when credit market conditions are tight, while Malmendier and Tate (2005) find that these CEOs exhibit lower sensitivity of investment to cash flow. Malmendier and Tate (2005) also document that CEOs with a technical education or experience display higher investment-to-cashflow sensitivity.

Board governance characteristics are controlled for in all models. The effectiveness of board functions is dependent on their size (*Board_size*) measured as the number of directors serving on the board, and composition (*Indep_Ned*) measured as the percentage of independent non-executive directors (NEDs) on the board. Yermack (1996) finds that smaller boards add value to their firm while Coles et al. (2008) suggests that larger boards are beneficial, especially for those with more NEDs who can offer advice to the MD. Additionally, the presence of independent NEDs on the board ensures effective monitoring of management's decisions that align with business strategies and long-term shareholder value creation (Weisbach, 1988). Directors' busyness (*Busy_Ned*) measured as the percentage of the board having NEDs who serve on two or more boards of other industry peer firms is also included in all models. While busy directors may be time constrained to effectively perform their oversight duties (Fich and Shivdasani, 2006), busyness also reflects the demand for their skills and experience (Field et al., 2013).

In addition, all models control for MEEs' economic characteristics comprising firm size (*MVE*), growth opportunity (*MTB*), stock performance (*RET*), and riskiness (*SD_RET*). Coles et al. (2008) suggest larger firms have greater advising needs while Field et al. (2013)

find that newly public firms and younger S&P 1500 firms benefit from the advice of busy directors who possess greater connections and experience. Further, young firms' strategic focus in exploring growth opportunities (Agarwal and Audretsch, 2001) requires significant board expertise to compensate for scarce managerial resources and experience (Zahra et al., 2006 and Machold et al., 2011).

4.2. Sample and data

Table 1, Panel A presents the sample selection process. An initial sample of all Australian metals and mining firms obtained from Connect 4/Boardroom consists of 8,877 firm-year observations of 1,059 unique firms over the period between 2004–2018.[24] Of the initial sample, mining firms with operating revenue greater than $1 million (1,752 firm-year observations) and those providing mining services (205 firm-year observations) were removed. [25] Further, the sample excluded 978 observations due to missing financial, market capitalisation and/or governance data. Finally, 794 firm-year observations of firms directly expensing the expenditure of E&E to the income statement were also excluded.[26] The final sample comprises 5,158 firm-year observations relating to 820 unique capitalising MEEs.

[Insert Table 1 here]

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[24] The sample period includes financial year 2019 as year *t+1*.

25 According to Bui et al. (2021), mining firms which generate more than $1 million in operating revenue may progress beyond the exploration phase of the mining life cycle.

[26] The differential motivation underlying the accounting choice for recording E&E expenditure leads to different disclosure and indication of probable future prospects. Consequently, this thesis only focuses on capitalising MEEs. These firms provide a clear breakdown of the capitalised E&E expenditures that indicate a continuing effort in undertaking exploration activities which are expected to result in future economic benefits.

Educational backgrounds and professional expertise of the board members were hand collected from biographies of directors disclosed in MEE annual reports, supplemented by additional sources (such as LinkedIn, Bloomberg and Company websites) where insufficient disclosure was made by MEEs.[27] Data on E&E assets were also hand collected from notes to the financial statements. Financial data was sourced from Morningstar DatAnalysis Premium database. Monthly stock prices and market capitalisation were obtained from the SIRCA-SPPR database. Corporate governance data was obtained from Connect 4.

As can be seen in Table 1, Panel B, the number of capitalising MEEs increases gradually from 2004 and peaks in years 2011 to 2015. From 2016 onwards, the yearly sample contribution remains relatively stable at about 7%.

4.3. Descriptive statistics

Table 2, Panel A reports firm and board characteristics of the sample. In terms of market capitalisation, capitalising MEEs have a mean (median) market capitalisation of $38.52 million ($11.35 million) which is half of (five times smaller than) the mean (median) market size of ASX listed companies of $71.56 million ($59.47 million) as reported in He et al. (2020). However, MEEs' market capitalisation is relatively similar to Australian loss-making firms reported in Wu et al. (2010), with a mean and median value of $39.97 million and $9.55 million, respectively. Early-stage MEEs are capital constrained and need to frequently access the equity market for external funding. Panel A reports that MEEs raise an average annual equity proceeds of $5.29 million (median of $1.61 million). As these firms' key operating

[27] While firms tend to use the same biography over a number of years, and the same biography can be used by multiple firms having the same director, the data collection involved checking each director's biography each year at each firm to ensure any additional information about their education, work history and professional memberships at industry associations were correctly captured.

strategy is to explore growth opportunities, a market-to-book ratio of greater than 1 is expected. The mean (median) *MTB* of 2.18 (1.23) reported in Panel A is consistent with the mean (median) of 2.60 (1.97) disclosed in Chen et al. (2018) in their study of E&E expenditures of Australian resource firms between 1993 and 2013.

[Insert Table 2 here]

Consistent with information disclosed in Chapter 2, there is a close association between MEEs' small firm size and board size. MEEs' mean and median board size of four members is close to the legal minimum as opposed to a six-member board commonly reported in Australian corporate governance studies (Daniliuc et al., 2020; He et al., 2020). On average, approximately one-third of MEE boards are independent and 12% of the board serve on two or more other boards of industry peer firms.

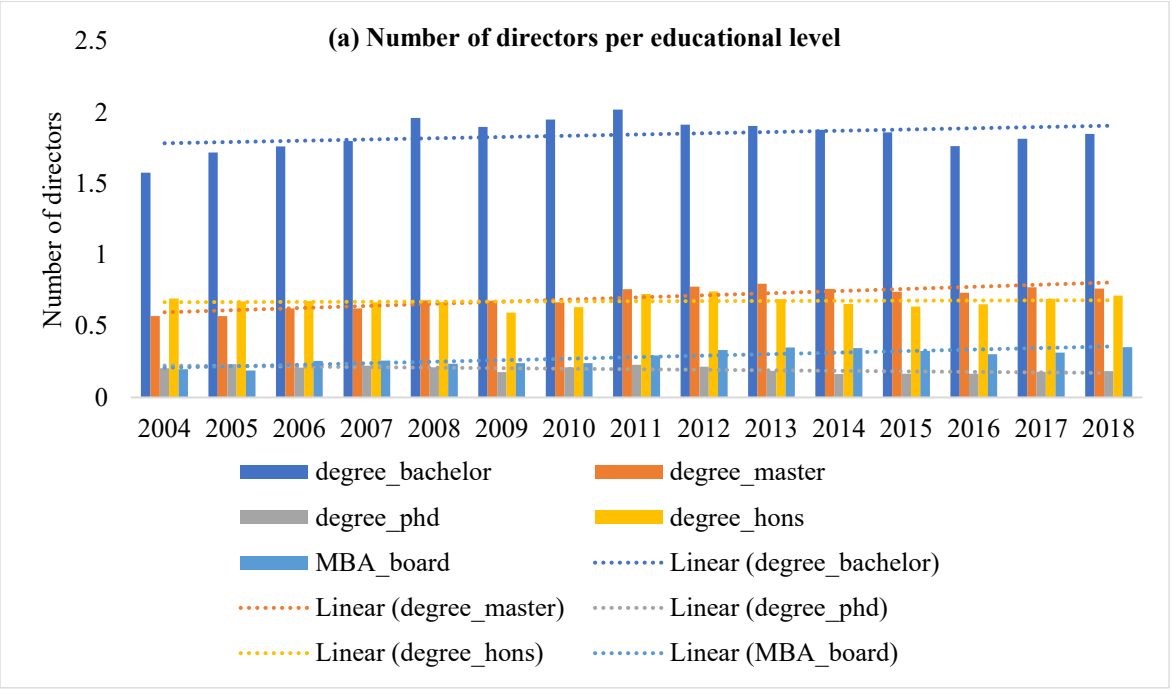
Panel B presents information on MEEs' E&E assets. As can be observed, the E&E asset account is the single most significant asset on the MEE balance sheet with the average closing balance of $11.24 million (median $5.59 million) making up approximately 54% (median 60%) of total assets. Note that the E&E account ending balance can be increased by additional investments in E&E assets or decreased by impairments of previously capitalised amounts, transfers to other classes of assets, or negative effects of currency translations. Consequently, to capture the incremental investments in E&E assets each year, this chapter focuses on two main E&E activities: E&E additions (*EE_Add*) and E&E acquisitions (*EE_Acq*). MEEs typically record expenditure on mining activities, such as geological studies, drilling and sampling under E&E asset additions. Panel B shows that the average expenditure for this component is $2.47 million (median of $1.09 million) which constitutes about 15% (median of 11%) of total assets. For acquisitions of tenements, mining projects or E&E assets, such activities are recorded under E&E asset acquisitions with an average value of $0.67

million. The sum of E&E additions and acquisitions (*EE_Comb*) amounts to $3.24 million on average or 20% of total MEEs' assets; this is used as the dependent variable capturing the aggregate exploration investments for testing H1 and H2.

Table 3, Panel A presents information on directors' educational backgrounds and professional expertise. In terms of education, on average, there are two board members (excluding the MD) holding a bachelor's degree, which constitutes about half of the average MEE board. The number of directors decreases as the level of education increases. As shown in Panel A, there is only one board member obtaining an honours degree or a master's degree and no director with an MBA qualification or PhD qualifications, on average. With regard to expertise, MEE boards appoint directors with both business expertise (such as financial and accounting expertise) and technical and general industry knowledge experts. Given MEEs' early-stage exploration activities, directors with technical mining expertise make up the largest proportion on the board (27%), followed by those with financial expertise (16%), and accounting and general-industry expertise (13% each, on average). The *edu_index_board* and *expert_index_board* suggest that the average MEE director has one degree and one area of expertise.

[Insert Table 3 here]

Looking at the trend over the sample period in Figure 1, both the number of directors and proportion of board members holding a bachelor's degree or a master's degree (including MBA degree) increased slightly over time. On the other hand, directors holding research degrees, such as honours degrees and PhDs, decreased over the same period.



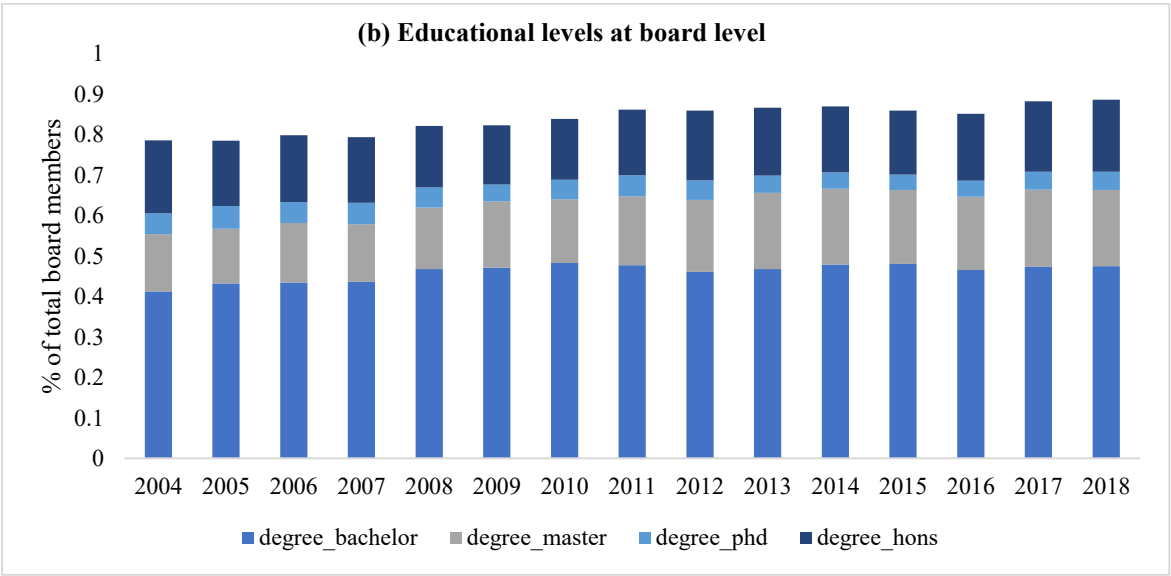


Figure 1: Directors' educational levels between 2004 and 2018.

For directors' expertise shown in Figure 2, industry-related expertise (both technical mining and general industry expertise) tends to decrease over time. In contrast, there is a noticeable increase in the proportion of the board having directors with financial expertise.

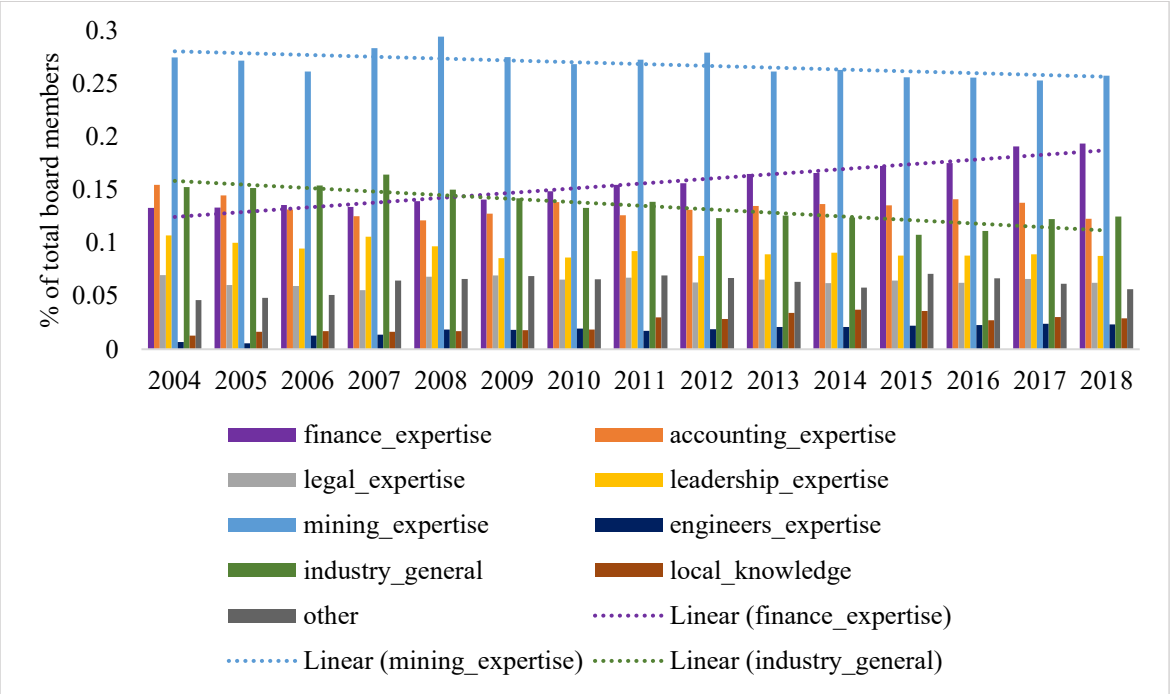


Figure 2: Directors' expertise between 2004 and 2018.

Table 3, Panel B provides information about the MDs' qualifications and expertise. Similar to other board members, the average MD has one formal academic qualification and has one area of expertise. Of the entire MEE sample, 35% of MDs have a bachelor's degree, followed by honours degree with 21%. In addition, only 8% of MDs in the sample have an MBA degree. However, there is an increase in the number of MDs holding MBA qualifications between the 2004–2018 period (from approximately 4% in 2004 to 10% in 2018) as presented in Figure 3. Similar to the patterns observed in board members' education, less MDs tend to hold honours or PhD degrees over time. The trend in MDs' expertise is also similar to that of other board members, with Figure 4 showing a downward trend observed for industry expertise and an upward trend for financial expertise.

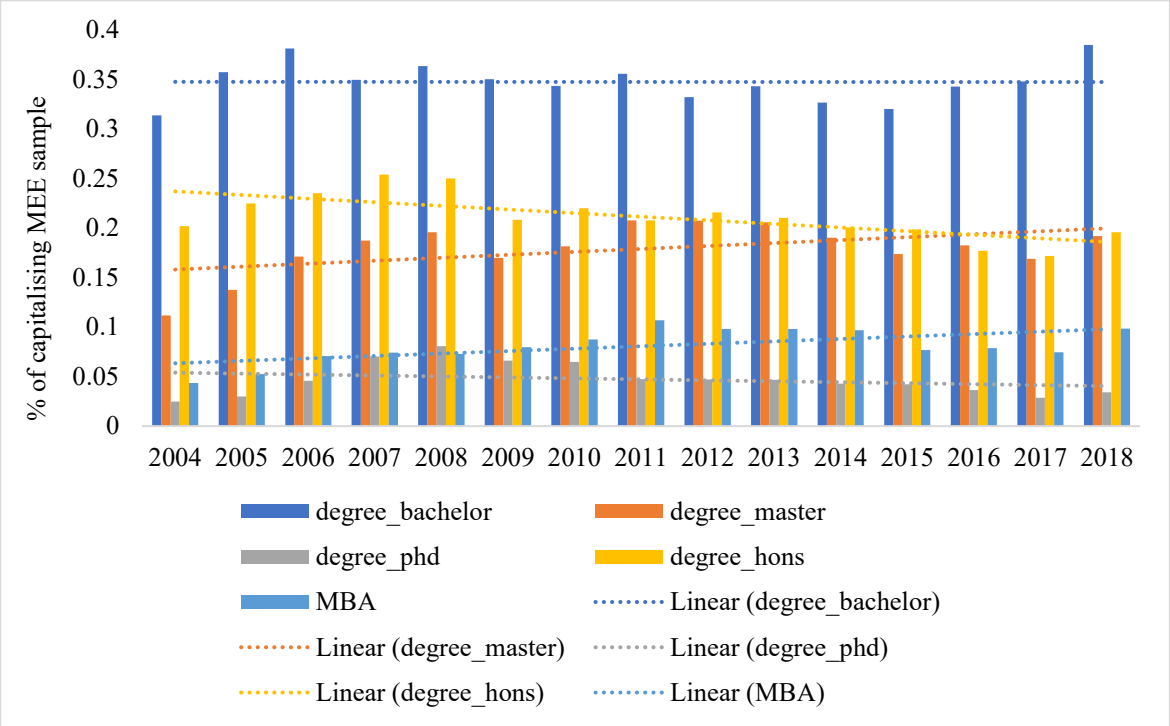


Figure 3: MD's educational levels between 2004 and 2018.

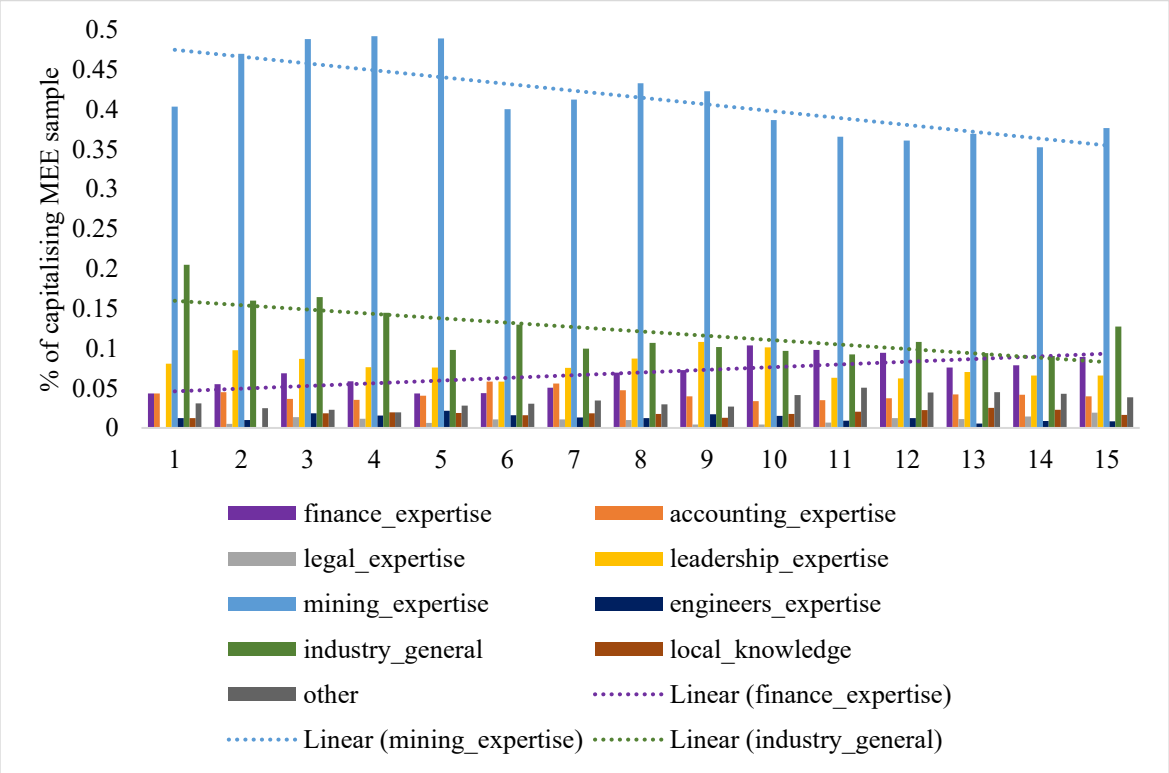


Figure 4: MD's expertise between 2004 and 2018.

Table 4 reports the diversity of education and expertise for the entire board and for board members excluding the MD. A higher Blau score suggests greater diversity of education and expertise. By construction, the Blau score for education diversity and expertise diversity ranges from 0 to 0.75 and 0 to 0.857, respectively.[28] Looking at variations in academic qualifications (expertise) at the board level, *D_degree_fullboard* (*D_expert_fullboard*) has an average score of 0.43 (0.60), suggesting a relatively high level of diversity represented on MEEs boards. Similar patterns can be observed in the diversity score of board members excluding the MD, but to a lesser extent.

[Insert Table 4 here]

Table 5 reports the Pearson's correlation matrix for all variables used for testing H1 and H2. As can be seen in Panel A, board members' education is significantly correlated with investments in E&E assets only ($r = 0.0343$, $p < 0.05$) while their expertise is significantly and positively correlated with both future E&E investments ($r = 0.0518$, $p < 0.01$) and equity raisings ($r = 0.0364$, $p < 0.01$). These results are largely consistent with the conjectures under H1a and H1b. Additionally, significant correlations are also observed between the MDs' academic qualifications and expertise and E&E investments and fund raising in the following year, suggesting the important role of the executives who are involved in MEEs' day-to-day corporate activities and decisions.

[Insert Table 5 here]

As reported in Panel B, degree diversity among all board members or among members excluding the MD is positively correlated with E&E investment ($r = 0.0851$, $p < 0.01$ for

[28] Expertise diversity is measured using seven categories with *other_expertise* comprising industry expertise, local expertise and other knowledge.

entire board; $r = 0.0616$, $p < 0.01$ when excluding MD) and equity financing ($r = 0.0480$, $p < 0.01$ for entire board and $r = 0.0395$, $p < 0.01$ when excluding MD) in year $t + 1$. For expertise diversity, there is a positive correlation with subsequent year equity raising at the entire board level ($r = 0.0298$, $p < 0.05$) and a positive correlation with future E&E investments when diversity is measured excluding the MD ($r = 0.0284$, $p < 0.05$). Overall, univariate correlation results suggest the benefits of board diversity outweigh the potential costs, rejecting the null associations under H2a and H2b.

The correlations between education and expertise reported in Panel C show it is not always the case that higher levels of education are positively correlated with expertise. For example, the proportion of board members with accounting expertise is negatively correlated with the proportion of directors on the board holding a master's degree ($r = -0.1736$, $p < 0.01$), honours degree ($r = -0.1490$, $p < 0.01$) or PhD degree ($r = -0.1271$, $p < 0.01$). This may suggest that excellence in a certain functional area can be attained through professional career with a minimum bachelor's qualification. However, it is also noticeable that there are significantly positive correlations between directors with mining expertise and honours, masters and PhD degrees ($r = 0.3657$, $p < 0.01$ for honours; $r = 0.1500$, $p < 0.01$ for master's; and $r = 0.2342$, $p < 0.01$ for PhD), which suggests that board members develop technical mining expertise through both academic studies and work experience. A similar trend can be seen between the MDs' degrees and mining expertise.

Finally, there is a significant and negative correlation between the bachelor's degree of board members and education diversity measured excluding the MD's education ($r = -0.0899$, $p < 0.01$), while there are significant and positive correlations between other educational levels and education diversity ($r = 0.6088$, $p < 0.01$ for master's degree; $r = 0.5579$, $p < 0.01$ for honours; and $r = 0.4025$, $p < 0.01$ for PhDs). Similar results are reported when education diversity is measured including the MD's education. These results indicate

that variations in education are driven by higher levels of education except for bachelor degrees given that it is common for board members to obtain a bachelor's degree. The correlations between expertise type and expertise diversity are generally positive and significant.

5. Main results

5.1. Board education and expertise

5.1.1. Board education

Table 6 presents findings of the associations between directors' educational backgrounds and future investment and financing outcomes. The analyses are based on an OLS regression controlling for both firm and year fixed-effects, with robust standard errors to account for heteroskedasticity.

Columns (1) to (4) of Panel A separately examine the relation between each level of directors' education and E&E asset investment in year *t+1*, respectively. As can be seen from Columns (1) and (2), directors holding bachelor's and master's degrees are significantly associated with higher levels of future investment in key exploration activities (coefficient = 1.1273, $p < 0.01$ for bachelor's degree; coefficient = 1.1669, $p < 0.05$ for master's degree). The results remain significantly positive in Column (5), with the coefficients for undergraduate and master's qualifications being 1.6424 ($p < 0.01$) and 0.9249 ($p < 0.1$), respectively, when all levels of education are taken into consideration[29]. These results lend

[29] The insignificant result for PhD does not necessarily indicate that directors holding PhD qualifications did not make significant contributions to MEEs. It could be that there was not enough variation in the sample (due to a small proportion of the board having directors with a PhD degree, 5% of the board on average as opposed to 47% with bachelor degree and 17% with master's as shown in Table 3). An alternative explanation suggested

support to H1a that there is a positive association between directors' education and strategic advice on investments. It is implied that appointing one additional board member (equivalent to a 25% increase for a median board size of four) with a bachelor's (master's) degree is associated with 50.77% (26.01%) increase in exploration asset investment in the following year.[30] Findings in Column (5) also suggest that MDs' education matters when making investment decisions. Specifically, MDs having a bachelor's qualification is associated with an increase in future asset investment of 63.82%.[31] The significantly positive coefficient of the indexed measure, *edu_index_board,* in Column (6) confirms findings reported in other columns. In sum, consistent with findings in Fedaseyeu et al. (2018), there is evidence in the MEE setting supporting H1a that highly educated directors have a positive role in facilitating strategic advice on decisions regarding future E&E expenditure.

[Insert Table 6 here]

Table 6, Panel B examines the association between directors' education and equity financing. Coefficient estimates reported in Columns (4) and (5) suggest that investors view boards with directors holding honours degree favourably and are more willing to provide equity capital. The estimated coefficient of 1.4616 ($p < 0.1$) implies that appointing one more director with an honours degree is associated with an increase in equity proceeds of 44.11%

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by King et al. (2017) is that PhD education may play a more significant role in output-focused industries such as R&D.

[30] The economic magnitude is calculated as $e^{(1.6424 \times 0.25)} - 1$ for bachelor's degree and $e^{(0.9249 \times 0.25)} - 1$ for master's degree. The economic effects of directors' education and equity financing are estimated in the same manner.

[31] The economic magnitude for the MD's Bachelor degree is calculated as $e^{(0.4936 \times 1)} - 1$. The measure of MD's bachelor degree is an indicator variable not proportional like other board members.

in year *t+1* for a median board of four members. It is also evident from Panel B that the MD's educational background plays an important role in enhancing investors' confidence in investing in the firm, leading to a higher amount of equity raised. Indeed, results in Column (5) indicate that MDs with a bachelor's (honours) degree are associated with an increase of 109.11% (185.48%) in external finance in the following year. These findings complement those of Chevalier and Ellison (1999) and King et al. (2017) about the positive relation between MD's education and firm performance.

5.1.2. Board expertise

Findings of the associations between directors' expertise and MEEs' future investment and fundraising outcomes are reported in Table 7 Panels A and B, respectively.

[Insert Table 7 here]

Columns (1) to (9) of Panel A separately regress future E&E investments on each type of expertise possessed by board members and the MD, while Column (10) incorporates all types of expertise represented on the board. Of particular interest is directors' technical mining expertise, which loads significantly with an estimated coefficient of 2.1487 ($p < 0.01$) and 2.7620 ($p < 0.01$) in Columns (5) and (10), respectively. The results suggest that directors with technical expertise essential for assessing project feasibility and associated risks are positively related to future investment in exploration assets. In terms of economic magnitude, where one more director with mining expertise joins the board, future exploration investments increase by 99.47% (Column 10).[32] General industry knowledge other than technical expertise

[32] The economic magnitude is calculated as $e^{(2.7620 \times 0.25)} - 1$. The economic effects of the associations between other types of expertise and future E&E asset investment and equity finance are measured in the same manner.

also plays a positive role but to a lesser extent, with the appointment of an additional general-industry expert associated with a 49.27% increase in future exploration investments. Further, other general business and commercial knowledge seems to have a positive impact on E&E asset investment as shown in Columns (9) and (10), with a coefficient of 1.5535 ($p < 0.1$) and 2.1861 ($p < 0.05$), respectively. The significant associations documented in Columns (5) to (10) are also observed for the indexed measure, *expert_index_board* (coefficient = 0.9208, $p < 0.01$). Overall, Table 7, Panel A shows MEE board of directors with technical and related industry expertise benefit future investment decisions of the firm, which is consistent with the prediction under H1b and findings documented in prior literature regarding the importance of directors with industry expertise in providing strategic advice to explore growth opportunities.

Results in Columns (4) and (5) show that MDs' leadership skills and technical expertise have positive impacts on investment decisions, which remains to be the case when all types of expertise are considered in Column (10). It can be interpreted that MDs who have previously held executive roles at publicly listed companies (have technical-mining expertise) are associated with an increase in future E&E asset investments of 111.59% (63.36%).

Table 7, Panel B presents the association between professional expertise of board members and equity raising in year *t+1*. As presented in Columns (5) and (10), both board members and MDs who have extensive technical expertise are better able to access the equity market for additional financial resources (coefficient = 2.4319, $p < 0.01$ for board members excluding the MD; coefficient = 1.1440, $p < 0.01$ for MDs). Economically, boards with an additional member who is a mining expert raise an additional 83.67% capital from the equity market, while a mining-expert MD increases equity raising by 213.93%. The significant economic impacts are realised because such technical expertise provides equity investors with greater confidence that funds raised will be used efficiently on mining activities in anticipation of future economic payoffs. Further, consistent with prior studies (Guner et al., 2008; Gilani

et al., 2021) that discuss the positive role of directors with financial expertise in providing firms with better access to external financial sources, Column (10) shows that the proportion of board members with financial expertise is positively and significantly associated with the level of future equity proceeds. The coefficient of 1.3960 ($p < 0.1$) suggests that a median board appointing one additional director with financial expertise is able to increase equity financing by 41.76%. The indexed measure of expertise for board members and for MDs reported in Column (11) provide further evidence supporting H1b that boards with expertise are favourably viewed by investors (coefficient = 0.8683, $p < 0.05$ for board members; coefficient = 0.3359, $p < 0.1$ for MDs).

5.1.3. Board education and expertise

Tables 8 and 9 provide regression results incorporating all measures of education and expertise, together with the indexed measures.

[Insert Table 8 here]

In terms of educational background, no consistent findings are documented under Table 8, Column (1) controlling for year fixed effects and Column (2) controlling for both year and firm fixed effects. However, there is some evidence in Column (2) indicating that board members holding bachelor's or honours degrees are positively associated with E&E investments in year *t+1* (coefficient = 1.8660, $p < 0.01$ for bachelor's degree; coefficient = 1.0672, $p < 0.1$ for the honours degree), which are consistent with results reported in Table 6. In terms of economic significance, for a median board of four members, the appointment of one more director with a bachelor's (honours) degree is associated with an increase in exploration investment by 59.44% (30.58%).

Regarding directors' expertise, consistent with findings presented in Table 7, technical mining experts, general-industry experts and other business experts all contribute positively

to future strategic investment advice. A coefficient of 2.2646 ($p < 0.01$) for technical expertise implies that as one more mining expert is appointed to the median board, MEEs' investment in exploration assets experiences a 76.15% increase. Similarly, appointing an additional member with general industry (business) expertise improves asset investment by 55.74% (77.61%). As for MDs, only their leadership expertise seems to have a positive impact on future investment (coefficient = 0.8065, $p < 0.05$) when both education and expertise are accounted for and the economic value is considerably larger. That is, if the MDs have prior experience as executives of publicly listed firms, such leadership and management expertise are associated with an increase in future investment of 124.01%.

Directors' educational background does not seem to play a significant role in external fund raising when expertise is also taken into consideration. However, both Columns (3) and (4) of Table 8 show that directors with technical mining expertise are better able to persuade investors to increase financial investment in MEEs. The coefficient estimates of 2.0385 ($p < 0.05$) for board members and 0.8038 ($p < 0.1$) for MDs in Column (4) suggest that an increase in equity proceeds of 66.47% and 123.40%, respectively, may be realised when the median board appoints one director or MD with technical expertise to ensure capital providers that funds will be spent on technical work. The significant results for expertise, but not education, are consistent with those in Fich (2005) who suggests that the role of formal qualifications is of less importance compared to professional expertise.

Table 9 replaces individual measures of education and expertise with their composite index measures where consistent findings are observed under different estimations shown across Columns (1) to (4). In addition, consistent with findings in Tables 6, 7 and 8, the sum of directors' educational levels and expertise is significantly and positively associated with both investment and financing outcomes (coefficient = 0.8686, $p < 0.01$ for future exploration investments in Column (2); coefficient = 0.5866, $p < 0.01$ for future equity raising in Column

(4)). There is also evidence showing that MDs with higher human capital are able to raise more equity finance as shown in Columns (1), (3) and (4).

[Insert Table 9 here]

Overall, findings in Table 8 and Table 9 provide evidence supporting H1c that directors with higher educational attainment and expertise provide superior strategic advice to management on investment and financing activities.

5.2. Board diversity

Tables 10 and 11 present the analyses of education diversity and expertise diversity among board members excluding the MD and among the entire board members, respectively.

The coefficient estimates for *D_degree_board* reported in Columns (1) to (4) of Table 10 are significantly positive at the 1% or 5% level; this suggests that diverse educational levels broaden cognitive perspectives on the board, the benefits of which help alleviate communication and coordination problems, leading to net positive impacts on E&E investments and external finance. Results from Columns (2) and (4) which control for both year and firm fixed effects suggest that a one standard-deviation increase in directors' education diversity (σ = 0.2638) is associated with 32.99% and 32.28% increase in future exploration asset investment and equity proceeds raised in the following year, respectively.[33] When the MDs' education and expertise are considered in deriving diversity for the entire board, stronger results are reported as can be seen in Table 11.

[Insert Table 10 here]

[33] The economic magnitude is estimated as $e^{(0.2638 \times 1.0807)} - 1$ for E&E investment and $e^{(0.2638 \times 1.0605)} - 1$ for equity finance in year t+1.

[Insert Table 11 here]

Findings from Table 10 and 11 suggest that expertise diversity is not significantly associated with board advice on MEE's investment and financing decisions. The results imply that communication difficulties may offset the benefits of a wider range of professional expertise. As directors devote a significant part of their career to a single field to achieve the depth of knowledge and excellence, it could be difficult for other board members to persuade them about something which is not within their expertise and consequently reach consensus in decisions. On the positive side, the communication challenges are not too significant to adversely affect board advice due to MEEs' small board size. The findings presented here are consistent with those from Giannetti and Zhao (2019) who show that there are both costs and benefits associated with board diversity.

5.3. Mediating effects of professional memberships

This section examines directors' professional memberships to provide insights into the channel through which directors' human capital, and their diversity, contribute to effective advice to management on investment and financial decisions. Membership of leading industry institutions offer two major benefits to directors and their firms. First, it broadens director networks beyond the boardroom, which provides access to a breadth of information resources needed by capital-constrained firms such as MEEs as they undertake exploration and fund-raising activities.[34] Second, joining industry peak bodies facilitates the exchange of highly technical knowledge with peers which deepens directors' expertise. Bhowmik and Rogers (1970) suggest homophily facilitates effective communication. Cohen et al. (2008) show that portfolio managers sharing the same education networks perform better (measured as excess

[34] The significant benefits of director networks are discussed in detail in Chapter 2.

stock returns of firms in which they invest). The positive outcomes are achieved because educational connections that managers share with investees' directors or executives enable them to obtain information more quickly and at a lower cost, which consequently allows them to make more effective investment decisions. Similar benefits are expected to arise in the MEE setting. Through connections within professional institutions, directors bring back valuable industry and technical knowledge which help management make superior decisions in both exploration investments and fund raising.

Data on professional memberships were manually collected each year from biographies of directors disclosed in MEE annual reports. For mining professional memberships, if no information is disclosed in the biographies, additional sources, including the Competent Persons (CP) statement and the quarterly activity statement, are used to identify whether industry memberships of an accredited CP as authorised by the ASX and the Joint Ore Reserve Code are disclosed. Descriptive information in Table 12 shows that the Australasian Institute of Mining and Metallurgy (AusIMM) attracts the highest number of members (both directors and MDs), followed by the Australian Institute of Company Directors (AICD). On average, 35% and 27% of the MEE sample are members and fellows of the AusIMM, respectively. For the AICD, 29% (22%) of the sample are members (fellows). It is noted that, apart from the AICD and the Governance Institute of Australia (GIA), other professional institutions primarily facilitate members' technical enhancement and career development within a single industry/sector.

[Insert Table 12 here]

The direct effects of directors' professional memberships and MEEs' corporate outcomes are presented in Table 13. Board members joining the Australian Institute of Geoscientists (AIG) are found to be significantly associated with MEEs' additional

investment in future exploration activities (coefficient = 0.5744, $p < 0.01$ in Column (11) of Panel A). On the other hand, directors who are fellows of the Financial Services Institute of Australasia (Finsia) encourage less investment in exploration.[35] Interestingly, MDs who have non-mining memberships, who are chartered accountants or members of the GIA, are shown to invest more heavily in exploration assets. Table 13, Panel B shows the results for equity raising. Column (11) shows that AusIMM membership is associated with improved access to the capital markets for fund raising (coefficient = 0.7241, $p < 0.01$ for board members; coefficient = 0.5602, $p < 0.1$ for MDs).

[Insert Table 13 here]

To demonstrate the channelling/mediating effect of professional memberships on the association between directors' human capital and their advisory role, this chapter follows a three-step analysis recommended by Baron and Kenny (1986).[36] Table 14 reports the mediating effect of mining professional memberships on the link between directors' education and expertise and future equity raising. [37] Column (1) demonstrates that directors with higher levels of human capital (both education and expertise) are more likely to join mining associations, the benefits of which are translated into more equity capital raised as seen in Column (3). The coefficient on *edu_expert_index_board* while remaining significant is

[35] Finsia does not have member level but has a senior associate level which requires at least 5 years of work experience (among other requirements), or a fellow level which requires at least 15 years of experience.

[36] Chapter 2 discusses in detail the three-step analysis recommended by Baron and Kenny (1986).

[37] Accounting/financial memberships (memberships with the CA, CPA, Finsia), AICD membership and GIA membership were also examined. However, the direct and mediating effects are not significant, and hence are untabulated.

reduced by about 15% ($p < 0.05$) from what is reported in Column (2) through *Mining_mem_board*$_t$.

[Insert Table 14 here]

The mediating effect of mining association memberships on the link between directors' education and expertise and future E&E investments was also examined. However, no significant effect is evident, which suggests the key benefit of joining professional institutions is networking with peers and increasing awareness of the firm with potential investors. This helps mitigate information asymmetry concerns inherent in early-stage firms that consequently increase the amount of equity capital.

Similarly, Table 15 investigates the mediating effect of professional memberships on the link between diversity of education and expertise, and investment and financing outcomes. Diverse academic qualifications and professional backgrounds reflect the breadth of cognitive skills and expertise rather than the depth of the board. As such, professional memberships considered in Table 15 only include member level, not fellow level which requires demonstration of extensive work experience and skills.

[Insert Table 15 here]

Column (1) of both Panels A and B show that boards with diverse educational backgrounds are more likely to have members joining mining associations (coefficient = 1.4460, $p < 0.01$). As expected, higher diversity of educational attainment on the MEE board helps gain access to the equity market through social networks. Column (3) of Panel A depicts a lower coefficient estimate on *D_degree_board* compared to that in Column (2) by about 14% ($p < 0.01$).

Further, Panel B provides weak evidence that through these social networks, directors gain relevant industry and technical knowledge in order to advise on strategic investment activities with a mediating effect of about 5% ($p < 0.1$). To the extent that communication difficulties may emerge due to diverse educational levels present on the board, having board members with professional memberships could partially mitigate such obstacles. The rationale is straight forward: directors with diverse educational backgrounds have the opportunity to not only interact with each other outside the boardroom to enhance mutual understanding but also with directors of peer firms, investors, and other stakeholders that extend and strengthen their knowledge about the mining sector. Hence, when they deliberate on firms' strategic exploration decisions, discussions and debates are facilitated more effectively, resulting in better advice.

6. Additional tests

A number of additional tests were performed to confirm and extend the main findings reported in Section 5.

6.1. Moderating effects

Chapter 2 describes the rationale underlying MEEs' significant demand for board capital (both social and human capital) due to the lack of managerial resources available internally (Fahlenbrach et al., 2010; Trench, 2013). Therefore, the importance of boards' qualifications and expertise is expected to be more pronounced for MEEs whose MDs have lower qualifications. Further, consistent with findings in Chapter 2 and prior studies, both the board's and MD's social capital contribute positively to improving information resources needed to execute strategic decisions. Therefore, if the MD of an MEE is not connected enough to bring in additional information, the board's own human capital is expected to play a stronger role.

Column (1) of Table 16 shows that MEEs' investment and financing outcomes are negatively affected by MDs' low educational and professional backgrounds (ranked in the lowest quintile of *edu_expert_index_MD*). However, such adversity on future exploration investment is moderated by boards' education and expertise, as evidenced by the interaction terms *edu_expert_index_board*×*edu_expert_index_MD_Q1* (coefficient = 0.9240, $p < 0.01$). There was no significant moderating effect in relation to capital raising.

[Insert Table 16 here]

Columns (3) and (4) examine the interaction between the MDs' social capital and the boards' human capital. MDs in the lowest quintile of centrality are significantly and negatively associated with investment in exploration assets and the amount of equity financing in the following year (coefficient = −2.7031, $p < 0.01$ for E&E investment; coefficient = −3.0825, $p < 0.01$ for equity financing). The negative impacts of low managerial social capital are mitigated by the boards' qualifications and expertise, as demonstrated by the positive and significant interaction term *edu_expert_index_board* × *centrality_MD_Q1* (coefficient = 1.3674, $p < 0.01$ for E&E investment, coefficient = 1.0054, $p < 0.05$ for equity financing). Taken together, findings from Table 16 demonstrate that MEEs boards are structured in a way which reflects the firms' demand for board capital and complements management's expertise and social capital.

6.2. Additional tests

6.2.1. Boards' leadership skills

Fich (2005) argues that directors with CEO experience are effective in identifying growth opportunities by contributing both expertise and business acumen. Similarly, Kang et al. (2018) posit that directors with both leadership skills and industry-specific experience are effective in advising their firm on investment strategies. Table 17 examines whether

leadership and management expertise improve the advice of board members who have common functional or technical expertise.

[Insert Table 17 here]

Consistent with findings documented in Table 7, Column (7) of Table 17 shows directors with technical mining expertise are effective advisors on exploration investment (coefficient = 1.5328, $p < 0.01$). Table 17 further highlights that the effectiveness of advice offered by directors with mining expertise is significantly improved when they also have leadership skills attained from past executive roles at publicly listed entities. The interaction term *mining_expertise_board* × *leader_board* is positive and significant at the 5% level. The result resonates with that of Kang et al. (2018) who document positive effects of industry-CEO experience in enhancing value-added growth.

6.2.2. Boards' general industry expertise

While the main findings of this chapter suggest the impacts of general-industry expertise on MEEs' corporate outcomes may not be as significant relative to technical-mining expertise, prior literature on industry expertise (using a broad classification that can also include technical expertise) consistently documents the positive role of directors with industry expertise. This section aims to investigate whether directors with both functional business expertise (accounting, finance and legal) and general industry expertise perform their advisory role any better than those who only possess the former.

[Insert Table 18 here]

As shown in Table 18, the interaction terms between finance, accounting, or legal expertise and general-industry expertise are generally insignificant, confirming the main findings that general-industry expertise does not play a significant role in providing value-enhancing advice. These results also highlight the importance of separating technical

expertise from general-industry expertise. A practical implication of the results is that when MEE boards consider appointing a new member with functional business expertise, they can extend the candidate search to industries beyond the mining sector. Such expertise is still essential to MEEs for general business activities necessary to maintain normal operations, despite the consequences not being directly reflected in investment and financing outcomes.

6.2.3. Future stock returns

To examine whether the benefits of directors' qualifications and expertise on the board could be indirectly reflected through improved stock performance, Tables 19 and 20 report the associations between directors' education and expertise and stock returns in year $t+1$, respectively.

[Insert Table 19 here]

As shown in Table 19, neither the board members' educational level nor that of the MD is significantly associated with future stock performance. The result is consistent with Fich (2005) who finds no positive capital market reaction to appointments of directors with MBAs or law degrees, which can be attributed to the preference for professional expertise.

[Insert Table 20 here]

Table 20 investigates the association between directors' education and professional expertise and stock returns. There is weak evidence that directors with financial expertise are viewed positively by the capital market (coefficient = 0.2102, $p < 0.1$ for a separate analysis of financial expertise in Column (1); coefficient = 0.2796, $p < 0.1$ for analysis which incorporates all types of education and expertise in Column (10)). In contrast, the market applies a significant discount on the value of directors with general-industry expertise (coefficient = −0.3511, $p < 0.05$ in Column (7); coefficient = −0.3114, $p < 0.05$ in Column (10)). One interpretation of this finding is the equity market is concerned that general-industry

experts may not add significant value to the advisory role of MEE boards given the presence of technical-mining experts on the board and the financially-constrained situation of these firms that allows only minimal spending on non-mining related expenditure.

6.3. Robustness tests

The use of an industry-focused setting and a two-way firm-year fixed-effects approach in this chapter should help mitigate concerns over omitted variables. Further, all dependent variables are measured in year $t + 1$, thus avoiding problems of reverse causality. However, endogeneity issues cannot be completely ruled out. This chapter aims to address endogeneity concerns by performing a two-stage least square (2SLS) regression with board members' education and expertise treated as endogenous.

Two instruments, $edu\_expert\_index\_local_t$ and EE_wo_t, are selected as determinants of directors' education and expertise. The choice of $edu\_expert\_index\_local_t$, which measures the local pool of director human capital, is based on the findings of Knyazeva et al. (2013), who document a positive association between the pool of local director talent and board composition.[38] It is not expected that the local supply of director qualifications and expertise would directly affect the focal MEEs' investing and financing decisions. The measure EE_wo_t captures the dollar amount of impairments and/or write-offs of exploration assets. According to the *AASB 6 Exploration for and Evaluation of Mineral Resources*, there are specific facts and circumstances suggesting that the carrying amount of capitalised E&E expenditure exceeds its recoverable amount. Various external factors are often cited by MEEs as triggering events for the impairment test; this includes unfavourable commodity price movements, or

[38] Based on MEEs' headquarters or principal business addresses, which were hand collected from each year's annual report (please refer to Appendix D for descriptive information on MEEs' headquarters), this chapter measures the local pool of directors' educational backgrounds and expertise based on a group of firms sharing the same two-digit postcode for each financial year.

changes in operating requirements introduced by local government and the regulator. These adverse circumstances decrease managers' risk appetite and increase their dependence on the board for strategic advice. Consequently, it is anticipated that the higher the level of impairment recorded by MEEs, the more pressing the need for the boards' knowledge and expertise to assess project feasibility and funding options. While events leading to impairment may require evaluation of investment and financing activities, the quantum of impairment is not expected to directly affect future corporate investment and finance.

For education and expertise diversity, this chapter follows Anderson et al. (2011) to use state-level diversity as the determinant of MEE directors' diversity, expecting that this characteristic will not directly influence MEEs' corporate policies and performance. Specifically, based on the states in which MEEs' headquarters are located, this chapter identifies and calculates the state-wide diversity of four demographic characteristics: age, gender, employment status, and ratio of employment in the mining sector.[39] The diversity of each attribute is then ranked by quintile in each year. The average of the four equally-weighted quintile-ranked state characteristics is used as a proxy for state-wide diversity.

Table 21 reports results for the analysis of directors' human capital and firms' future E&E investment and fund raising. As expected, the first-stage regression in Column (1) shows a significant association between the local pool of directors' human capital and MEE directors' education and expertise. In addition, a higher level of impairment reflects a greater demand for directors' human capital. The second-stage regression results in Column (2) confirms the main findings reported in Table 9 on the positive link between directors' academic qualifications and expertise, and MEEs' value-added investing activities

[39] Data on each Australian state's demographic characteristics was obtained from the Australian Bureau of Statistics.

(coefficient on *edu_expert_index_board* = 1.8881, $p < 0.05$). However, the second-stage results in Column (3) do not seem to suggest the importance of board qualifications and expertise on future equity financing.

[Insert Table 21 here]

Untabulated empirical findings confirm the significant association between state-wide diversity and the diversity of MEE directors' education and expertise. However, no significant evidence is documented in the second stage to suggest diversity in education and expertise are associated with future investment and equity raisings. Overall, there is some evidence from the 2SLS regression suggesting that directors with higher levels of human capital are more equipped to perform their advisory role.

7. Conclusion

In conclusion, this chapter shows board human capital contributes positively to its advisory functions. Specifically, board members with bachelor's and honours degrees are found to be associated with higher investments in exploration assets, which are expected to create future economic benefits. In terms of expertise, directors with technical mining expertise not only help assess exploration investments but also enhance investor confidence in MEEs' use of equity proceeds. Findings in this chapter also demonstrate the importance of separating technical mining expertise from general-industry knowledge, given the latter does not appear to have a large impact on MEEs' corporate outcomes relative to the former. Additionally, directors' education diversity broadens the board's perspectives and approaches to decision-making, which consequently enhances its advising capability. This chapter further highlights that joining professional associations is a channel through which board human capital can facilitate superior advice to the management via increased social capital.

Despite the important role of board members, the role of managing directors, who are involved in MEEs' daily operations, cannot be ignored. The main results show that, similar

to other board members, MDs' educational level and technical mining expertise are positively associated with future investment and financing outcomes. The MDs' leadership skills also play a role in facilitating greater asset investment. However, when the MDs' social and human capital are limited, either due to a lack of connectedness or low qualifications, board human capital can play a more active role to ensure effective corporate decisions.

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Chapter 3 Tables

Table 1: Sample construction

Panel A: Sample selection		
	Firm-year observations	Unique firms
Board information of metals & mining firms, 2004−2018	8,887	1,059
Less:		
Large mining firms (firms with operating revenue greater than $1 million)	–1,752	
Firms offering mining services	–205	
Missing financial, market capitalisation, governance data	–978	
Firms directly expensing their exploration and evaluation expenditure (Expensers)	–794	
Final sample of mining exploration entities (MEEs), 2004–2018	5,158	820

Panel B: Sample distribution by year		
Year	Observations	Percentage
2004	161	3.12
2005	200	3.88
2006	219	4.25
2007	256	4.96
2008	322	6.24
2009	377	7.31
2010	377	7.31
2011	402	7.79
2012	468	9.07
2013	459	8.90
2014	444	8.61
2015	403	7.81
2016	356	6.90
2017	349	6.77
2018	365	7.08
Total	**5,158**	**100.00**

Table 2: Descriptive statistics

Panel A: Firm and board characteristics

	Firm-level variables					Board characteristics				
Variables	Obs	Min	Mean	Median	Max		Min	Mean	Median	Max
MVE ($000)	5,158	677.00	38,519.00	11,354.00	637,576.00	*Board_Size*	2.00	4.00	4.00	7.00
MVE	5,158	13.42	16.36	16.25	20.27	*Indep_Ned (Number)*	0.00	1.42	1.00	4.00
Equity ($000)	5,158	0.00	5,292.00	1,613.00	82,046.00	*Indep_Ned (%)*	0.00	0.35	0.33	1.00
RET	5,158	–0.89	0.17	–0.17	5.86	*Busy_Ned (Number)*	0.00	0.49	0.00	3.00
SD_RET	5,158	0.31	0.92	0.82	2.82	*Busy_Ned (%)*	0.00	0.12	0.00	0.67
MTB	5,158	–6.57	2.18	1.23	24.75					

Panel A reports firm and governance statistics of capitalising MEEs for the period 2004–2018. *MVE ($000)* and *MVE* are values in thousands and the natural logarithm of market capitalisation, respectively. *Equity ($000)* is the value in thousands of proceeds from equity financing. *RET* is the annual buy-and-hold stock return adjusted for dividends and capital changes. *SD_RET* is the annualised standard deviation of monthly stock returns in the prior two years. *MTB* is the market-to-book value of equity. *Board_Size* is the number of directors sitting on the board. *Indep_Ned (Number)* and *Indep_Ned (%)* are the number and percentage of independent non-executive directors (NEDs) on the board, respectively. *Busy_Ned (Number)* and *Busy_Ned* (%) are the number and percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board, respectively.

Panel B: Exploration & evaluation (E&E) assets

	Observations in thousand dollars					Observations scaled by total assets			
Variables	Obs	Min	Mean	Median	Max	Min	Mean	Median	Max
EE_Add	5,158	0.00	2,465.96	1,094.32	22,118.97	0.00	0.15	0.11	0.99
EE_Acq	5,158	0.00	665.14	0.00	20,616.91	0.00	0.04	0.00	0.79
EE_Comb	5,158	0.00	3,242.00	1,347.48	31,656.67	0.00	0.20	0.13	1.21
EE_Bal	5,158	0.00	11,237.77	5,592.81	112,501.00	0.00	0.54	0.60	0.99

Panel B describes the key capitalised components of the E&E asset account for the period 2004–2018. *EE_Add* on the left side and right side of the table are the amount of exploration and evaluation (E&E) asset additions and the proportion of E&E asset additions in total assets, respectively; *EE_Acq* on the left side and right side of the table are the amount of E&E asset acquisitions comprising both tenements and other E&E assets and the proportion of E&E asset acquisitions in total assets, respectively; *EE_Comb* on the left side and right side of the table are the sum of *EE_Add* and *EE_Acq* and the proportion of both *EE_Add* and *EE_Acq* in total assets, respectively. *EE_Bal* is the closing balance of the E&E asset account on the left side of the table and the proportion of closing E&E asset balance out of total assets on the right side of the table.

Table 3: Education and expertise

Panel A: Board members excluding the MD

	Total number of members					Proportion of the board			
Variables	Obs	Min	Mean	Median	Max	Min	Mean	Median	Max
Education									
degree_bachelor_board	5,158	0	2	2	6	0	0.47	0.50	1.00
degree_master_board	5,158	0	1	1	5	0	0.17	0.14	0.75
degree_phd_board	5,158	0	0	0	3	0	0.05	0.00	0.40
degree_hons_board	5,158	0	1	0	5	0	0.16	0.00	0.67
MBA_board	5,158	0	0	0	3	0	0.07	0.00	0.75
Expertise									
finance_expertise_board	5,158	0	1	0	6	0	0.16	0.00	0.67
accounting_expertise_board	5,158	0	1	0	4	0	0.13	0.00	0.67
legal_expertise_board	5,158	0	0	0	3	0	0.06	0.00	0.50
leadership_expertise_board	5,158	0	0	0	4	0	0.09	0.00	0.57
mining_expertise_board	5,158	0	1	1	6	0	0.27	0.25	0.75
engineers_expertise_board	5,158	0	0	0	2	0	0.02	0.00	0.33
other_expertise_board	5,158	0	1	1	5	0	0.22	0.25	0.75
industry_expertise_board	5,158	0	1	0	4	0	0.13	0.00	0.67
local_ expertise_board	5,158	0	0	0	4	0	0.03	0.00	0.40
other_knowledge_board	5,158	0	0	0	3	0	0.06	0.00	0.50
Index									
edu_index_board	5,158	0	1	1	2				
expert_index_board	5,158	0	1	1	2				
edu_expert_index_board	5,158	1	2	2	4				

Panel A presents academic qualifications and expertise of board members excluding the managing director (MD) for the period 2004–2018. The degrees and expertise of directors are indicator variables coded 1 if they have a certain degree or type of expertise, and 0 otherwise; *other_expertise_board* was further classified into three sub-categories comprising general industry expertise, local expertise, and other business and commercial expertise not classified under any other categories. Information disclosed on the left side of the table represents the sum of each type of degree and expertise of all board members except for the MD. Information disclosed on the right side of the table represents the proportion of the board having a certain degree or type of expertise; *edu_index_board* and *expert_index_board* are the average number of degrees and expertise for board members excluding the MD, respectively; and *edu_expert_index_board* is the average number of both degrees and expertise for board members excluding the MD.

Panel B: The managing director (MD)

Variables	Obs	Min	Mean	Median	Max
Education					
degree_bachelor_MD	5,158	0	0.35	0	1
degree_master_MD	5,158	0	0.18	0	1
degree_phd_MD	5,158	0	0.05	0	1
degree_hons_MD	5,158	0	0.21	0	1
MBA_MD	5,158	0	0.08	0	1
Expertise					
finance_expertise_MD	5,158	0	0.07	0	1
accounting_expertise_MD	5,158	0	0.04	0	1
legal_expertise_MD	5,158	0	0.01	0	1
leadership_expertise_MD	5,158	0	0.08	0	1
mining_expertise_MD	5,158	0	0.41	0	1
engineers_expertise_MD	5,158	0	0.01	0	1
other_expertise_MD	5,158	0	0.16	0	1
industry_ expertise_MD	5,158	0	0.11	0	1
local_ expertise_MD	5,158	0	0.02	0	1
other_knowledge_MD	5,158	0	0.04	0	1
Index					
edu_index_MD	5,158	0	1	1	3
expert_index_MD	5,158	0	1	1	2
edu_expert_index_MD	5,158	0	2	2	4

Panel B presents the academic qualifications and expertise of the MD for the period 2004–2018. The degrees and expertise for the MD are indicator variables coded 1 if the MD has a certain degree or type of expertise, and 0 otherwise; *other_expertise_MD* was further classified into three sub-categories comprising general industry expertise, local expertise, and other business and commercial expertise not classified under any other categories*; edu_index_MD* and *expert_index_MD* are the number of degrees and expertise of the MD, respectively; *edu_expert_index_MD* is the number of both degrees and expertise for the MD.

Table 4: Diversity of education and expertise

	Obs	min	mean	p50	max
Entire board					
D_degree_fullboard	5,158	0	0.43	0.50	0.73
D_expert_fullboard	5,158	0	0.60	0.64	0.80
diversity_index	5,158	2	5.71	6.00	10.00
Board members excluding MD					
D_degree_board	5,158	0	0.38	0.44	0.74
D_expert_board	5,158	0	0.57	0.63	0.80
diversity_index_board	5,158	2	5.59	6.00	10.00

This table presents the Blau diversity of educational levels and expertise among the entire board members and among board members excluding the MD for the period 2004–2018. Blau diversity is measured as: $1 - \sum p_i^2$ where p is the proportion of a certain type of degree or expertise out of the total types of degree or expertise represented on the board; *diversity_index* and *diversity_index_board* are the sum of the quintile ranked diversity of degrees and of expertise for the entire board and for board members excluding the MD, respectively.

Table 5: Pearson's correlation matrix

Panel A: Education and expertise index

	EE_Comb_{t+1}	$Equity_{t+1}$	$edu\_index\_board_t$	$expert\_index\_board_t$	$edu\_index\_MD_t$	$expert\_index\_MD_t$	$edu\_expert\_index\_MD_t$
EE_Comb_{t+1}	1						
$Equity_{t+1}$	0.1804***	1					
$edu\_index\_board_t$	0.0343**	0.0222	1				
$expert\_index\_board_t$	0.0518***	0.0364***	0.1854***	1			
$edu\_index\_MD_t$	0.0903***	0.0634***	0.1260***	0.1017***	1		
$expert\_index\_MD_t$	0.0570***	0.0953***	0.0594***	0.1175***	0.6106***	1	
$edu\_expert\_index\_MD_t$	0.0815***	0.0863***	0.1074***	0.1213***	0.9105***	0.8799***	1
$edu\_expert\_index\_board_t$	0.0530***	0.0394***	0.8453***	0.6751***	0.1489***	0.1122***	0.1479***
$Board\_Size_t$	0.0908***	0.0502***	0.1018***	0.0851***	0.2110***	0.2529***	0.2577***
$Indep\_Ned_t$	–0.0200	0.0081	0.0369***	0.0263*	0.0262*	0.0103	0.0210
$Busy\_Ned_t$	–0.0367***	–0.0315**	0.0018	0.0542***	0.0304**	–0.0161	–0.0177
MVE_t	0.1747***	0.1600***	0.0609***	0.1256***	0.1515***	0.2039***	0.1994***
RET_t	0.0980***	0.1506***	–0.0162	0.0048	0.0151	0.0339**	0.0257*
SD_RET_t	0.0273**	0.0923***	–0.0128	–0.0534***	–0.0494***	–0.0598***	–0.0608***
MTB_t	–0.0441***	0.1446***	–0.0421***	–0.0214	–0.0065	0.014	0.0032

Cont.	$edu\_expert\_index\_board_t$	$Board\_Size_t$	$Indep\_Ned_t$	$Busy\_Ned_t$	MVE_t	RET_t	SD_RET_t	MTB_t
$edu\_expert\_index\_board_t$	1							
$Board\_Size_t$	0.1188***	1						
$Indep\_Ned_t$	0.0438***	0.0552***	1					
$Busy\_Ned_t$	–0.0183	–0.0587***	0.0707***	1				
MVE_t	0.1152***	0.3787***	0.0654***	0.0206	1			
RET_t	–0.0074	–0.0036	–0.0182	–0.022	0.3799***	1		
SD_RET_t	–0.0356**	–0.1109***	–0.009	–0.0259*	–0.0558***	0.2696***	1	
MTB_t	–0.0426***	–0.0318**	0.0086	0.0026	0.2900***	0.3520***	0.1207***	1

Panel B: Diversity

	EE_Comb_{t+1}	$Equity_{t+1}$	$diversity\_expert_t$	$diversity\_degree_t$	$diversity\_degree\_board_t$	$diversity\_expert\_board_t$	$diversity\_index_t$
EE_Comb_{t+1}	1						
$Equity_{t+1}$	0.1804***	1					
$D\_degree\_fullboard_t$	0.0851***	0.0480***	1				
$D\_expert\_fullboard_t$	0.0107	0.0298**	0.0957***	1			
$D\_degree\_board_t$	0.0616***	0.0395***	0.8243***	0.0886***	1		
$D\_expert\_board_t$	0.0284**	0.0175	0.1418***	0.8088***	0.1800***	1	
$diversity\_index_t$	0.0540***	0.0548***	0.6814***	0.6008***	0.5843***	0.5293***	1
$diversity\_index\_board_t$	0.0439***	0.0463***	0.6011***	0.5200***	0.7229***	0.6414***	0.8065***
$Board\_Size_t$	0.0608***	0.0370***	0.6563***	0.6680***	0.5501***	0.5887***	0.7905***
$Indep\_Ned_t$	0.0727***	0.0212	0.5553***	0.5284***	0.6467***	0.7044***	0.6467***
$Busy\_Ned_t$	–0.0367***	–0.0315**	–0.0319**	–0.0065	–0.0427***	0.0141	–0.0312**
MVE_t	–0.0200	0.0081	0.0319**	0.0082	0.0251*	0.0263*	0.0514***
RET_t	–0.0298**	–0.0133	0.1825***	0.0676***	0.2018***	0.1232***	0.1704***
SD_RET_t	0.1747***	0.1600***	0.1394***	0.1619***	0.1232***	0.1514***	0.2157***
MTB_t	0.0980***	0.1506***	–0.0041	0.0065	–0.0055	–0.0022	–0.0108

Cont.	$diversity\_index\_board_t$	$Board\_Size_t$	$Indep\_Ned_t$	$Busy\_Ned_t$	MVE_t	RET_t	SD_RET_t	MTB_t
$diversity\_index\_board_t$	1							
$Board\_Size_t$	0.4476***	1						
$Indep\_Ned_t$	0.0508***	0.0552***	1					
$Busy\_Ned_t$	0.0039	0.0142	–0.0587***	0.0707***				
MVE_t	0.1855***	0.3787***	0.0654***	0.0206	1			
RET_t	–0.0204	–0.0036	–0.0182	–0.0220	0.3799***	1		
SD_RET_t	–0.0722***	–0.1109***	–0.0090	–0.0259*	–0.0558***	0.2696***	1	
MTB_t	–0.0506***	–0.0318**	0.0086	0.0026	0.2900***	0.3520***	0.1207***	1

Panel C: Education, expertise and diversity

	degree_bachelor_board$_t$	*degree_master_board$_t$*	*degree_phd_board$_t$*	*degree_hons_board$_t$*	*degree_bachelor_MD$_t$*	*degree_master_MD$_t$*	*degree_phd_MD$_t$*	*degree_hons_MD$_t$*
degree_bachelor_board$_t$	1							
degree_master_board$_t$	0.0633***	1						
degree_phd_board$_t$	–0.1330***	0.1623***	1					
degree_hons_board$_t$	–0.3459***	0.1524***	0.1998***	1				
degree_bachelor_MD$_t$	–0.1351***	–0.0021	0.0356**	–0.0552***	1			
degree_master_MD$_t$	–0.0492***	0.0175	0.0679***	–0.0050	0.1988***	1		
degree_phd_MD$_t$	–0.0615***	0.0076	0.0100	–0.0175	0.0444***	0.0203	1	
degree_hons_MD$_t$	–0.0662***	0.0065	–0.0552***	0.0549***	–0.2898***	0.1580***	0.1514***	1
finance_expertise_board$_t$	0.1254***	0.1116***	–0.0516***	–0.0084	–0.0679***	–0.0255*	–0.0206	–0.0242*
accounting_expertise_board$_t$	0.1458***	–0.1736***	–0.1271***	–0.1490***	–0.1292***	–0.0817***	0.0051	–0.0272*
legal_expertise_board$_t$	0.1585***	–0.0275**	–0.0533***	0.0444***	–0.0423***	–0.0184	0.0156	0.0250*
leadership_expertise_board$_t$	–0.0061	0.0719***	0.0495***	0.0923***	–0.0247*	0.0317**	–0.0317**	0.0542***
mining_expertise_board$_t$	–0.0580***	0.1500***	0.2342***	0.3657***	–0.0078	–0.0107	–0.0312**	–0.0396***
engineers_expertise_board$_t$	0.0638***	0.0274**	–0.0007	0.0038	–0.0089	–0.0103	0.0156	0.0256*
industry_expertise_board$_t$	0.0081	–0.0321**	–0.0774***	–0.0714***	–0.0438***	0.0142	–0.0418***	0.0254*
local_expertise_board$_t$	0.0495***	0.1061***	–0.0022	–0.0570***	–0.0161	–0.0032	–0.0161	–0.0384***
other_knowledge_board$_t$	–0.0100	–0.0089	–0.0147	–0.0957***	–0.0580***	–0.0865***	–0.0170	–0.0796***

Cont.	*degree_bachelor_board_p$_t$*	*degree_master_board_p$_t$*	*degree_phd_board_p$_t$*	*degree_hons_board_p$_t$*	*degree_bachelor_MD$_t$*	*degree_master_MD$_t$*	*degree_phd_MD$_t$*	*degree_hons_MD$_t$*
finance_expertise_MD$_t$	–0.0352**	0.0289**	0.0388***	0.0125	0.1606***	0.1007***	–0.0377***	0.0324**
accounting_expertise_MD$_t$	–0.0393***	–0.0126	–0.0046	–0.0225	0.2188***	–0.0523***	–0.0472***	–0.0946***
legal_expertise_MD$_t$	–0.0288**	0.0003	0.0124	–0.0127	0.1262***	–0.0105	0.0061	0.0135
leadership_expertise_MD$_t$	–0.0489***	0.0068	0.0018	–0.0206	0.1376***	0.0950***	0.0039	0.0799***
mining_expertise_MD$_t$	–0.1316***	–0.0222	–0.0489***	–0.0169	0.2071***	0.2617***	0.1617***	0.4697***
engineers_expertise_MD$_t$	–0.0365***	–0.0372***	–0.0276**	–0.0270*	0.0605***	0.0073	0.2229***	–0.0212
industry_expertise_MD$_t$	–0.1058***	–0.0348**	0.0633***	–0.0179	0.1990***	0.0693***	–0.0544***	–0.1353***
local_expertise_MD$_t$	–0.0010	–0.0010	–0.0347**	–0.0412***	0.0497***	0.0646***	–0.0097	0.0026

other_knowledge_MD$_t$	–0.0375***	–0.0060	–0.0259*	–0.0466***	0.0990***	0.0180	0.0801***	–0.0485***
edu_index_board$_t$	0.3884***	0.6782***	0.3966***	0.3973***	0.0498***	0.1025***	–0.0017	0.0929***
expert_index_board$_t$	0.0704***	0.0782***	0.0040	0.1100***	0.0148	0.0493***	–0.0097	0.1396***
edu_index_MD$_t$	–0.1553***	0.0122	0.0290**	–0.0116	0.5573***	0.6898***	0.3796***	0.4536***
expert_index_MD$_t$	–0.2107***	–0.0323**	–0.0086	–0.0565***	0.4825***	0.2921***	0.1272***	0.2872***
edu_expert_index_board$_t$	0.3237***	0.5532***	0.3005***	0.3558***	0.0461***	0.1021***	–0.0076	0.1450***
edu_expert_index_MD$_t$	–0.2001***	–0.0075	0.0129	–0.0370***	0.5848***	0.5605***	0.2856***	0.4175***
D_degree_board$_t$	–0.0899***	0.6088***	0.4025***	0.5579***	0.0150	0.0424***	0.0100	0.0552***
D_expert_board$_t$	0.1814***	0.0830***	0.0103	0.0317**	–0.0621***	–0.0041	–0.0109	0.0489***
D_degree_fullboard$_t$	–0.1442***	0.5163***	0.3689***	0.4844***	0.0104	0.2866***	0.1689***	0.2984***
D_expert_fullboard$_t$	0.1289***	0.0300**	–0.0177	–0.0419***	0.0455***	0.0098	0.0196	0.0613***

Cont.	*finance_ expertise_ board$_t$*	*accounting_ expertise_ board$_t$*	*legal_ expertise_ board$_t$*	*leadership_ expertise_ board$_t$*	*mining_ expertise_ board$_t$*	*engineers_ expertise_ board$_t$*	*industry_ expertise_ board$_t$*	*local_ expertise_ board$_t$*	*other_ knowledge_ board$_t$*
finance_expertise_board$_t$	1								
accounting_expertise_board$_t$	–0.2409***	1							
legal_expertise_board$_t$	–0.1405***	–0.0614***	1						
leadership_expertise_board$_t$	–0.0683***	–0.0473***	–0.0625***	1					
mining_expertise_board$_t$	–0.2377***	–0.2261***	–0.1633***	0.1537***	1				
engineers_expertise_board$_t$	–0.0381***	–0.0883***	–0.0154	0.0782***	–0.1120***	1			
industry_expertise_board$_t$	–0.0616***	0.0082	–0.0812***	0.0396***	–0.1796***	–0.0723***	1		
local_expertise_board$_t$	0.0006	–0.0605***	–0.0139	0.0096	0.0132	–0.0182	–0.0016	1	
other_knowledge_board$_t$	–0.0743***	–0.0848***	–0.0968***	–0.1051***	–0.0804***	–0.0070	–0.1292***	–0.0519***	1
finance_expertise_MD$_t$	0.0646***	–0.0909***	–0.0441***	0.0249*	–0.0350**	0.0070	–0.0567***	0.0456***	–0.0320**
accounting_expertise_MD$_t$	–0.0624***	–0.0366***	–0.0123	–0.0188	0.0327**	0.0039	–0.0568***	–0.0188	–0.0172
legal_expertise_MD$_t$	–0.0215	–0.0422***	0.0109	0.0208	–0.0181	–0.0126	–0.0002	0.0052	–0.0069
leadership_expertise_MD$_t$	–0.0507***	–0.0424***	0.0157	0.0604***	–0.0035	0.0299**	–0.0084	0.0045	–0.0045
mining_expertise_MD$_t$	–0.0757***	–0.0389***	0.0443***	–0.0183	–0.0350**	–0.0366***	0.0114	–0.0450***	–0.0815***
engineers_expertise_MD$_t$	0.0042	–0.0041	–0.0515***	0.0537***	–0.0285**	0.0279**	–0.0274**	–0.0111	–0.0298**
industry_expertise_MD$_t$	–0.0724***	–0.0628***	–0.0382***	0.0245*	–0.0026	0.0171	–0.0164	–0.0181	–0.0428***

local_expertise_MD$_t$	–0.0030	0.0141	–0.0180	0.0459***	–0.0563***	0.0137	0.0102	0.1816***	–0.0193
other_knowledge_MD$_t$	–0.0334**	0.0253*	–0.0135	–0.0701***	–0.0353**	0.0099	–0.0562***	0.0181	0.0310**
edu_index_board$_t$	0.0731***	–0.1503***	0.0798***	0.0886***	0.2644***	0.0525***	–0.1019***	0.0346**	–0.1062***
expert_index_board$_t$	0.1003***	0.0785***	0.0259*	0.5686***	0.2442***	0.0526***	0.2976***	0.1860***	0.0295**
edu_index_MD$_t$	–0.0704***	–0.1300***	–0.0184	0.0201	–0.0378***	0.0071	–0.0171	–0.0350**	–0.1216***
expert_index_MD$_t$	–0.1183***	–0.1190***	–0.0122	0.0233*	–0.0573***	0.0044	–0.0591***	0.0033	–0.0969***
edu_expert_index_board$_t$	0.1063***	–0.0730***	0.0734***	0.3747***	0.3296***	0.0683***	0.0848***	0.1285***	–0.0653***
edu_expert_index_MD$_t$	–0.1013***	–0.1389***	–0.0186	0.0251*	–0.0530***	0.0064	–0.0401***	–0.0185	–0.1241***
D_degree_board$_t$	0.0337**	–0.2049***	0.0064	0.0829***	0.3045***	0.0464***	–0.0572***	0.0431***	–0.0414***
D_expert_board$_t$	0.0952***	0.1326***	0.1730***	0.3625***	0.0499***	0.1526***	0.1683***	0.0998***	0.0272*
D_degree_fullboard$_t$	–0.0058	–0.1958***	0.0114	0.0849***	0.2400***	0.0440***	–0.0468***	0.0053	–0.0800***
D_expert_fullboard$_t$	0.0776***	0.1657***	0.1833***	0.3245***	–0.1036***	0.1571***	0.1335***	0.0784***	0.0086

Cont.	*finance_ expertise_ MD$_t$*	*accounting_ expertise_ MD$_t$*	*legal_ expertise_ MD$_t$*	*leadership_ expertise_ MD$_t$*	*mining_ expertise_ MD$_t$*	*engineers_ expertise_ MD$_t$*	*industry_ expertise_ MD$_t$*	*local_ expertise_ MD$_t$*	*other_ knowledge_ MD$_t$*
finance_expertise_MD$_t$	1								
accounting_expertise_MD$_t$	–0.0589***	1							
legal_expertise_MD$_t$	–0.0275**	–0.0206	1						
leadership_expertise_MD$_t$	0.0186	0.0546***	–0.0286**	1					
mining_expertise_MD$_t$	–0.1827***	–0.1729***	–0.0816***	0.1547***	1				
engineers_expertise_MD$_t$	–0.0322**	–0.0241*	–0.0112	–0.0143	–0.0955***	1			
industry_expertise_MD$_t$	0.0557***	0.2821***	–0.0100	0.0410***	–0.2930***	–0.0413***	1		
local_expertise_MD$_t$	–0.0209	–0.0210	0.0472***	0.0154	0.0282**	–0.0155	0.0025	1	
other_ knowledge_MD$_t$	–0.0255*	–0.0403***	–0.0188	–0.0275**	0.0193	–0.0220	–0.0692***	–0.0259*	1
edu_index_board$_t$	0.0771***	–0.0052	0.0066	0.0148	0.0577***	–0.0450***	–0.0008	–0.0117	–0.0241*
expert_index_board$_t$	0.0088	–0.0439***	–0.0004	0.0613***	0.1403***	0.0093	–0.0046	0.0739***	–0.0336**
edu_index_MD$_t$	0.1514***	0.0444***	0.0788***	0.1703***	0.5343***	0.0887***	0.0691***	0.0599***	0.0621***
expert_index_MD$_t$	0.2405***	0.2614***	0.0558***	0.5121***	0.5226***	0.0450***	0.3231***	0.1796***	0.2071***
edu_expert_index_board$_t$	0.0589***	–0.0230*	0.0041	0.0502***	0.1188***	–0.0285**	–0.0004	0.0315**	–0.0335**
edu_expert_index_MD$_t$	0.2147***	0.1684***	0.0714***	0.3724***	0.5872***	0.0764***	0.2108***	0.1296***	0.1410***
D_degree_board$_t$	0.0457***	0.0025	0.0006	0.0134	0.0235*	–0.0500***	0.0195	–0.0127	–0.0316**

D_expert_board$_t$	–0.0289**	–0.0367***	–0.0102	0.0340**	0.0327**	–0.0034	–0.0245*	0.0359***	–0.0277**
D_degree_fullboard$_t$	0.0583***	–0.0429***	0.0006	0.0248*	0.1934***	0.0261*	–0.0009	0.0052	–0.0271*
D_expert_fullboard$_t$	0.0229*	0.0763***	0.0262*	0.1655***	0.0563***	0.0508***	0.0818***	0.0430***	0.0373***

Cont.	*edu_index_board*$_t$	*expert_index_board*$_t$	*edu_index_MD*$_t$	*expert_index_MD*$_t$	*edu_expert_index_board*$_t$	*edu_expert_index_MD*$_t$	*diversity_degree_board*$_t$	*diversity_expert_board*$_t$	*diversity_degree*$_t$	*diversity_expert*$_t$
edu_index_board$_t$	1									
expert_index_board$_t$	0.1854***	1								
edu_index_MD$_t$	0.1260***	0.1017***	1							
expert_index_MD$_t$	0.0594***	0.1175***	0.6106***	1						
edu_expert_index_board$_t$	0.8453***	0.6751***	0.1489***	0.1122***	1					
edu_expert_index_MD$_t$	0.1074***	0.1213***	0.9105***	0.8799***	0.1479***	1				
D_degree_board$_t$	0.6576***	0.1061***	0.0603***	0.0297**	0.5466***	0.0518***	1			
D_expert_board$_t$	0.1116***	0.5343***	–0.0169	–0.0056	0.3639***	–0.0120	0.1800***	1		
D_degree_fullboard$_t$	0.5715***	0.1166***	0.3425***	0.1575***	0.4869***	0.2848***	0.8243***	0.1418***	1	
D_expert_fullboard$_t$	0.0605***	0.4556***	0.0683***	0.1992***	0.2890***	0.1440***	0.0886***	0.8088***	0.0957***	1

This table presents the correlation for all variables used in H1 and H2. *EE_Comb*$_{t+1,}$ and *Equity*$_{t+1}$ are the natural logarithm of the amount of E&E asset additions and acquisitions and equity proceeds raised in the following year, respectively. **For indexed measures of education and expertise**, *edu_index_board*$_t$ and *expert_index_board*$_t$ are the average number of degrees and expertise for board members excluding the MD for the current year, respectively; *edu_expert_index_board*$_t$ is the average number of both degrees and expertise for board members excluding the MD for the current year; *edu_index_MD*$_t$ and *expert_index_MD*$_t$ are the number of degrees and expertise of the MD for the current year, respectively; *edu_expert_index_MD*$_t$ is the number of both degrees and expertise for the MD for the current year. **For education**, *degree_bachelor_board*$_t$, *degree_master_board*$_t$, *degree_phd_board*$_t$, and *degree_hons_board*$_t$ are the proportion of board members excluding the MDs who hold bachelor, masters, PhD and honours degrees for the current year, respectively; *degree_bachelor_MD*$_t$, *degree_master_MD*$_t$, *degree_phd_MD*$_t$, and *degree_hons_MD*$_t$ are indicators for cases where the MD holds bachelor, masters, PhD and honours degrees for the current year, respectively. **For expertise**, *finance_expertise_board*$_t$, *accounting_expertise_board*$_t$, *legal_expertise_board*$_t$, *leadership_expertise_board*$_t$, *mining_expertise_board*$_t$, *engineers_expertise_board*$_t$, *industry_expertise_board*$_t$, *local_expertise_board*$_t$, and *other_knowledge_board*$_t$ are the proportion of board members excluding the MDs who possess expertise in the areas of finance, accounting, legal, leadership (prior executive role at publicly listed firms), technical mining, engineer, general industry expertise, local expertise and other knowledge for the current year, respectively; *finance_expertise_MD*$_t$, *accounting_expertise_MD*$_t$, *legal_expertise_MD*$_t$, *leadership_expertise_MD*$_t$, *mining_expertise_MD*$_t$, *engineers_expertise_MD*$_t$, *industry_expertise_MD*$_t$, *local_expertise_MD*$_t$, and *other_knowledge_MD*$_t$ are indicators for cases where the MD possesses expertise in the areas of finance, accounting, legal, leadership (prior executive role at publicly listed firms), technical mining, engineer, general industry expertise, local expertise and other knowledge for the current year, respectively. **For degree diversity and expertise diversity**, *D_degree_fullboard*$_t$ and *D_expert_fullboard*$_t$ are the Blau measures of degree diversity and expertise diversity among all board members including the MD for the current year, respectively; *D_degree_board*$_t$ and *D_expert_board*$_t$ are the Blau measures of degree diversity and expertise diversity among board members excluding the MD for the current year, respectively; *diversity_index*$_t$ and *diversity_index_board*$_t$ are the sum of quintile ranked degree diversity and expertise diversity for the entire board and for board members excluding the MD for the current year, respectively. Finally, *Board_Size*$_t$ is the number of directors sitting on the board for the current year. *Indep_Ned*$_t$ is the percentage of independent non-executive directors (NEDs) on the board for the current year. *Busy_Ned*$_t$ is the percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. *MVE*$_t$ is the natural logarithm of market capitalisation for the current year. *RET*$_t$ is the annual buy-and-hold stock return adjusted for dividends and capital

changes for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns in the prior two years. *MTB* is the market-to-book value of equity. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 6: Associations between education and E&E investments and equity raising

Panel A: E&E investments

				EE_Comb$_{t+1}$		
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
degree_bachelor_board$_t$	1.1273***				1.6424***	
	(0.4090)				(0.4485)	
degree_bachelor_MD$_t$	0.3525*				0.4936**	
	(0.1920)				(0.2058)	
degree_master_board$_t$		1.1669**			0.9249*	
		(0.4972)			(0.5032)	
degree_master_MD$_t$		0.3228			0.2601	
		(0.2396)			(0.2496)	
degree_phd_board$_t$			1.1124		0.9085	
			(0.9938)		(1.0107)	
degree_phd_MD$_t$			0.2366		0.1382	
			(0.3952)		(0.3992)	
degree_hons_board$_t$				0.7486	1.4193**	
				(0.5214)	(0.5696)	
degree_hons_MD$_t$				0.2287	0.4798*	
				(0.2293)	(0.2471)	
edu_index_board$_t$						1.0180***
						(0.2384)
edu_index_MD$_t$						0.2068*
						(0.1147)
Constant	0.0746	0.4561	0.4498	0.3962	–0.2043	–0.1220
	(1.4493)	(1.4365)	(1.4367)	(1.4372)	(1.4547)	(1.4471)
Observations	5,158	5,158	5,158	5,158	5,158	5,158
Unique firms	820	820	820	820	820	820
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	44.83%	44.79%	44.71%	44.72%	45.00%	45.04%

This table presents the association between directors' education and E&E investments over the period 2004–2018 using the following model:

$$EE\_Comb_{i,t+1} = \theta_0 + \sum_j \theta_1^j Q\_board_{j,i,t} + \sum_j \theta_2^j Q\_MD_{j,i,t} + \theta_3 Board\_Size_{i,t} + \theta_4 Indep\_Ned_{i,t} + \theta_5 Busy\_Ned_{i,t} + \theta_6 MVE_{i,t} + \theta_7 RET_{i,t} + \theta_8 SD\_RET_{i,t} + \theta_9 MTB_{i,t} + \boldsymbol{\varphi} + \boldsymbol{\omega} + \epsilon_{i,t}, \quad (1)$$

$EE\_Comb_{t+1,}$ is the natural logarithm of the amount of E&E asset additions and acquisitions in the following year. Q_board_t from Columns (1) to (5) is the proportion of board members excluding the MDs who hold bachelor, masters, PhD and honours degrees for the current year, respectively. Q_MD_t from Columns (1) to (5) is an indicator variable coded 1 for cases where the MD holds bachelor, masters, PhD and honours degrees for the current year, respectively. In Column (6), Q_board_t is replaced by $edu\_index\_board_t$ which is the average number of degrees obtained by board members excluding the MD for the current year. Q_MD_t is replaced by $edu\_index\_MD_t$ which is the MD's number of degrees for the current year. $Board\_Size_t$ is the number of directors sitting on the board for the current year. $Indep\_Ned_t$ is the percentage of independent non-executive directors (NEDs) on the board for the current year. $Busy\_Ned_t$ is the percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. MVE_t is the natural logarithm of market capitalisation for the current year. RET_t is the annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns in the prior two years. MTB_t is the market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels. Robust standard errors are reported in parentheses.

Panel B: Equity raising

				$Equity_{t+1}$		
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
degree_bachelor_board$_t$	–0.2884				0.2479	
	(0.5360)				(0.5794)	
degree_bachelor_MD$_t$	0.3568				0.7377**	
	(0.2820)				(0.3060)	
degree_master_board$_t$		0.4558			0.3200	
		(0.6438)			(0.6625)	
degree_master_MD$_t$		–0.2804			–0.5536	
		(0.3447)			(0.3619)	
degree_phd_board$_t$			0.5188		0.4200	
			(1.2285)		(1.2536)	
degree_phd_MD$_t$			0.6549		0.2453	
			(0.6288)		(0.6470)	
degree_hons_board$_t$				1.3703*	1.4616*	
				(0.7275)	(0.7881)	
degree_hons_MD$_t$				0.7286**	1.0490***	
				(0.3314)	(0.3685)	
edu_index_board$_t$						0.4800
						(0.2937)
edu_index_MD$_t$						0.2734
						(0.1692)
Constant	8.3347***	8.1044***	8.1283***	8.1187***	8.1972***	7.9691***
	(1.7593)	(1.7527)	(1.7529)	(1.7497)	(1.7585)	(1.7566)
Observations	5,158	5,158	5,158	5,158	5,158	5,158
Unique firms	820	820	820	820	820	820
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	23.16%	23.14%	23.14%	23.26%	23.31%	23.22%

This table presents the association between directors' education and equity raising over the period 2004–2018 using the following model:

$$Equity_{i,t+1} = \theta_0 + \sum_j \theta_1^j Q\_board_{j,i,t} + \sum_j \theta_2^j Q\_MD_{j,i,t} + \theta_3 Board\_Size_{i,t} + \theta_4 Indep\_Ned_{i,t} + \theta_5 Busy\_Ned_{i,t} + \theta_6 MVE_{i,t} + \theta_7 RET_{i,t} + \theta_8 SD\_RET_{i,t} + \theta_9 MTB_{i,t} + \boldsymbol{\varphi} + \boldsymbol{\omega} + \epsilon_{i,t}, \quad (1)$$

$Equity_{t+1}$ is the natural logarithm of equity proceeds raised in the following year. Q_board_t from Columns (1) to (5) is the proportion of board members excluding the MDs who hold bachelor, masters, PhD and honours degrees for the current year, respectively. Q_MD_t from Columns (1) to (5) is an indicator variable coded 1 for cases where the MD holds bachelor, masters, PhD and honours degrees for the current year, respectively. In Column (6), Q_board_t is replaced by $edu\_index\_board_t$ which is the average number of degrees obtained by board members excluding the MD for the current year. Q_MD_t is replaced by $edu\_index\_MD_t$ which is the MD's number of degrees for the current year. $Board\_Size_t$ is the number of directors sitting on the board for the current year. $Indep\_Ned_t$ is the percentage of independent non-executive directors (NEDs) on the board for the current year. $Busy\_Ned_t$ is percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. MVE_t is the natural logarithm of market capitalisation for the current year. RET_t is the annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns in the prior two years. MTB_t is the market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 7: Associations between expertise and E&E investments and equity raising

Panel A: E&E investments

					EE_Comb$_{t+1}$						
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
finance_expertise_board$_t$	–0.8706									0.4236	
	(0.5417)									(0.6169)	
finance_expertise_MD$_t$	0.2226									0.5130	
	(0.3233)									(0.3445)	
accounting_expertise_board$_t$		–0.7053								0.3329	
		(0.6458)								(0.7144)	
accounting_expertise_MD$_t$		0.4178								0.7449	
		(0.4537)								(0.4860)	
legal_expertise_board$_t$			–0.4087							0.8214	
			(0.8835)							(0.9354)	
legal_expertise_MD$_t$			0.9811							1.4693*	
			(0.7748)							(0.7767)	
leadership_expertise_board$_t$				–0.1244						–0.5166	
				(0.6572)						(0.6738)	
leadership_expertise_MD$_t$				0.7723**						0.7495*	
				(0.3774)						(0.3881)	
mining_expertise_board$_t$					2.1487***					2.7620***	
					(0.4617)					(0.5785)	
mining_expertise_MD$_t$					0.3477*					0.4908**	
					(0.1944)					(0.2232)	
engineers_expertise_board$_t$						–2.4168				–0.8526	
						(1.4128)				(1.4855)	
engineers_expertise_MD$_t$						–0.3040				0.1693	
						(1.0717)				(1.0805)	
industry_expertise_board$_t$							0.4324			1.6023**	
							(0.5868)			(0.6399)	

Panel A: E&E investments

						EE_Comb_{t+1}					
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
industry_expertise_MD$_t$							–0.1095			0.0388	
							(0.3061)			(0.3303)	
local_expertise_board$_t$								0.2065		0.7539	
								(1.3149)		(1.3362)	
local_expertise_MD$_t$								–0.5258		–0.3163	
								(0.5759)		(0.5850)	
other_knowledge_board$_t$									1.5535*	2.1861**	
									(0.8065)	(0.8511)	
other_knowledge_MD$_t$									0.0843	0.3391	
									(0.4460)	(0.4476)	
expert_index_board$_t$											0.9208***
											(0.2967)
expert_index_MD$_t$											0.2060
											(0.1394)
Constant	0.6361	0.6289	0.4798	0.4829	0.1902	0.3413	0.3965	0.4801	0.3369	–0.4281	–0.1865
	(1.4437)	(1.4545)	(1.4382)	(1.4338)	(1.4339)	(1.4370)	(1.4400)	(1.4403)	(1.4329)	(1.4877)	(1.4600)
Observations	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158
Unique firms	820	820	820	820	820	820	820	820	820	820	820
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R–squared	44.74%	44.72%	44.70%	44.76%	45.03%	44.72%	44.70%	44.69%	44.74%	45.16%	42.71%

This table presents the association between directors' expertise and E&E investments over the period 2004–2018 using the following model:

$$EE\_Comb_{i,t+1} = \theta_0 + \sum_k \theta_1^k E\_board_{k,i,t} + \sum_k \theta_2^k E\_MD_{k,i,t} + \theta_3 Board\_Size_{i,t} + \theta_4 Indep\_Ned_{i,t} + \theta_5 Busy\_Ned_{i,t} + \theta_6 MVE_{i,t} + \theta_7 RET_{i,t} + \theta_8 SD\_RET_{i,t} + \theta_9 MTB_{i,t} + \boldsymbol{\varphi} + \boldsymbol{\omega} + \epsilon_{i,t}, \quad (1)$$

$EE\_Comb_{t+1,}$ is the natural logarithm of the amount of E&E asset additions and acquisitions in the following year. E_board_t in Columns (1) to (10) is the proportion of board members excluding the MDs who possess expertise in the areas of finance, accounting, legal, leadership, technical mining, engineer, general industry expertise, local expertise and other

knowledge for the current year, respectively. E_MD_t in Columns (1) to (10) is an indicator variable coded 1 for cases where the MD possesses expertise in the areas of finance, accounting, legal, leadership, technical mining, engineer, general industry expertise, local expertise and other knowledge for the current year, respectively. In Column (11), E_board_t is replaced by $expert\_index\_board_t$ which is the average number of areas of expertise possessed by board members excluding the MD for the current year. E_MD_t is replaced by $expert\_index\_MD_t$ which is the number of areas of expertise possessed by the MD for the current year.
$Board\_Size_t$ is the number of directors sitting on the board for the current year. $Indep\_Ned_t$ is the percentage of independent non-executive directors (NEDs) on the board for the current year. $Busy\_Ned_t$ is the percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. MVE_t is the natural logarithm of market capitalisation for the current year. RET_t is the annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns in the prior two years. MTB_t is the market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Panel B: Equity raising

					$Equity_{t+1}$						
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
finance_expertise_board$_t$	0.2315									1.3960*	
	(0.6617)									(0.8183)	
finance_expertise_MD$_t$	0.0111									0.4688	
	(0.4732)									(0.4997)	
accounting_expertise_board$_t$		–0.7242								0.6220	
		(0.8370)								(0.9642)	
accounting_expertise_MD$_t$		–0.2014								0.2938	
		(0.6628)								(0.6911)	
legal_expertise_board$_t$			–0.8861							0.2897	
			(1.1533)							(1.2360)	
legal_expertise_MD$_t$			–0.2565							0.3984	
			(1.6441)							(1.6852)	
leadership_expertise_board$_t$				–1.0997						–1.4547	
				(0.9441)						(0.9707)	
leadership_expertise_MD$_t$				0.0358						–0.1619	
				(0.4848)						(0.4943)	
mining_expertise_board$_t$					1.3831**					2.4319***	
					(0.6014)					(0.7821)	
mining_expertise_MD$_t$					0.8184***					1.1440***	
					(0.2788)					(0.3287)	
engineers_expertise_board$_t$						0.4344				2.2787	
						(2.0423)				(2.1242)	
engineers_expertise_MD$_t$						0.4537				1.1893	
						(1.5182)				(1.4971)	
industry_expertise_board$_t$							0.0763			1.1617	
							(0.7723)			(0.8456)	

Panel B: Equity raising

						***Equity*$_{t+1}$**					
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
industry_expertise_MD$_t$							–0.1355			0.4326	
							(0.3980)			(0.4337)	
local_expertise_board$_t$								1.9900		2.6321	
								(1.5840)		(1.6224)	
local_expertise_MD$_t$								0.0064		0.1761	
								(1.0729)		(1.0766)	
other_knowledge_board$_t$									0.1272	0.7584	
									(1.0797)	(1.1497)	
other_knowledge_MD$_t$									0.2805	0.4040	
									(0.7874)	(0.7971)	
expert_index_board$_t$											0.8683**
											(0.4132)
expert_index_MD$_t$											0.3359*
											(0.1963)
Constant	8.1004***	8.3209***	8.2230***	8.0495***	8.1647***	8.1668***	8.1342***	8.3050***	8.1334***	7.6911***	7.5886***
	(1.7596)	(1.7676)	(1.7570)	(1.7556)	(1.7462)	(1.7577)	(1.7614)	(1.7635)	(1.7522)	(1.8201)	(1.7776)
Observations	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158
Unique firms	820	820	820	820	820	820	820	820	820	820	820
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R–squared	23.12%	23.13%	23.13%	23.14%	23.33%	23.12%	23.12%	23.14%	23.12%	23.24%	23.27%

This table presents the association between directors' expertise and equity raising over the period 2004–2018 using the following model:

$$EE\_Comb_{i,t+1} = \theta_0 + \sum_k \theta_1^k E\_board_{k,i,t} + \sum_k \theta_2^k E\_MD_{k,i,t} + \theta_3 Board\_Size_{i,t} + \theta_4 Indep\_Ned_{i,t} + \theta_5 Busy\_Ned_{i,t} + \theta_6 MVE_{i,t} + \theta_7 RET_{i,t} + \theta_8 SD\_RET_{i,t} + \theta_9 MTB_{i,t} + \boldsymbol{\varphi} + \boldsymbol{\omega} + \epsilon_{i,t}, \quad (1)$$

$Equity_{t+1}$ is the natural logarithm of equity proceeds raised in the following year. E_board_t in Columns (1) to (10) is the proportion of board members excluding the MDs who possess expertise in the areas of finance, accounting, legal, leadership, technical mining, engineer, general industry expertise, local expertise and other knowledge for the current year, respectively. E_MD_t in Columns (1) to (10) is an indicator variable coded 1 for cases where the MD possesses expertise in the areas of finance, accounting, legal, leadership, technical mining, engineer, general industry expertise, local expertise and other knowledge for the current year, respectively. In Column (11), E_board_t is replaced by $expert\_index\_board_t$ which is the average number of areas of expertise possessed by board members excluding the MD for the current year. E_MD_t is replaced by $expert\_index\_MD_t$ which is the number of areas of expertise possessed by the MD for the current year.
$Board\_Size_t$ is the number of directors sitting on the board for the current year. $Indep\_Ned_t$ is the percentage of independent non-executive directors (NEDs) on the board for the current year. $Busy\_Ned_t$ is percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. MVE_t is the natural logarithm of market capitalisation for the current year. RET_t is the annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns in the prior two years. MTB_t is the market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 8: Associations between education and expertise and E&E investments and equity raising

Variables	EE_Comb_{t+1} (1)	EE_Comb_{t+1} (2)	$Equity_{t+1}$ (3)	$Equity_{t+1}$ (4)
degree_bachelor_board	-0.0801	1.8660***	-0.7440*	0.3050
	(0.3344)	(0.4770)	(0.3960)	(0.6172)
degree_master_board	-0.0214	0.8267	0.6810	0.1657
	(0.4053)	(0.5045)	(0.4658)	(0.6783)
degree_phd_board	-0.3163	0.2439	0.0843	0.2727
	(0.6947)	(1.0398)	(0.8499)	(1.2766)
degree_hons_board	0.5152	1.0672*	-0.1119	1.1974
	(0.4562)	(0.6083)	(0.5607)	(0.8588)
degree_bachelor_MD	0.8642***	0.4101	0.4723*	0.6021
	(0.2134)	(0.2623)	(0.2605)	(0.3912)
degree_master_MD	-0.1196	0.2736	-0.6270***	-0.6337*
	(0.1969)	(0.2554)	(0.2419)	(0.3695)
degree_phd_MD	-0.1054	0.2060	0.0777	0.0415
	(0.3333)	(0.4245)	(0.4126)	(0.6638)
degree_hons_MD	0.8413***	0.4576	0.6013**	0.8018*
	(0.2358)	(0.2945)	(0.2947)	(0.4398)
finance_expertise_board	-0.5211	-0.0235	0.5759	1.2882
	(0.4814)	(0.6296)	(0.5801)	(0.8343)
accounting_expertise_board	-1.0899**	-0.0538	0.5652	0.7398
	(0.5501)	(0.7417)	(0.6415)	(0.9964)
legal_expertise_board	1.0444	-0.2553	0.7598	0.0119
	(0.6809)	(0.9707)	(0.8281)	(1.2925)
leadership_expertise_board	-0.1087	-0.6458	-0.8559	-1.5653
	(0.5079)	(0.6806)	(0.6219)	(0.9769)
mining_expertise_board	1.4461***	2.2646***	1.4435**	2.0385**
	(0.4646)	(0.6074)	(0.5670)	(0.8541)
engineers_expertise_board	2.2314**	-1.4311	2.9089**	1.8557
	(1.1112)	(1.4984)	(1.3401)	(2.1378)
industry_expertise_board	0.4985	1.7721***	-0.2388	1.3617
	(0.4706)	(0.6413)	(0.5476)	(0.8510)
local_expertise_board	0.6246	0.5147	2.8912***	2.5479
	(0.9758)	(1.3378)	(1.0825)	(1.6264)
other_knowledge_board	1.2862**	2.2977***	-0.6280	0.9080
	(0.6218)	(0.8576)	(0.7779)	(1.1596)
finance_expertise_MD	0.3107	0.2787	0.3647	0.2266
	(0.3222)	(0.3709)	(0.3818)	(0.5195)
accounting_expertise_MD	-1.3491***	0.6813	-0.1512	0.0395
	(0.4263)	(0.5008)	(0.4866)	(0.7173)
legal_expertise_MD	-0.2745	1.1233	-1.1496	-0.1046
	(0.7313)	(0.8150)	(0.9680)	(1.6930)
leadership_expertise_MD	-0.5581*	0.8065**	0.1335	-0.1195
	(0.2902)	(0.3904)	(0.3232)	(0.5002)
mining_expertise_MD	0.1199	0.2622	1.0525***	0.8038*
	(0.2483)	(0.2931)	(0.2850)	(0.4251)
engineers_expertise_MD	1.4709***	0.0782	-1.7935*	0.8650
	(0.4953)	(1.1655)	(0.9302)	(1.5789)
industry_expertise_MD	-0.1273	0.0123	0.5385*	0.3487
	(0.2641)	(0.3469)	(0.3175)	(0.4644)
local_expertise_MD	-0.9614	-0.3436	0.1126	0.2341
	(0.6574)	(0.5846)	(0.6639)	(1.0668)
other_knowledge_MD	-0.6492	0.3721	0.2733	0.3806

	(0.4317)	(0.4574)	(0.4760)	(0.8197)
Board_Size$_t$	0.0045	-0.4232***	-0.0135	-0.3288**
	(0.0772)	(0.0952)	(0.0986)	(0.1289)
Indep_Ned$_t$	-0.0359	-0.0757	0.2790	0.6476
	(0.2765)	(0.2992)	(0.3302)	(0.4017)
Busy_Ned$_t$	-1.0227**	-0.7716	-1.1006**	-0.5404
	(0.4337)	(0.4878)	(0.5147)	(0.6812)
MVE$_t$	0.5210***	0.8581***	0.3999***	0.2569**
	(0.0737)	(0.0945)	(0.0830)	(0.1172)
RET$_t$	0.3068***	0.2018***	0.1484*	0.1759**
	(0.0725)	(0.0674)	(0.0825)	(0.0872)
SD_RET$_t$	0.6324***	-0.0375	1.1725***	0.7801***
	(0.1782)	(0.1670)	(0.2067)	(0.2335)
MTB$_t$	-0.1813***	-0.0519*	0.1557***	0.1588***
	(0.0281)	(0.0292)	(0.0227)	(0.0266)
Constant	2.5194**	-0.9718	2.3119*	7.5384***
	(1.1851)	(1.4921)	(1.3344)	(1.8253)
Observations	5158	5158	5158	5158
Year fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	No	Yes	No	Yes
Adj. R-squared	8.71%	45.40%	9.35%	23.26%

This table presents the association between directors' education & expertise and E&E investments and equity raising over the period 2004–2018 using the following model:

$$EE\_Comb_{i,t+1} \text{ or } Equity_{i,t+1} = \theta_0 + \sum_j \theta_1^j Q\_board_{j,i,t} + \sum_k \theta_2^k E\_board_{k,i,t} + \sum_j \theta_3^j Q\_MD_{j,i,t} + \sum_k \theta_4^k E\_MD_{k,i,t} + \theta_5 Board\_Size_{i,t} + \theta_6 Indep\_Ned_{i,t} + \theta_7 Busy\_Ned_{i,t} + \theta_8 MVE_{i,t} + \theta_9 RET_{i,t} + \theta_{10} SD\_RET_{i,t} + \theta_{11} MTB_{i,t} + \boldsymbol{\varphi} + \boldsymbol{\omega} + \epsilon_{i,t}, \quad (1)$$

EE_Comb$_{t+1,}$ and *Equity*$_{t+1}$ are the natural logarithm of the amount of E&E asset additions and acquisitions and equity proceeds raised in the following year, respectively. *Q_board*$_t$ is the proportion of board members excluding the MDs who hold bachelor, masters, PhD and honours degrees and *E_board*$_t$ is the proportion of board members excluding the MDs who possess expertise in the areas of finance, accounting, legal, leadership, technical mining, engineer, general industry expertise, local expertise and other knowledge for the current year. *Q_MD*$_t$ is an indicator variable coded 1 for cases where the MD holds bachelor, masters, PhD and honours degrees, and *E_MD*$_t$ is an indicator variable coded 1 for cases where the MD possesses expertise in the areas of finance, accounting, legal, leadership, technical mining, engineer, general industry expertise, local expertise and other knowledge for the current year.

Board_Size$_t$ is the number of directors sitting on the board for the current year. *Indep_Ned*$_t$ is the percentage of independent non-executive directors (NEDs) on the board for the current year. *Busy_Ned*$_t$ is the percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. *MVE*$_t$ is the natural logarithm of market capitalisation for the current year. *RET*$_t$ is the annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. *SD_RET*$_t$ is the annualised standard deviation of monthly stock returns in the prior two years. *MTB*$_t$ is the market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 9: Associations between education and expertise and E&E investments and equity raising – Indexed measures

Variables	EE_Comb_{t+1} (1)	EE_Comb_{t+1} (2)	$Equity_{t+1}$ (3)	$Equity_{t+1}$ (4)
edu_expert_index_board	0.3227**	0.8686***	0.3653**	0.5866***
	(0.1285)	(0.1743)	(0.1463)	(0.2268)
edu_expert_index_MD	0.1590***	0.1139	0.3076***	0.1765*
	(0.0574)	(0.0698)	(0.0707)	(0.1021)
$Board\_Size_t$	0.0490	-0.3157***	0.0857	-0.2390*
	(0.0740)	(0.0905)	(0.0954)	(0.1244)
$Indep\_Ned_t$	-0.1145	-0.0552	0.2422	0.5565
	(0.2753)	(0.2927)	(0.3280)	(0.3966)
$Busy\_Ned_t$	-0.8864**	-0.7150	-0.8886*	-0.6505
	(0.4238)	(0.4910)	(0.4988)	(0.6746)
MVE_t	0.5307***	0.8390***	0.3952***	0.2788**
	(0.0736)	(0.0936)	(0.0825)	(0.1156)
RET_t	0.3181***	0.2165***	0.1515*	0.1717**
	(0.0722)	(0.0678)	(0.0822)	(0.0867)
SD_RET_t	0.6224***	0.0066	1.2221***	0.8087***
	(0.1804)	(0.1672)	(0.2076)	(0.2332)
MTB_t	-0.1819***	-0.0588**	0.1538***	0.1556***
	(0.0277)	(0.0291)	(0.0231)	(0.0265)
Constant	2.0774*	-0.6734	1.6693	7.4801***
	(1.1631)	(1.4618)	(1.2885)	(1.7721)
Observations	5158	5158	5158	5158
Year fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	No	Yes	No	Yes
Adj. R-squared	7.48%	45.12%	8.59%	23.31%

This table presents the association between directors' education, expertise and E&E investments and equity raising over the period 2004–2018 using the following model:

$$EE\_Comb_{i,t+1} \text{ or } Equity_{i,t+1} = \theta_0 + \theta_1 QE_{i,t} + \theta_2 QE\_MD_{i,t} + \theta_3 Board\_Size_{i,t} + \theta_4 Indep\_Ned_{i,t} + \theta_5 Busy\_Ned_{i,t} + \theta_6 MVE_{i,t} + \theta_7 RET_{i,t} + \theta_8 SD\_RET_{i,t} + \theta_9 MTB_{i,t} + \boldsymbol{\varphi} + \boldsymbol{\omega} + \epsilon_{i,t} \quad (1A)$$

$EE\_Comb_{t+1,}$ and $Equity_{t+1}$ are the natural logarithm of the amount of E&E asset additions and acquisitions and equity proceeds raised in the following year, respectively. QE_t is the *edu_expert_index_board*$_t$ which is the average of the sum of both degree levels and expertise for board members excluding the MD for the current year. QE_MD_t is *edu_expert_index_MD*$_t$ which is the sum of both degree levels and expertise of the MD for the current year.

$Board\_Size_t$ is the number of directors sitting on the board for the current year. $Indep\_Ned_t$ is the percentage of independent non-executive directors (NEDs) on the board for the current year. $Busy\_Ned_t$ is the percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. MVE_t is the natural logarithm of market capitalisation for the current year. RET_t is the annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns in the prior two years. MTB_t is the market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 10: Associations between education diversity and expertise diversity and E&E investments and equity raising

Variables	EE_Comb_{t+1} (1)	EE_Comb_{t+1} (2)	$Equity_{t+1}$ (3)	$Equity_{t+1}$ (4)
D_degree_board	0.8167***	1.0807***	0.7920**	1.0605**
	(0.2901)	(0.3692)	(0.3435)	(0.4792)
D_expertise_board	-0.3024	-0.0480	0.0026	0.2907
	(0.4082)	(0.4819)	(0.4835)	(0.6103)
$Board\_Size_t$	0.0558	-0.3396***	0.1164	-0.2778**
	(0.0798)	(0.0979)	(0.1013)	(0.1332)
$Indep\_Ned_t$	-0.0966	-0.0393	0.2641	0.5371
	(0.2755)	(0.2947)	(0.3289)	(0.3949)
$Busy\_Ned_t$	-0.8091*	-0.7067	-0.8203	-0.6781
	(0.4213)	(0.4936)	(0.5031)	(0.6773)
MVE_t	0.5676***	0.8881***	0.4517***	0.3226***
	(0.0735)	(0.0936)	(0.0820)	(0.1156)
RET_t	0.3126***	0.1989***	0.1445*	0.1588*
	(0.0724)	(0.0678)	(0.0824)	(0.0869)
SD_RET_t	0.6077***	-0.0156	1.1972***	0.7856***
	(0.1801)	(0.1681)	(0.2081)	(0.2329)
MTB_t	-0.1857***	-0.0621**	0.1488***	0.1545***
	(0.0276)	(0.0291)	(0.0230)	(0.0263)
Constant	2.2735**	0.3404	1.6243	7.9390***
	(1.1436)	(1.4437)	(1.2741)	(1.7512)
Observations	5158	5158	5158	5158
Year fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	No	Yes	No	Yes
Adj. R-squared	7.34%	44.82%	8.17%	23.21%

This table presents the association between diversity of education and expertise and E&E investments and equity raising over the period 2004–2018 using the following model:

$$EE\_Comb_{i,t+1} \text{ or } Equity_{i,t+1} = \theta_0 + \theta_1 D\_degree\_board_{i,t} + \theta_2 D\_expertise\_board_{i,t} + \theta_3 Board\_Size_{i,t} + \theta_4 Indep\_Ned_{i,t} + \theta_5 Busy\_Ned_{i,t} + \theta_6 MVE_{i,t} + \theta_7 RET_{i,t} + \theta_8 SD\_RET_{i,t} + \theta_9 MTB_{i,t} + \boldsymbol{\varphi} + \boldsymbol{\omega} + \epsilon_{i,t}, \quad (2A)$$

$EE\_Comb_{t+1,}$ and $Equity_{t+1}$ are the natural logarithm of the amount of E&E asset additions and acquisitions and equity proceeds raised in the following year, respectively. $D\_degree\_board_t$ and $D\_expert\_board_t$ are the Blau measure of education diversity and expertise diversity among board members excluding the MD for the current year, respectively. Blau diversity is measured as: $1 - \sum p^2$, where p is the proportion of a certain type of degree or expertise out of the total types of degree or expertise represented among all board members excluding the MD.

$Board\_Size_t$ is the number of directors sitting on the board for the current year. $Indep\_Ned_t$ is the percentage of independent non-executive directors (NEDs) on the board for the current year. $Busy\_Ned_t$ is the percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. MVE_t is the natural logarithm of market capitalisation for the current year. RET_t is the annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns in the prior two years. MTB_t is the market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 11: Associations between education diversity and expertise diversity and E&E investments and equity raising – Entire board

Variables	EE_Comb_{t+1} (1)	EE_Comb_{t+1} (2)	$Equity_{t+1}$ (3)	$Equity_{t+1}$ (4)
D_degree_fullboard	1.2859***	1.4586***	1.0513***	1.5444***
	(0.3219)	(0.3985)	(0.3664)	(0.5233)
D_expertise_fullboard	-0.7969*	-0.4083	0.5168	-0.0361
	(0.4425)	(0.5748)	(0.5426)	(0.7426)
$Board\_Size_t$	0.0598	-0.3275***	0.0962	-0.2679**
	(0.0768)	(0.0965)	(0.0986)	(0.1299)
$Indep\_Ned_t$	-0.1174	-0.0291	0.2565	0.5506
	(0.2751)	(0.2944)	(0.3288)	(0.3945)
$Busy\_Ned_t$	-0.8111*	-0.6770	-0.8304*	-0.6381
	(0.4195)	(0.4933)	(0.5011)	(0.6769)
MVE_t	0.5635***	0.8838***	0.4392***	0.3176***
	(0.0735)	(0.0936)	(0.0823)	(0.1159)
RET_t	0.3132***	0.2026***	0.1468*	0.1629*
	(0.0724)	(0.0677)	(0.0825)	(0.0868)
SD_RET_t	0.6140***	-0.0234	1.2061***	0.7781***
	(0.1804)	(0.1682)	(0.2077)	(0.2326)
MTB_t	-0.1843***	-0.0613**	0.1502***	0.1548***
	-0.0277	-0.0290	-0.0230	-0.0263
Constant	2.3803**	0.3771	1.4349	7.9193***
	-1.1487	-1.4585	-1.2756	-1.7636
Observations	5158	5158	5158	5158
Year fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	No	Yes	No	Yes
Adj. R-squared	7.56%	44.90%	8.24%	23.28%

This table presents the association between education and expertise diversity and E&E investments and equity raising over the period 2004–2018 using the following model:

$$EE\_Comb_{i,t+1} \text{ or } Equity_{i,t+1} = \theta_0 + \theta_1 D\_degree\_fullboard_{i,t} + \theta_2 D\_expertise\_fullboard_{i,t} + \theta_3 Board\_Size_{i,t} + \theta_4 Indep\_Ned_{i,t} + \theta_5 Busy\_Ned_{i,t} + \theta_6 MVE_{i,t} + \theta_7 RET_{i,t} + \theta_8 SD\_RET_{i,t} + \theta_9 MTB_{i,t} + \boldsymbol{\varphi} + \boldsymbol{\omega} + \epsilon_{i,t}, \quad (2B)$$

$EE\_Comb_{t+1,}$ and $Equity_{t+1}$ are the natural logarithm of the amount of E&E asset additions and acquisitions and equity proceeds raised in the following year, respectively. $D\_degree\_fullboard_y$ and $D\_expert\_fullboard_y$ are the Blau measure of education diversity and expertise diversity among all board members including the MD for the current year, respectively. Blau diversity is measured as: $1 - \sum p^2$, where p is the proportion of a certain type of degree or expertise out of the total types of degree or expertise represented on the board.

$Board\_Size_t$ is the number of directors sitting on the board for the current year. $Indep\_Ned_t$ is the percentage of independent non-executive directors (NEDs) on the board for the current year. $Busy\_Ned_t$ is the percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. MVE_t is the natural logarithm of market capitalisation for the current year. RET_t is the annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns in the prior two years. MTB_t is the market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 12: Professional memberships

Variables		Member level				Fellow level			
	Obs	Min	Mean	Median	Max	Min	Mean	Median	Max
AusIMM_board	5,158	0	0.35	0	1	0	0.27	0	1
AICD_board	5,158	0	0.29	0	1	0	0.22	0	1
CA_board	5,158	0	0.25	0	1	0	0.11	0	1
AIG_board	5,158	0	0.15	0	1	0	0.03	0	1
CPA_board	5,158	0	0.13	0	1	0	0.10	0	1
Finsia_board	5,158	0	0.00	0	0	0	0.10	0	1
SEG_board	5,158	0	0.04	0	1	0	0.03	0	1
GIA_board	5,158	0	0.00	0	1	0	0.06	0	1
IEAust_board	5,158	0	0.02	0	1	0	0.03	0	1
GSA_board	5,158	0	0.03	0	1	0	0.00	0	1
AusIMM_MD	5,158	0	0.19	0	1	0	0.07	0	1
AICD_MD	5,158	0	0.12	0	1	0	0.02	0	1
CA_MD	5,158	0	0.03	0	1	0	0.01	0	1
AIG_MD	5,158	0	0.10	0	1	0	0.02	0	1
CPA_MD	5,158	0	0.01	0	1	0	0.00	0	1
Finsia_MD	5,158	0	0.00	0	0	0	0.02	0	1
SEG_MD	5,158	0	0.02	0	1	0	0.01	0	1
GIA_MD	5,158	0	0.00	0	0	0	0.00	0	1
IEAust_MD	5,158	0	0.01	0	1	0	0.00	0	1
GSA_MD	5,158	0	0.02	0	1	0	0.00	0	0

This table presents professional memberships of board members excluding the managing director (*_board*) and of the managing director (*_MD*) for the period 2004–2018. Membership of each professional body is an indicator variable, coded 1 if the board (excluding the MD) has at least one member excluding the MD holding memberships at the Australasian Institute of Mining and Metallurgy (AusIMM), the Australian Institute of Company Directors (AICD), Chartered Accountants (CA), the Australian Institute of Geoscientists (AIG), the Certified Public Accountant (CPA), the Society of Economic Geologists (SEG), the Governance Institute of Australia (GIA) (formerly known as the Institute of Chartered Secretaries and Administrators), the Institution of Engineers Australia (IEAust), the Geological Society of Australia (GSA), and the Financial Services Institute of Australasia (Finsia). Similar classification applies for the MD's professional memberships.

Table 13: Associations between professional memberships and E&E investments and equity raising

Panel A: E&E investments

					EE_Comb_{t+1}						
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
AusIMM_board$_t$	0.1508										0.1029
	(0.1887)										(0.1982)
AusIMM_MD$_t$	0.0988										0.0910
	(0.2062)										(0.2208)
AICD_board$_t$		0.1157									0.1276
		(0.1935)									(0.2020)
AICD_MD$_t$		0.4148									0.2348
		(0.2571)									(0.2721)
CA_board$_t$			–0.0959								–0.0112
			(0.2189)								(0.2226)
CA_MD$_t$			1.2463***								1.1113***
			(0.4194)								(0.4160)
AIG_board$_t$				0.5874**							0.5744**
				(0.2416)							(0.2547)
AIG_MD$_t$				–0.0290							–0.0185
				(0.3284)							(0.3388)
CPA_board$_t$					0.1111						0.1728
					(0.2587)						(0.2755)
CPA_MD$_t$					0.6139						0.3036
					(0.7534)						(0.7873)
SEG_board$_t$						0.6528					0.3372
						(0.3999)					(0.4121)
SEG_MD$_t$						0.6368					0.5587
						(0.5821)					(0.6443)
GIA_board$_t$							0.2657				0.3167
							(0.4065)				(0.4155)

Panel A: E&E investments

						EE_Comb_{t+1}					
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
GIA_MD$_t$							3.6007**				3.2015**
							(1.5471)				(1.4971)
IEAust_board$_t$								–0.3483			–0.3627
								(0.4064)			(0.4099)
IEAust_MD$_t$								0.7479			0.8060
								(1.1300)			(1.1284)
GSA_board$_t$									0.0337		–0.2345
									(0.4886)		(0.5170)
GSA_MD$_t$									0.6023		0.1430
									(0.6840)		(0.7451)
Finsia_board$_t$										–0.7483**	–0.7806**
										(0.3328)	(0.3390)
Finsia_MD$_t$										0.4329	0.1609
										(0.6063)	(0.6345)
Constant	0.4593	0.4906	0.5378	0.3303	0.4351	0.4104	0.4816	0.4005	0.4690	0.4505	0.3483
	(1.4367)	(1.4397)	(1.4413)	(1.4336)	(1.4372)	(1.4333)	(1.4375)	(1.4356)	(1.4413)	(1.4365)	(1.4461)
Observations	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158
Unique firms	820	820	820	820	820	820	820	820	820	820	820
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	44.70%	44.73%	44.78%	44.77%	44.70%	44.73%	44.77%	44.70%	44.69%	44.77%	44.87%

Panel B: Equity raising

					Equity$_{t+1}$					
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
AusIMM_board$_t$	0.7483***										0.7241***
	(0.2535)										(0.2623)
AusIMM_MD$_t$	0.6519**										0.5602*
	(0.2964)										(0.3059)
AICD_board$_t$		0.3485									0.2758
		(0.2604)									(0.2657)
AICD_MD$_t$		0.8361**									0.5422
		(0.3540)									(0.3760)
CA_board$_t$			–0.4710								–0.4193
			(0.2980)								(0.3048)
CA_MD$_t$			–0.3154								–0.4749
			(0.7692)								(0.7891)
AIG_board$_t$				0.2927							0.2830
				(0.3289)							(0.3517)
AIG_MD$_t$				0.1287							–0.1642
				(0.4575)							(0.4803)
CPA_board$_t$					–0.2316						–0.2960
					(0.3401)						(0.3475)
CPA_MD$_t$					0.7577						0.5154
					(0.8611)						(0.8883)
SEG_board$_t$						–0.7185					–1.1110*
						(0.5599)					(0.5953)
SEG_MD$_t$						1.1260					0.9983
						(0.9264)					(0.9746)
GIA_board$_t$							0.5174				0.6509
							(0.5632)				(0.5706)
GIA_MD$_t$							2.8985				2.8398
							(2.0758)				(2.1554)
IEAust_board$_t$								0.5666			0.2993
								(0.6393)			(0.6378)
IEAust_MD$_t$								–0.9616			–1.0732

Panel B: Equity raising

					Equity$_{t+1}$						
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
								(1.2693)			(1.2693)
GSA_board$_t$									0.1302		–0.1508
									(0.7381)		(0.7673)
GSA_MD$_t$									0.8472		0.3880
									(1.4069)		(1.4717)
Finsia_board$_t$										0.2715	0.2380
										(0.4643)	(0.4679)
Finsia_MD$_t$										1.2681	0.9716
										(0.9800)	(0.9957)
Constant	8.1676***	8.2171***	8.2414***	8.0806***	8.1460***	8.1483***	8.1845***	8.2348***	8.1501***	8.2236***	8.4657***
	(1.7505)	(1.7514)	(1.7565)	(1.7530)	(1.7538)	(1.7545)	(1.7553)	(1.7636)	(1.7549)	(1.7540)	(1.7679)
Observations	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158
Unique firms	820	820	820	820	820	820	820	820	820	820	820
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	23.35%	23.25%	23.17%	23.13%	23.14%	23.18%	23.17%	23.14%	23.13%	23.16%	23.37%

This table presents the association between directors' professional memberships and E&E investments and equity raising over the period 2004–2018.

$$EE\_Comb_{i,t+1} or\ Equity_{i,t+1} = \theta_0 + \sum_h \theta_1^h PM_{h,i,t} + \sum_h \theta_2^h PM\_MD_{h,i,t} + \theta_3 Board\_Size_{i,t} + \theta_4 Indep\_Ned_{i,t} + \theta_5 Busy\_Ned_{i,t} + \theta_6 MVE_{i,t} + \theta_7 RET_{i,t} + \theta_8 SD\_RET_{i,t} + \theta_9 MTB_{i,t} + \boldsymbol{\varphi} + \boldsymbol{\omega} + \epsilon_{i,t}$$

EE_Comb$_{t+1,}$ and *Equity$_{t+1}$* are the natural logarithm of the amount of E&E asset additions and acquisitions and equity proceeds raised in the following year, respectively. *PM$_t$* is an indicator variable coded 1 if the board has at least one member excluding the MD holding memberships (either at member level or fellow level) at professional organisations for the current year including the Australasian Institute of Mining and Metallurgy (AusIMM), the Australian Institute of Company Directors (AICD), Chartered Accountants (CA), the Australian Institute of Geoscientists (AIG), the Certified Public Accountant (CPA), the Society of Economic Geologists (SEG), the Governance Institute of Australia (GIA) (formerly known as the Institute of Chartered Secretaries and Administrators), the Institution of Engineers Australia (IEAust), the Geological Society of Australia (GSA) and the Financial Services Institute of Australasia (Finsia). *PM_MD$_t$* is an indicator coded 1 if the MD holds professional memberships at one of the above institutes for the current year.

Board_Size$_t$ is the number of directors sitting on the board for the current year. *Indep_Ned$_t$* is the percentage of independent non-executive directors (NEDs) on the board for the current year. *Busy_Ned$_t$* is the percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. *MVE$_t$* is the natural logarithm of market capitalisation for the current year. *RET$_t$* is the annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. *SD_RET$_t$* is

the annualised standard deviation of monthly stock returns in the prior two years. MTB_t is the market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 14: Mediating effect of professional memberships on the association between education, expertise and equity raising

Variables	*Mining_mem_board$_t$* Logit (1)	*Equity$_{t+1}$* (2)	*Equity$_{t+1}$* (3)
edu_expert_index_board$_t$	1.3111***	0.5866***	0.4990**
	(0.1899)	(0.2074)	(0.2081)
edu_expert_index_MD$_t$		0.1765*	0.2035**
		(0.0960)	(0.0968)
Mining_mem_board$_t$			0.5403**
			(0.2495)
Constant	–5.6893***	11.0694*	11.1103*
	(1.3118)	(5.9400)	(5.9374)
Mediating effect			0.0876**
[p-value]			[0.024]
% of total effect mediated			14.93%
Observations	5,158	5,158	5,158
Unique firms	820	820	820
Controls	Yes	5158	5158
Year fixed-effects	Yes	Yes	Yes
Firm fixed-effects	No	Yes	Yes
Adj. R-squared	9.08%	23.31%	23.37%

This table presents the mediating effect of professional mining memberships on the associations between education and expertise and MEEs' future equity raising over the period 2004–2018. *Mining_mem_board$_t$* is an indicator variable coded 1 if at least one director on the board holds either a general membership or fellow membership with one of the following mining associations: AusIMM, AIG, SEG, IEAust and GSA for the current year. *Equity$_{t+1}$* is natural logarithm of equity proceeds raised in the following year; *edu_expert_index_board$_t$* is the average of the sum of both degree levels and expertise for board members excluding the MD, while *edu_expert_index_MD$_t$* is the sum of both degree levels and expertise for the MD for the current year. Controls include *Board_Size$_t$, Indep_Ned$_t$, Busy_Ned$_t$, MVE$_t$, RET$_t$, SD_RET$_t$, MTB* as previously defined. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 15: Mediating effect of professional memberships on the association between diversity and equity raising and E&E investments

Panel A: Equity raising			
Variables	***Mining_mem$_t$*** **Logit (1)**	***Equity$_{t+1}$*** **(2)**	***Equity$_{t+1}$*** **(3)**
D_degree_board$_t$	1.4460***	1.0605**	0.9092*
	(0.3977)	(0.4691)	(0.4704)
D_expert_board$_t$	0.7830*	0.2907	0.2267
	(0.4493)	(0.6395)	(0.6389)
Mining_mem$_t$			0.9171***
			(0.2574)
Constant	–2.9728**	12.3460**	11.8951**
	(1.2874)	(5.9123)	(5.9057)
Mediating effect			0.1513***
[p-value]			[0.002]
% of total effect mediated			14.27%
Observations	5,158	5,158	5,158
Unique firms	820	820	820
Controls	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes
Firm fixed-effects	No	Yes	Yes
Adj. R-squared	3.76%	23.21%	23.42%

Panel B: E&E investments			
Variables	***Mining_mem$_t$*** **Logit (1)**	***EE_Comb$_{t+1}$*** **(2)**	***EE_Comb$_{t+1}$*** **(3)**
D_degree_board$_t$	1.4460***	1.0807***	1.0276***
	(0.3977)	(0.3291)	(0.3303)
D_expert_board$_t$	0.7830*	–0.0480	–0.0705
	(0.4493)	(0.4486)	(0.4487)
Mining_mem$_t$			0.3218*
			(0.1808)
Constant	–2.9728**	4.7042	4.5460
	(1.2874)	(4.1475)	(4.1474)
Mediating effect			0.0531*
[p-value]			[0.082]
% of total effect mediated			4.91%
Observations	5,158	5,158	5,158
Unique firms	820	820	820
Controls	Yes	5158	5158
Year fixed-effects	Yes	Yes	Yes
Firm fixed-effects	No	Yes	Yes
Adj. R-squared	3.76%	44.82%	44.85%

This table presents the mediating effect of professional mining memberships on the associations between the diversity of education and expertise and MEEs' future equity raising and E&E investments over the period 2004–2018. *Mining_mem$_t$* is an indicator variable coded 1 if at least one director on the board is a member of one of the following mining associations: AusIMM, AIG, SEG, IEAust and GSA for the current year. *EE_Comb$_{t+1,}$* and *Equity$_{t+1}$* are the natural logarithm of the amount of E&E asset additions and acquisitions and equity proceeds raised in the following year, respectively. *D_degree_board$_t$* and *D_expert_board$_t$* are the Blau measure of degree diversity and expertise diversity among board members excluding the MD for the current

year, respectively. Controls include *Board_Size*$_t$, *Indep_Ned*$_t$, *Busy_Ned*$_t$, *MVE*$_t$, *RET*$_t$, *SD_RET*$_t$, *MTB* as previously defined. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses

Table 16: Moderating effect of board education and expertise

Variables	EE_Comb_{t+1} (1)	$Equity_{t+1}$ (2)	EE_Comb_{t+1} (3)	$Equity_{t+1}$ (4)
edu_expert_index_MD_Q1$_t$	–2.0654***	–2.0769**		
	(0.7677)	(0.9557)		
edu_expert_index_board×*edu_expert_index_MD_Q1*$_t$	0.9240***	0.6824		
	(0.3389)	(0.4214)		
centrality_MD_Q1$_t$			–2.7031***	–3.0825***
			(0.8111)	(1.0218)
edu_expert_index_board×*centrality_MD_Q1*$_t$			1.3674***	1.0054**
			(0.3548)	(0.4513)
centrality_board$_t$			0.1386**	0.0981
			(0.0687)	(0.0950)
edu_expert_index_MD$_t$			0.1975**	–0.0410
			(0.0997)	(0.1454)
edu_expert_index_board$_t$	0.6070***	0.3631	0.5279***	0.2903
	(0.1917)	(0.2577)	(0.1863)	(0.2528)
Board_Size$_t$	–0.2930***	–0.2460**	–0.3501***	–0.2504**
	(0.0902)	(0.1236)	(0.0911)	(0.1259)
Indep_Ned$_t$	–0.0322	0.6196	0.0054	0.6277
	(0.2930)	(0.3994)	(0.2925)	(0.3977)
Busy_Ned$_t$	–0.7930	–0.6937	–1.1962**	–1.0066
	(0.4906)	(0.6746)	(0.5222)	(0.7447)
MVE_t	0.8364***	0.2623**	0.8155***	0.2425**
	(0.0936)	(0.1160)	(0.0938)	(0.1157)
RET_t	0.2206***	0.1775**	0.2201***	0.1850**
	(0.0681)	(0.0868)	(0.0679)	(0.0869)
SD_RET$_t$	–0.0057	0.8025***	0.0088	0.8123***
	(0.1668)	(0.2334)	(0.1662)	(0.2335)
MTB_t	–0.0570*	0.1565***	–0.0569*	0.1588***
	(0.0293)	(0.0266)	(0.0294)	(0.0266)
Constant	0.0364	8.6798***	–0.0245	8.9980***
	(1.5081)	(1.8398)	(1.4912)	(1.8382)
Observations	5,158	5,158	5,158	5,158
Unique firms	820	820	820	820
Year fixed-effects	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes
Adj. R-squared	45.21%	23.38%	45.42%	23.50%

This table presents the moderating effects on the association between directors' education and expertise and E&E investments and equity raising over the period 2004–2018. $EE\_Comb_{t+1,}$ and $Equity_{t+1}$ are the natural logarithm of the amount of E&E asset additions and acquisitions and equity proceeds raised in the following year, respectively; *edu_expert_index_MD_Q1*$_t$ is an indicator coded 1 if *edu_expert_index_MD*$_t$ is in the bottom quintile for the current year, and 0 otherwise; *centrality_MD_Q1*$_t$ is an indicator coded 1 if the factor score of the MD's key centrality measures (degree, betweenness, closeness, and eigenvector centrality) is in the bottom quintile for the current year, and 0 otherwise; *centrality_board*$_t$ is the quintile rank of the average factor score of four key centrality measures of individual board members excluding the MD for the current year; *edu_expert_index_board*$_t$ is the average of the sum of both degree levels and expertise for board members excluding the MD while *edu_expert_index_MD*$_t$ is the sum of both degree levels and expertise for the MD for the current year.

Board_Size$_t$ is the number of directors sitting on the board for the current year. *Indep_Ned*$_t$ is the percentage of independent non-executive directors (NEDs) on the board for the current year. *Busy_Ned*$_t$ is the percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. MVE_t is the natural logarithm of market capitalisation for the current year. RET_t is annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. *SD_RET*$_t$ is the annualised standard deviation of monthly stock returns in the prior two years. MTB_t is the market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 17: Moderating effect of leadership experience

Variables	EE_Comb_{t+1} (1)	$Equity_{t+1}$ (2)	EE_Comb_{t+1} (3)	$Equity_{t+1}$ (4)	EE_Comb_{t+1} (5)	$Equity_{t+1}$ (6)	EE_Comb_{t+1} (7)	$Equity_{t+1}$ (8)
finance_expertise_board$_t$	–0.7525	0.1871						
	(0.6034)	(0.7294)						
finance_expertise_board×*leader_board*$_t$	–0.2272	–0.0718						
	(1.0058)	(1.3765)						
finance_expertise_MD$_t$	0.1923	–0.0223						
	(0.3242)	(0.4752)						
accounting_expertise_board$_t$			–0.3482	–0.5770				
			(0.7066)	(0.9072)				
accounting_expertise_board× *leader_board*$_t$			–1.5650	–0.7173				
			(1.1192)	(1.5955)				
accounting_expertise_MD$_t$			0.3889	–0.2215				
			(0.4548)	(0.6637)				
legal_expertise_board$_t$					–0.1704	–0.5798		
					(0.9793)	(1.2555)		
legal_expertise_board× *leader_board*$_t$					–0.8469	–1.6968		
					(1.4251)	(2.1701)		
legal_expertise_MD$_t$					1.0652	–0.3236		
					(0.7837)	(1.6512)		
mining_expertise_board$_t$							1.5328***	1.4296**
							(0.5404)	(0.6993)
mining_expertise_board× *leader_board*$_t$							2.1373**	0.3916
							(0.8339)	(1.1409)
mining_expertise_MD$_t$							0.3051	0.8378***
							(0.1955)	(0.2798)
leader_board$_t$	0.0971	–0.3804	0.2707	–0.3145	0.1324	–0.3043	–0.6648**	–0.6002
	(0.2385)	(0.3553)	(0.2367)	(0.3436)	(0.2202)	(0.3206)	(0.2996)	(0.4301)

Variables	EE_Comb_{t+1} (1)	$Equity_{t+1}$ (2)	EE_Comb_{t+1} (3)	$Equity_{t+1}$ (4)	EE_Comb_{t+1} (5)	$Equity_{t+1}$ (6)	EE_Comb_{t+1} (7)	$Equity_{t+1}$ (8)
$leader\_MD_t$	0.7298*	0.0430	0.7928**	0.0610	0.7856**	0.0261	0.7380*	–0.1322
	(0.3798)	(0.4875)	(0.3777)	(0.4861)	(0.3781)	(0.4849)	(0.3780)	(0.4863)
Constant	0.5087	7.8622***	0.4421	8.0255***	0.3790	7.9420***	0.2095	7.9001***
	(1.4498)	(1.7724)	(1.4603)	(1.7774)	(1.4447)	(1.7654)	(1.4392)	(1.7571)
Observations	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158
Unique firms	820	820	820	820	820	820	820	820
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	44.77%	23.10%	44.78%	23.12%	44.75%	23.13%	45.15%	23.34%

This table presents the moderating effect of leadership experience. $EE\_Comb_{t+1,}$ and $Equity_{t+1}$ are the natural logarithm of the amount of E&E asset additions and acquisitions and equity proceeds raised in the following year, respectively; $finance\_expertise\_board_t$, $accounting\_expertise\_board_t$, $legal\_expertise\_board_t$ and $mining\_expertise\_board_t$ are the proportion of board members excluding the MDs who possess expertise in the areas of finance, accounting, legal, and technical mining for the current year, respectively; $finance\_expertise\_MD_t$, $accounting\_expertise\_MD_t$, $legal\_expertise\_MD_t$ and $mining\_expertise\_MD_t$ are indicator variables coded 1 for cases where the MD possesses expertise in the areas of finance, accounting and legal and technical mining for the current year, respectively; $leader\_board_t$ and $leader\_MD_t$ are indicator variables coded 1 if the board has at least 1 director having experience serving as an executive of a publicly listed firm and the MD having experience serving as an executive of a publicly listed firm for the current year, respectively, and 0 otherwise. Controls include $Board\_Size_t$, $Indep\_Ned_t$, $Busy\_Ned_t$, MVE_t, RET_t, SD_RET_t, MTB are as previously defined. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 18: Moderating effect of general industry expertise

Variables	EE_Comb_{t+1} (1)	$Equity_{t+1}$ (2)	EE_Comb_{t+1} (3)	$Equity_{t+1}$ (4)	EE_Comb_{t+1} (5)	$Equity_{t+1}$ (6)
finance_expertise_board$_t$	–1.2209*	–0.0291				
	(0.6643)	(0.8166)				
finance_expertise_board×*industry_board*$_t$	0.8714	0.5152				
	(0.9765)	(1.2479)				
finance_expertise_MD$_t$	0.2473	0.0013				
	(0.3300)	(0.4805)				
accounting_expertise_board$_t$			–1.3743*	–0.9397		
			(0.8078)	(1.0294)		
accounting_expertise_board×*industry_board*$_t$			1.6189	0.6431		
			(1.1108)	(1.4391)		
accounting_expertise_MD			0.5759	–0.1766		
			(0.4674)	(0.6639)		
legal_expertise_board$_t$					0.8463	–0.8813
					(1.1176)	(1.3594)
legal_expertise_board×*industry_board*$_t$					–3.0786**	–0.1256
					(1.5249)	(2.0721)
legal_expertise_MD$_t$					0.9100	–0.2768
					(0.7757)	(1.6522)
industry_board$_t$	–0.0717	–0.3405	–0.0896	–0.3338	0.2856	–0.2572
	(0.2615)	(0.3382)	(0.2474)	(0.3282)	(0.2221)	(0.2923)
industry_MD$_t$	–0.1864	–0.1975	–0.2293	–0.1882	–0.1124	–0.2049
	(0.3075)	(0.4026)	(0.3097)	(0.3955)	(0.3031)	(0.3971)
Constant	0.6848	8.1411***	0.7632	8.3684***	0.3959	8.2355***
	(1.4451)	(1.7615)	(1.4551)	(1.7671)	(1.4403)	(1.7550)
Observations	5,158	5,158	5,158	5,158	5,158	5,158
Unique firms	820	820	820	820	820	820

Variables	EE_Comb_{t+1} (1)	$Equity_{t+1}$ (2)	EE_Comb_{t+1} (3)	$Equity_{t+1}$ (4)	EE_Comb_{t+1} (5)	$Equity_{t+1}$ (6)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	44.72%	23.09%	44.73%	23.10%	44.73%	23.10%

This table examines the interactions between general industry expertise and functional expertise over the period 2004–2018. $EE\_Comb_{t+1,}$ and $Equity_{t+1}$ are the natural logarithm of the amount of E&E asset additions and acquisitions and equity proceeds raised in the following year, respectively; $finance\_expertise\_board_{t,}$ $accounting\_expertise\_board_t$ and $legal\_expertise\_board_t$ are the proportion of board members excluding the MDs who possess expertise in the areas of finance, accounting, legal for the current year, respectively; $finance\_expertise\_MD_{t,}$ $accounting\_expertise\_MD_t$ and $legal\_expertise\_MD_t$ are an indicator variable coded 1 where the MD possesses expertise in the areas of finance, accounting and legal for the current year, respectively; $industry\_board_t$ and $industry\_MD_t$ are an indicator variable coded 1 if the board has at least one director having general industry expertise and the MD having general industry expertise for the current year, respectively, and 0 otherwise. Controls include $Board\_Size_{t,}$ $Indep\_Ned_{t,}$ $Busy\_Ned_t$, $MVE_{t,}$ $RET_{t,}$ SD_RET_t, MTB are as previously defined. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 19: Associations between education and future stock returns

			RET_{t+1}		
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
degree_bachelor_board$_t$	–0.0474				–0.0283
	(0.0964)				(0.1038)
degree_bachelor_MD$_t$	–0.0271				0.0079
	(0.0468)				(0.0507)
degree_master_board$_t$		–0.0175			0.0002
		(0.1190)			(0.1223)
degree_master_MD$_t$		–0.0813			–0.0929
		(0.0570)			(0.0591)
degree_phd_board$_t$			–0.2338		–0.2364
			(0.1951)		(0.2036)
degree_phd_MD$_t$			0.0347		–0.0032
			(0.0891)		(0.0935)
degree_hons_board$_t$				0.0738	0.0750
				(0.1218)	(0.1316)
degree_hons_MD$_t$				0.0792	0.0871
				(0.0539)	(0.0595)
Constant	7.0934***	7.0706***	7.0809***	7.0893***	7.0966***
	(0.4237)	(0.4175)	(0.4177)	(0.4194)	(0.4273)
Observations	5,158	5,158	5,158	5,158	5,158
Controls	Yes	Yes	Yes	Yes	Yes
Unique firms	820	820	820	820	820
Year fixed-effects	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	24.08%	24.11%	24.10%	24.11%	24.07%

This table presents the association between directors' education and future stock return over the period 2004–2018.

$$RET_{i,t+1} = \theta_0 + \sum_j \theta_1^j Q\_board_{j,i,t} + \sum_j \theta_2^j Q\_MD_{j,i,t} + \theta_3 Board\_Size_{i,t} + \theta_4 Indep\_Ned_{i,t} + \theta_5 Busy\_Ned_{i,t} + \theta_6 MVE_{i,t} + \theta_7 RET_{i,t} + \theta_8 SD\_RET_{i,t} + \theta_9 MTB_{i,t} + \boldsymbol{\varphi} + \boldsymbol{\omega} + \epsilon_{i,t}$$

RET_{t+1} is the annual buy-and-hold stock return adjusted for dividends and capital changes in the following year. Q_board_t is the proportion of board members excluding the MDs who hold bachelor, masters, PhD and honours degrees for the current year. Q_MD_t is an indicator variable coded 1 for cases where the MD holds bachelor, masters, PhD and honours degrees for the current year. $Board\_Size_t$ is the number of directors sitting on the board for the current year. $Indep\_Ned_t$ is the percentage of independent non-executive directors (NEDs) on the board for the current year. $Busy\_Ned_t$ is the percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. MVE_t is the natural logarithm of market capitalisation for the current year. RET_t is the annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns in the prior two years. MTB_t is the market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 20: Associations between education and expertise and future stock returns

					RET_{t+1}					
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
finance_expertise_board$_t$	0.2102*									0.2796*
	(0.1194)									(0.1467)
finance_expertise_MD$_t$	0.0186									0.0556
	(0.0826)									(0.0946)
accounting_expertise_board$_t$		0.0613								0.2187
		(0.1467)								(0.1723)
accounting_expertise_MD$_t$		–0.0619								–0.0393
		(0.0879)								(0.1000)
legal_expertise_board$_t$			–0.2220							–0.0999
			(0.2116)							(0.2345)
legal_expertise_MD$_t$			0.1322							0.1799
			(0.2170)							(0.2372)
leadership_expertise_board$_t$				0.0279						0.0484
				(0.1719)						(0.1807)
leadership_expertise_MD$_t$				0.0385						0.0494
				(0.0777)						(0.0788)
mining_expertise_board$_t$					0.0702					0.1402
					(0.1085)					(0.1485)
mining_expertise_MD$_t$					0.0403					0.0435
					(0.0500)					(0.0775)
engineers_expertise_board$_t$						0.1141				0.1461
						(0.3639)				(0.3763)
engineers_expertise_MD$_t$						–0.0537				–0.0534
						(0.2169)				(0.2226)
industry_expertise_board$_t$							–0.3511**			–0.3114**
							(0.1447)			(0.1537)
industry_expertise_MD$_t$							–0.0851			–0.0328

Variables	(1)	(2)	(3)	(4)	RET_{t+1} (5)	(6)	(7)	(8)	(9)	(10)
							(0.0655)			(0.0780)
local_expertise_board$_t$								–0.1150		–0.0580
								(0.2974)		(0.2977)
local_expertise_MD$_t$								0.0534		0.0714
								(0.1674)		(0.1674)
other_knowledge_board$_t$									0.0598	0.0763
									(0.1738)	(0.1837)
other_knowledge_MD$_t$									0.0343	0.0467
									(0.1195)	(0.1294)
degree_bachelor_board$_t$										–0.0682
										(0.1082)
degree_master_board$_t$										–0.0205
										(0.1243)
degree_phd_board$_t$										–0.2545
										(0.2090)
degree_hons_board$_t$										0.0089
										(0.1449)
degree_bachelor_MD$_t$										–0.0093
										(0.0638)
degree_master_MD$_t$										–0.0939
										(0.0620)
degree_phd_MD$_t$										0.0186
										(0.0955)
degree_hons_MD$_t$										0.0552
										(0.0731)
Constant	7.0434***	7.0639***	7.0983***	7.0826***	7.0811***	7.0836**	7.1365***	7.0677***	7.0753***	7.0600***
	(0.4186)	(0.4203)	(0.4186)	(0.4166)	(0.4191)	(0.4171)	(0.4181)	(0.4183)	(0.4175)	(0.4317)

	RET_{t+1}									
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Observations	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158	5,158
Unique firms	820	820	820	820	820	820	820	820	820	820
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	24.13%	24.08%	24.10%	24.07%	24.09%	24.07%	24.20%	24.07%	24.07%	24.01%

This table presents the association between directors' education and expertise and future stock return over the period 2004–2018.

$$RET_{i,t+1} = \theta_0 + \sum_j \theta_1^j Q\_board_{j,i,t} + \sum_k \theta_2^k E\_board_{k,i,t} + \sum_j \theta_3^j Q\_MD_{j,i,t} + \sum_k \theta_4^k E\_MD_{k,i,t} + \theta_5 Board\_Size_{i,t} + \theta_6 Indep\_Ned_{i,t} + \theta_7 Busy\_Ned_{i,t} + \theta_8 MVE_{i,t} + \theta_9 RET_{i,t} + \theta_{10} SD\_RET_{i,t} + \theta_{11} MTB_{i,t} + \boldsymbol{\varphi} + \boldsymbol{\omega} + \epsilon_{i,t},$$

RET_{t+1} is the annual buy-and-hold stock return adjusted for dividends and capital changes in the following year. Q_board_t is the proportion of board members excluding the MDs who hold bachelor, masters, PhD and honours degrees and E_board_t is the proportion of board members excluding the MDs who possess expertise in the areas of finance, accounting, legal, leadership, technical mining, engineer, general industry expertise, local expertise and other knowledge for the current year. Q_MD_t is an indicator variable coded 1 where the MD holds bachelor, masters, PhD and honours degrees and E_MD_t is an indicator variable coded 1 for cases where the MD possesses expertise in the areas of finance, accounting, legal, leadership, technical mining, engineer, general industry expertise, local expertise and other knowledge for the current year.

$Board\_Size_t$ is the number of directors sitting on the board for the current year. $Indep\_Ned_t$ is the percentage of independent non-executive directors (NEDs) on the board for the current year. $Busy\_Ned_t$ is the percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. MVE_t is the natural logarithm of market capitalisation for the current year. RET_t is the annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. SD_RET_t is the annualised standard deviation of monthly stock returns in the prior two years. MTB_t is the market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 21: Associations between education and expertise and E&E investments and equity raising – Instrumental variable approach

	2SLS First stage	2SLS Second stage	
	edu_expert_index_board	***EE_Comb$_{t+1}$***	***Equity$_{t+1}$***
Variables	**(1)**	**(2)**	**(3)**
edu_expert_index_local$_t$	0.7006***		
	(0.0643)		
EE_wo$_t$	0.0022**		
	(0.0011)		
edu_expert_index_board$_t$		1.8881**	1.5703
		(0.7556)	(1.1100)
edu_expert_index_MD$_t$	0.0257***	0.0855	0.1433
	(0.0074)	(0.0667)	(0.0970)
Board_Size$_t$	0.0321***	–0.3542***	–0.2686**
	(0.0089)	(0.0878)	(0.1204)
Indep_Ned$_t$	0.0661**	–0.1527	0.5161
	(0.0297)	(0.2713)	(0.3694)
Busy_Ned$_t$	0.0157	–0.7649*	–0.8145
	(0.0462)	(0.4511)	(0.6185)
MVE$_t$	0.0360***	0.8109***	0.2440**
	(0.0085)	(0.0887)	(0.1115)
RET$_t$	–0.0161**	0.2286***	0.1786**
	(0.0065)	(0.0642)	(0.0820)
SD_RET$_t$	–0.0125	0.0280	0.8323***
	(0.0168)	(0.1530)	(0.2154)
MTB$_t$	–0.0045*	–0.0575**	0.1591***
	(0.0025)	(0.0269)	(0.0246)
Constant	–0.2378	–10.3444***	12.5243***
	(0.2078)	(1.7317)	(2.1177)
Observations	5,158	5,158	5,158
Unique firms	820	820	820
Year fixed-effects	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes
State fixed-effects	Yes	Yes	Yes
Adj. R-squared	58.38%	44.59%	23.00%

This table presents the associations between directors' education and expertise and E&E investments and equity raising over the period 2004–2018 using 2SLS regression. Where *edu_expert_index_board$_t$* is the average of the sum of both degree levels and expertise for board members excluding the MD for the current year; *edu_expert_index_MD$_t$* is the sum of both degree levels and expertise of the MD for the current year; *EE_Comb$_{t+1,}$* and *Equity$_{t+1}$* are the natural logarithm of the amount of E&E asset additions and acquisitions and equity proceeds raised in the following year, respectively; *edu_expert_index_local$_t$* is the average number of both degree levels and expertise possessed by directors from firms sharing the same 2-digit postcode for the current year based on the firms' headquarters/ principal place of business; and *EE_wo$_t$* is the natural logarithm of the amount of E&E asset written off for the current year.

Board_Size$_t$ is the number of directors sitting on the board for the current year. *Indep_Ned$_t$* is the percentage of independent non-executive directors (NEDs) on the board for the current year. *Busy_Ned$_t$* is the percentage of NEDs on the board who hold two or more board positions in industry peer firms other than the current board for the current year. *MVE$_t$* is the natural logarithm of market capitalisation for the current year. *RET$_t$* is the annual buy-and-hold stock return adjusted for dividends and capital changes for the current year. *SD_RET$_t$* is the annualised standard deviation of monthly stock returns in the prior two years. *MTB$_t$* is the market-to-book value of equity for the current year. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Appendix A: Definition of expertise in previous studies

Papers	Definition/classification
Defond et al. (2005)	• "a) *Accounting* financial expert – all directors with experience as a public accountant, auditor, principal or chief financial officer, controller, or principal or chief accounting officer b) *Nonaccounting* financial expert – all directors with experience as the CEO or president of a for-profit" (p. 162). • "We follow the narrow definition of financial expert prescribed in the original SEC proposal to identify appointments that fall into the *accounting* financial expert category. The original proposal, as well as the finally adopted rule, states that a director can acquire attributes of an audit committee financial expert through education and experience as a principal financial officer, principal accounting officer, controller, public accountant, or auditor or experience in one or more positions that involve the performance of similar functions. Defining the work experience that qualifies a director as a *nonaccounting* financial expert requires more judgment" (p. 162).
Malmendier and Tate (2005)	• "CEOs with a career in finance if they previously worked in a financial institution, or if they previously worked as a CFO, treasurer, accountant, or other finance-related professional; CEOs with a technical career if they are individual patent holders, or if they previously worked as an engineer or other technically oriented professional" (p. 2668).
Guner et al. (2008)	• "Director's main employment into one of the following categories: (1) commercial bank executive, (2) investment bank executive, (3) executive of a non-bank financial institution, (4) finance executive (CFO, Accountant, Treasurer, or Vice President for Finance), (5) 'finance' professor (including finance, economics, accounting, and business), (6) consultant, (7) lawyer, (8) executive of a nonfinancial firm that falls outside these categories, and (9) noncorporate worker (including careers in academia, nonprofit or civil activist organizations, and politics) […] To be considered a banker, the director has to be an executive of the bank, not just a board member of the bank" (p. 326).
Kim and Lim (2010)	• "Manufacturing – The ratio of outside directors who have experiences in manufacturing industry to total outside directors for each firm and year" (p. 290). • "Government – The ratio of outside directors who have government experiences to total outside directors for each firm and year" (p. 290). • "Financial – The ratio of outside directors who have experiences in financial industry to total outside directors for each firm and year" (p. 290). • "Accountant – The ratio of outside directors who are accountants to total outside directors for each firm and year" (p. 290). • "Lawyer – The ratio of outside directors who are attorneys to total outside directors for each firm and year" (p. 290).
Anderson et al. (2011)	• "We measure director functional area heterogeneity as the number of different expertise areas represented on the board of directors. Expertise is defined as board experience in law, consulting, accounting, and investment banking (or venture capital)" (p. 32).
Krishnan et al. (2011)	• "We define a director as a legal expert if s/he has a law school degree, such as JD [Juris Doctor], LLM [Master of Laws], or LLD [Doctor of Laws], and/or has working experience as a lawyer at, for example, a law firm or as a legal counsel" (p. 2105). • "CPA certification, CFO experience, and other accounting experience indicate accounting financial expertise" (p. 2110).
Knyazeva et al. (2013)	• *"Legal Expertise* is defined as having an attorney, counsel, or similar law-related title or holding a law degree. *Financial Expertise* is defined as

Papers	Definition/classification
	holding the CFO, treasurer, banking, finance, investment or accounting position" (p. 1598). • "*R&D expertise (%)* and *Tech expertise (%)* – Percent of outside directors with corporate experience at firms with positive R&D and high-tech firms, (SIC codes 2833–2836, 3570–3577, 3600–3674, 7371–7379, or 8731–8734, following Baginski, Hassell, and Kimbrough 2004), respectively, among outside directors with identifiable corporate jobs (officer on another board, where RiskMetrics identifies the firm)" (p. 1598).
Dass et al. (2014)	• "The director is designated as a DRI [director from related industries] if she is either an officer or a director in any firm belonging to an industry that is vertically related to the given firm's industry" (p. 1545).
Huang (2014)	• "Specialist CEOs if they specialize in managing a subset, but not all, of the firm's divisions" (p. 354). • "CEOs classified as widely experienced, in contrast, have had a long tenure with the firm (more than 10 years) at the time of divestiture or (in relatively rare cases) have rotated through all the divisions of the firm prior to the CEO appointment" (p. 354). • "I use the 10-year criterion based on the literature regarding CEO turnover and longevity" (p. 354).
Litov et al. (2014)	• "Directors who received one or more of the following degrees were considered to be lawyer directors: JD [Juris Doctor], LLB [Bachelor of Laws], LLM [Master of Laws], Doctor of Jurisprudence" (p. 429). • "In order to identify directors who received a legal education, we used the educational background information provided by BoardEx" (p. 429).
Minto et al. (2014)	• "An independent director is classified as a financial expert if he or she i) has held an executive position at a banking institution (Former bank executive), ii) holds an executive position at a nonbank financial institution (Executive of nonbank financials), iii) holds a finance-related position (e.g., chief financial officer (CFO), accountant, treasurer, vice president (VP) finance) of a nonfinancial firm (Finance executive of nonfinancials), iv) holds an academic position in a related field (e.g., Professor of finance, economics, or accounting), or v) works as a hedge fund or private equity fund manager, or venture capitalist (Professional investor)" (p. 355).
Gray and Nowland (2017)	• "Banker – Dummy variable equal to one if the director is classified as a banker (experience in banking or finance industries)" (p. 461). • "Accountant – Dummy variable equal to one if the director is classified as an accountant (experience as a CPA/CA or CFO)" (p. 461). • "Consultant – Dummy variable equal to one if the director is classified as a consultant (management, marketing, IT or industry specific)" (p. 461). • "Doctor – Dummy variable equal to one if the director is classified as a medical doctor" (p. 461). • "Engineer – Dummy variable equal to one if the director is classified as an engineer (engineering experience)" (p. 461). • "Executive – Dummy variable equal to one if the director is classified as a general executive/businessperson (not classified into another occupation group)" (p. 461). • "Lawyer – Dummy variable equal to one if the director is classified as a lawyer (experience as a practicing lawyer)" (p. 461). • "Politician – Dummy variable equal to one if the director is classified as a politician (previously held a political office)" (p. 461). • "Scientist – Dummy variable equal to one if the director is classified as a scientist (experience as a scientist)" (p. 461).
Adams et al. (2018)	• "We code directors' skills using a text-based algorithm. We started by manually coding director skills in 2010 using a Conference Board (2010) analysis of Regulation S-K disclosure in 30 Dow Jones companies as a

Papers	Definition/classification
	guideline. Using the 2010 coding we created a dictionary of the most frequent words and phrases belonging to each skill and used them to code skills in 2010–2013" (p. 644).
Bernile et al. (2018)	• "HHI_FINEXPERT using the binary variable for financial expertise provided by RiskMetrics" (p. 593).
Faleye et al. (2018)	• "We define a director as an industry expert if the firm where he is a board member shares the same two-digit SIC code with at least one firm in his employment history" (p. 446).
Fedaseyeu et al. (2018)	• "We identify individuals with legal or consulting experience by prior or current employment as a consultant, lawyer, attorney, or judge" (p. 821). • "We collect prior and current accounting and finance experience including Chartered Financial Analyst (CFA™), Certified Public Accountant (CPA) or Chartered Accountant (CA) credentials as well as performing finance related functions in other companies" (p. 822). • "We identify management experience by prior or current executive positions, including current and retired CEOs" (p. 823). • "We identify individuals with political experience by prior or current employment, service or consulting experience with any Presidential Administration since President Lyndon B. Johnson, and members of Congress and Senators" (p. 823). • "We identify individuals with military experience by relevant prior or current employment, service, or consulting experience with the US Department of Defense, its divisions, or the US Department of Homeland Security" (p. 823).
Kang et al. (2018)	• *"*Variable Indu_Exp is the fraction of independent directors who have full time work experience in a firm(s) with the same three-digit SIC code*"* (p. 911–912).
Cumming and Leung (2021)	• *Ratio of business experts* is defined as "ratio of directors with qualification in accounting, finance, law, and business to total directors. It measures business expertise as opposed to business diversity" (p. 282). • *Science profession ratio* is defined as "proportion of directors with professional qualification in engineering, pharmacy, and medical science" (p. 282).
Gilani et al. (2021)	• Financial expertise is defined as per the SEC which "identifies financial experts based on their current and past working experience and education. https://www.sec.gov/news/press/ z2003-6.htm. Financial working experience is when directors currently hold or held a position in a bank/financial organisation, have an experience working as a CFO, accountant at a non-financial firm. Financial education includes if a director has a MBA, CFA, CPA, or a Finance related degree" (p. 7).
Liu and Sun (2021)	• "An independent director is defined as a legal expert if the person is or was a lawyer or a law faculty member, or has received a law degree" (p. 5).

Appendix B: Variable definitions

Variable	Definition	Data source
Dependent variables:		
EE_Comb_{t+1}	Natural logarithm of the amount of combined E&E asset additions and acquisitions in the following year.	Hand collected from annual reports
$Equity_{t+1}$	Natural logarithm of equity proceeds raised in the following year.	DatAnalysis
Explanatory variables:		
$edu\_index\_board_t$	Average number of degrees for board members excluding the MD for the current year.	Hand collected from annual reports and publicly available sources
$expert\_index\_board_t$	Average types of expertise for board members excluding the MD for the current year	Hand collected from annual reports and publicly available sources
$edu\_expert\_index\_board_t$	Average number of both degrees and expertise for board members excluding the MD for the current year.	Hand collected from annual reports and publicly available sources
$edu\_index\_MD_t$	Number of degrees of the MD for the current year.	Hand collected from annual reports and publicly available sources
$expert\_index\_MD_t$	Number of types of expertise of the MD for the current year.	Hand collected from annual reports and publicly available sources
$edu\_expert\_index\_MD_t$	Number of both degrees and expertise for the MD for the current year.	Hand collected from annual reports and publicly available sources
$D\_degree\_board_t$	Blau measures of degree diversity among board members excluding the MD for the current year.	Hand collected from annual reports and publicly available sources
$D\_expertise\_boardt_t$	Blau measures of expertise diversity among board members excluding the MD for the current year.	Hand collected from annual reports and publicly available sources
$D\_degree\_fullboardt_t$	Blau measures of degree diversity among all board members including the MD for the current year.	Hand collected from annual reports and publicly available sources

Variable	Definition	Data source
$D\_expertise\_fullboardt_t$	Blau measures of expertise diversity among all board members including the MD for the current year.	Hand collected from annual reports and publicly available sources
Board characteristics:		
$Board\_Size_t$	Number of directors sitting on the board for the current year.	Connect 4
$Busy\_Ned_t$	Percentage of non-executive directors (NEDs) on the board who hold two or more board positions in industry peers other than the current board for the current year.	Connect 4
$Indep\_Ned_t$	Percentage of NEDs on the board who are independent for the current year.	Connect 4
Firm economic characteristics:		
MVE_t	Natural logarithm of market capitalisation for the current year.	Sirca – SPPR
RET_t	Annual buy-and-hold stock return adjusted for dividends and capital changes for the current year.	Sirca – SPPR
SD_RET_t	Annualised standard deviation of monthly stock returns over the 24-month period until financial year-end.	Sirca – SPPR
MTB_t	Market-to-book value of equity for the current year.	DatAnalysis

Appendix C: Examples of expertise classification

Directors' biographies were hand-collected from annual reports and publicly available sources such as Linkedin, Bloomberg and Company websites. While firms tend to use the same biography over a number of years and the same biography can be used by multiple firms having the same director, the data collection involved checking each director's biography each year at each firm to ensure any additional information about their education, work history and professional memberships at industry associations are correctly captured.

Information presented in the bracket is the annual report where the information was obtained. For example, csm2004 suggests information is sourced from the 2004 annual report of Consolidated Minerals Limited (ASX: CSM); (vml17) suggests information is sourced from the 2017 annual report of Vital Metals Limited (ASX: VML).

Finance

Mr Macoboy is a certified practising accountant. He has extensive experience in banking, finance and general management in a range of industries having held senior positions in banking, investment banking, media and mining companies (csm2004). He has a wealth of business and corporate finance experience and is a Fellow of the AICD and a CPA. He was Finance Director of Consolidated Minerals Ltd from 1999 to 2005 and Executive Director Finance and Corporate with Portman Mining Ltd from 1996 to 1999. He has also held senior executive positions with Challenge Bank, Merrill Lynch and Australian Capital Equity. Mr Macoboy has more than 25 years cross-industry experience especially in the areas of corporate strategy, finance, treasury, risk management and international fund raising to the Ammtec Board (aec2010). He holds a Bachelor of Economics and a Bachelor of Commerce from the University of WA, and was a Fellow of the Australian Institute of Company Directors and a Certified Practicing Accountant. Mr Macoboy's cross-industry experience, especially in the areas of corporate strategy, finance, treasury, risk management and international fund raising,

are skills needed to ensure the company's projects are appropriately funded and promoted (vml17).

Accounting

Mr Reynolds has been the Company's Chief Financial Officer since 2001. Prior to that he held the position of Chief Financial Officer with a number of other listed entities and before that was a senior manager with an international firm of chartered accountants. He is a member of the Institute of Chartered Accountants in Australia, a fellow of the Financial Services Institute of Australasia and holds a Bachelor of Commerce (honours) degree (ivk2006 & nsn2009). Mr Reynolds is a chartered accountant with more than 25 years' experience across many sectors spent mostly in financial management roles. Most recently, he has been the finance director of a resource investment house, managing investments across a range of commodities, including coal. Prior to that he held the position of Chief Financial Officer with a number of listed entities and before that was a senior manager with an international firm of chartered accountants (ahq18).

Lawyer

Mr Christensen is a lawyer based in Perth and senior partner at Gadens Perth, specialising in dispute resolution, insolvency and corporate restructures. He has many years of commercial litigation and insolvency law experience having acted in major insolvencies ranging from Rothwells, Bond Corporation, Bell Group, to Great Southern and Griffin Coal (wvl2015). Mr Christensen specialises in dispute resolution, banking and finance, insolvency and corporate restructures. Mr Christensen has many years of commercial litigation experience (erl18). His bio from CX Law website as at 2020 says *"Lee's career in insolvency and commercial litigation has involved many major assignments of the last 30 years in Australia. Decisions in which Lee has acted have helped shape the interpretation of insolvency legislation and the*

conduct of restructuring and insolvency. He has acted as both a barrister and solicitor in many Courts, including the High Court of Australia. Lee's experience extends to corporate disputes in ASX-listed companies, debt and creditor recovery disputes, trust law, beneficiary/shareholder disputes, ASIC and personal disputes" https://www.cxlaw.com.au/team/ .

Technical mining

Mark Calderwood has extensive experience in exploring for and mining both gold and tantalum. He was managing director of Afminex's West African operations and had 8 years' experience in and a network of contacts throughout the region (afm2004). Mark Calderwood is a member of the Australasian Institute of Mining and Metallurgy and has 20 years experience in exploring for and mining gold. He is experienced in resource/reserve estimation and feasibility studies. He is Managing Director of Perseus Mining Ltd and has been closely involved over the last 4 years with the Kyrgyz mineral properties (msr2009). He has over 16 years of experience in West Africa and has a wide network of contacts throughout the region (pru2013). Mr Calderwood has 30 years experience with both exploration and production companies in Australia and Africa. He served as MD and CEO of Perseus Mining Ltd from 2004 to 2012, a period which saw the junior exploration firm mature to an ASX100 company. He led Perseus from discovery to production at its Edikan Gold Mine in Ghana and has held key roles in several World Class gold deposits including Tarmoola in Western Australia, Kibali in DRC, and Edikan in Ghana (anl17).

Engineering

Mr Brans qualified as a civil engineer at what is now known as Monash University in 1974. Mr Brans has 30 years' experience in the design and construction of mineral treatment facilities (PRU2005). Mr Brans has operated a consultancy providing project management services to

the international mining industry for the past 14 years. His experience extends across the full range of mining activities, from feasibility studies through to commissioning operations (tgs2010).

Local expertise:

Mr Joseph has extensive experience in Nigeria and the West African region. A 23 year resident of Nigeria, he has invaluable in-country relationships which assist the group in executing its exploration and development programs. Mr Joseph is a former Executive Director of Operations for OANDO Petroleum, one of two major local marketers of petroleum in Nigeria. In this role led supply chain development in the West African Region and had executive responsibility for new business development (eio2012). Similar information in 2018 annual report of Kogi Iron Ltd (ASX: KFE).

General Industry knowledge:

Karen Field has more than 30 years of experience in the minerals industry with a wealth of mining experience and expertise in the areas of strategy, commercialisation, people and project management. During her career she has held executive roles in a variety of mining industry sectors throughout Australia and in South America and served as President of Minera Alumbrera Limited, which manages the Bajo de la Alumbrera copper gold project in north western Argentina (pem2008). Ms Field has been involved in the minerals industry for over 30 years and has a strong background in strategic planning, project management and human resources (mld2011) – same info in sri18.

Leadership

From1990 to 1994 Dr Folie was a director of Shell Australia, and was the Executive Director responsible for Billiton Australia activities (alumina, gold, base metals and exploration) and Shell Coal – the third largest Australian producer. From 1994, he was the founding Managing

Director and CEO of ASX listed gold explorer and producer Acacia Resources Limited (hlx2004).

Other knowledge

- **Business:** Mr Sucipto has been involved in the mining industry for the last 5 years, together with experience in senior management positions including CEO for various companies for over 15 years. Mr Sucipto has developed excellent business connections with senior business leaders and large corporations in China, Philippines, Hong Kong and Indonesia (gtr2012) – Similar information in the 2018 annual report.
- **Strategic advice**: Ms Leggat has over 10 years commercial, managerial and operational experience in corporate strategy, risk management, compliance and business improvement largely focussed on the resource, finance and construction sectors (pkr2014). Ms Leggat is a corporate advisor and company director with over 15 years' experience in assisting international organisations that operate in Africa, Asia, Australia and Europe. Ms Leggat's experience covers: negotiations, mergers and acquisitions, fund raising, defining and executing business improvement strategies (gpr17 & kgd18).
- **Project management:** Luke Humphreys is a Project Manager with over 15 years-experience in guiding projects across a wide range of industries from concept through to implementation. In the role of General Manager of Winmar, Luke managed the progression of the Hamersley Iron Project into a mature exploration target (wfe16). He was at Qantas for 13 years as IT project manager & business manager, IT service. He also held other managerial roles for a period of 1–2 years until he became Exec Director of Winmar in 2011 **(**https://www.linkedin.com/in/lukeahumphreys/?originalSubdomain=au).
- **Marketing:** Ms Lacaze was Chief Executive Officer of Commander Communications, Executive Chairman of Orion Telecommunications, and Chief Executive Officer of AOL\7. Prior to that, Ms Lacaze was Managing Director of Marketing at Telstra and held various

business management roles at ICI Australia (now Orica and Incitec Pivot) (lyc2014 & lyc18). She was Marketing manager for Nestle for about 5 years, followed by business manager at Incitec covering both Agricultural Marketing Director for the Fertiliser Business (at Incitec) and Business Manager for the Specialty Chemicals Business. From 1994 to 2000 she was MD of marketing for Telstra, followed by various MD/CEO roles (https://www.linkedin.com/in/amandalacaze/?originalSubdomain=au)

- **Investor relation:** Mr Jarvis is the managing director and co-founder of Six Degrees Investor Relations (founded in 2006), an Australian advisory firm that provides investor relations and investor communication services to a wide range of resources, technology, healthcare and industrial services companies listed on the Australian Securities Exchange (agd201, enl2012, agd18). His 2020 bio from Six Degrees "*Ben co-founded Six Degrees in 2006 and he has over 22 years' consulting experience. He provides strategic investor relations and communication advice to a number of ASX-listed companies across multiple sectors. Ben was educated at the University of Adelaide, South Australia."* https://www.sdir.com.au/about-us.

Appendix D: Sample distribution by geographical location

Location	Obs	%
Western Australia	3,184	61.7
NSW	725	14.1
Victoria	476	9.2
Queensland	414	8.0
South Australia	248	4.8
Overseas	92	1.8
Northern Territory	12	0.2
Australian Capital Territory	7	0.1
Total	**5,158**	**100.0**

City	Obs	%
West Perth, Western Australia	1,452	28.2
Sydney, NSW	531	10.3
Subiaco, Western Australia	495	9.6
Perth, Western Australia	465	9.0
Melbourne, Victoria	284	5.5
Brisbane, Queensland	179	3.5
Nedlands, Western Australia	109	2.1
Adelaide, South Australia	85	1.6
South Perth, Western Australia	82	1.6
West Leederville, Western Australia	70	1.4
Balcatta, Western Australia	68	1.3
Other cities [40]	1,338	25.9
Total	**5,158**	**100.0**

[40] Other cities include the remaining cities that each makes up less than 1% of the sample

Chapter 4: Board social capital and audit outcomes

1. Introduction

While studies in Chapters 2 and 3 have clearly discussed and demonstrated the importance of MEE boards' advisory role, their monitoring role cannot be ignored. Directors are selected by shareholders to ensure appropriate oversight over the management's decisions on their behalf. In the case of MEEs, due to their small firm size, most entities do not establish subcommittees, leaving the entire board to be responsible for monitoring tasks, including those of the audit committee.

Chapter 4 aims to investigate whether board centrality, an important indicator of board social capital, facilitates or hinders the financial reporting quality and audit outcomes in small and early-stage MEEs. The motivation for this chapter is two-fold. First, while network analysis in auditing has gained significant attention of accounting researchers, the majority of research papers have investigated the networks between external auditors and directors of audit clients or between audit committee members and management. This chapter focuses on the boardroom network of audit clients. It is expected that audit clients' board centrality is associated with enhanced financial reporting quality. This is because boards of well-connected directors are more visible and have a higher reputational risk. The fear of having a tarnished reputation encourages careful oversight of the accounting process. In addition, better-connected boards are familiar with industry trends and market practices, which enable them to understand and make more accurate judgement of management decisions in relation to financial reporting. Consequently, MEEs with high quality pre-audit financial statements are expected to be less likely to receive qualified audit opinions because of less adjustments required.

However, specialist auditors may moderate the audit outcomes facilitated by high-centrality boards. This is because there is an increased likelihood that auditors of MEEs with highly-connected boards would be mentioned by well-connected directors when they engage with other directors of peer firms that are planning to appoint a new auditor, increasing the chance that the auditors would be appointed. Given the referral, auditors may reciprocate by being lenient

when issuing an audit opinion (Guan et al., 2016). However, better-connected boards are more visible to the market. Consequently, their firms would attract more market attention, which implies auditors may face more reputational and litigation risks. This is particularly the case for specialist auditors because of the higher reputational capital they need to preserve (Lim & Tan, 2008). Such reputational concerns motivate specialist auditors to uphold high audit quality and mitigate reciprocal incentives.

This chapter contributes to the literature in two main ways. First, it adds to the growing research on the relation between social networks and audit outcomes by investigating the role of clients' network centrality in facilitating the quality of pre-audit financial statements. Audit studies have applied social network analysis to examine auditors' connections in joint audits (Bianchi, 2018; Horton et al., 2014; Pittman et al., 2021), the connections between external auditors and clients' executives and directors (Guan et al., 2016; He et al., 2017), and the ties between audit committee members and management (Bruynseels & Cardinaels, 2014). This chapter investigates the connections of the clients' boards of directors, similar to the approach used by Intintoli et al. (2018) and Omer et al. (2020). The key difference between this chapter and those two papers is the context. Both Intintoli et al. (2018) and Omer et al. (2020) source director connections from BoardEx— Intintoli et al. (2018) include all connections US directors make through employment history, educational experience and professional experience, while Omer et al. (2020) focus on boardroom connections only. This chapter also investigates formal boardroom networks but within a single sector. The MEE context is an interesting setting given industry homogeneity has been found to facilitate auditors' knowledge transfer and consequently enable cost efficiencies (Bills et al., 2015; Cairney & Stewart, 2015).

In the MEE setting, there are alterative explanations for the demand for quality audit. On the one hand, there could be a lower demand for extensive audit scope and risk assessment from external auditors due to MEEs' financially constrained position and simple operating structure. Consequently, management incentives to misuse the company's resources for personal interest is

less likely (Linck et al., 2008). Further, as explained by Jensen (1986), the limited cash reserves available suggest that the equity market will act as an external monitor of MEEs each time they return to the market for additional capital. On the other hand, there may be a higher demand for quality audit due to the high information asymmetry associated with MEEs' early-stage and risky operations. This may increase the cost of verification by shareholders and investors, leading to a greater demand for external assurance of their financial statements to reduce the concerns of capital providers (Defond & Zhang, 2014).

However, MEEs' demand for auditing should not be separated from their competencies in driving audit outcomes (Defond & Zhang, 2014). This chapter finds that MEEs' competency in the form of their board centrality is positively associated with improved accounting quality, resulting in a reduced likelihood of receiving a modified audit opinion (MAO). This result suggests that boards of these firms are motivated to develop strong social capital that provides them with relevant industry and technical information to facilitate effective oversight of management's decisions about financial reporting practices.

This chapter also contributes to the literature on auditors' risk assessment. Shu (2000) and Johnstone and Bedard (2004) find that auditors are more likely to resign as clients' risks increase. In this chapter, it is documented that more conservative audit opinions are issued by specialist auditors who experience higher engagement risks resulting from their associations with more centrally-connected boards. In other words, specialist auditors perceive greater public scrutiny facing clients with high board centrality as one of their audit risks. Such reputational risks provide a stronger incentive than reciprocity for the referral by high-centrality directors, resulting in a higher likelihood for specialist auditors to issue an MAO. From the client's perspective, while a well-connected board enhances the oversight of financial reporting, there may be an unintended consequence in the form of the auditor's more conservative opinion.

2. Literature review

2.1. Financial reporting and audit outcomes

Audit clients' characteristics, such as corporate governance, internal control mechanisms, and audit committee, have been found to affect the audit process and outcomes. Beasley and Petroni (2001) argue that outside directors seek to ensure effective oversight by involving specialist auditors to provide assurance of their firms' financial statements. Their empirical findings show a higher proportion of outside directors on the board is associated with a greater likelihood that specialist auditors are appointed. Examining more comprehensive characteristics of board governance, Carcello et al. (2002) document positive associations between boards' independence, diligence and expertise, and audit fees. The authors explain that audit fees reflect more audit effort as client boards demand higher audit quality and greater assurance. Larcker and Richardson (2004) also suggest that corporate governance cannot be ignored when investigating the relation between audit fees and earnings quality. They show that the negative association between the level of audit fees and accruals is most pronounced in firms with weak governance.

Another board characteristic drawing increased attention from corporate governance researchers is gender diversity. Lai et al. (2017) find that gender diversity is positively associated with both audit fees and the likelihood of specialist auditors being appointed, which implies that boards with a higher proportion of female directors are more likely to demand higher quality audit. This is because prior literature shows female directors facilitate greater board monitoring and are more sensitive to risks, and thus have more incentives to protect their reputation. On the other hand, Nekhili et al. (2020) report a negative relation between female directors and audit fees. The authors argue, from a supply-side perspective, that stronger monitoring by female independent directors leads to lower assessed level of control risk and thus a lower demand for external auditor's assurance and lower audit fees. The authors further suggest that their contradicting findings to Lai et al. (2017) reflect different factors driving the demand for auditing services.

In terms of internal control, Naiker and Sharma (2009) show that the presence of former audit partners on the audit committee is associated with lower incidence of reported internal control deficiencies (ICDs). The result suggests that the knowledge and expertise obtained from

their professional career in assessing internal control, risks and financial reporting processes make audit partners more effective monitors of firms' internal controls, resulting in a lower likelihood of ICDs being reported. Given the importance of internal control in ensuring high quality financial reporting, Johnstone et al. (2011) document that following the disclosure of internal control material weaknesses, boards increase the number financial expert members on the audit committee.

Audit committees discharge significant responsibilities to ensure the integrity of a firm's financial statements. Carcello and Neal (2000) find that an audit committee with a higher level of non-independent members is less likely to receive a going concern opinion from the auditor, which suggests that such audit committee does not effectively support the external auditor to not succumb to management pressure when issuing their audit opinion. Similarly, Klein (2002) shows that audit committee independence is negatively associated with abnormal accruals. Another attribute of the audit committee perceived to drive audit outcomes is the presence of accounting and financial expertise. Bedard et al. (2004) and Abbott et al. (2004) demonstrate that an audit committee with at least one accounting and financial expert member is more effective in mitigating earnings management and financial restatements, respectively. In addition, the appointment of financial experts to the audit committee is viewed favourably by the market (Defond et al., 2005). Using a sample of UK firms and comprehensive proxies for audit committee effectiveness (measured by four dimensions comprising independence of committee members, financial expertise of committee members, frequency of committee meetings and the size of the audit committee), Zaman et al. (2011) find that a more effective audit committee performs more monitoring, resulting in a greater audit scope and higher audit fees.

Financial reporting quality may not only be associated with accounting expertise. Wang et al. (2015) argue that audit committee members with industry expertise can provide better oversight of accounting quality, evidenced by a decrease in earnings management. This improved oversight is achieved because industry experts possess relevant knowledge about a firm's operations and

risk exposures, which allows them to better understand and evaluate executives' decisions. Relatedly, Intintoli et al. (2018) find that the knowledge about market trends and conditions pertinent to firms' operations, which was obtained through directors' social networks, help them better monitor their firms' financial reporting.

2.2. Social networks in auditing research

Research in corporate finance and accounting has paid significant attention to the effects of social networks on corporate polices and performance. The role of social capital in driving audit outcomes is also a growing research area. To examine the connections among auditors, researchers take advantage of specific audit settings where joint audits are required, as in Italy (Bianchi, 2018), France (Horton et al., 2014), or China (Pittman et al., 2021). Horton et al. (2014) document that more connected audit partners benefit from network information and a greater sense of influence, which help strengthen their capabilities and confidence, resulting in higher audit quality and fees. Investigating a sample of Italian private companies, Bianchi (2018) shows that knowledge and expertise transfer in joint audit engagements facilitates better audit quality.

Social ties between external auditors and management or directors of their clients are often found to be detrimental to audit quality. Guan et al. (2016) show that management's connections with external auditors are likely to impair audit quality due to collusive motivation, resulting in higher chances of clients receiving favourable audit opinions and restating earnings downward in subsequent periods. External auditors' social ties with audit committee members also have adverse impacts on audit quality. He et al. (2017) discuss that sharing common connections make auditors more reluctant to challenge clients' audit committees. The fear of damaging their social connections make them less sceptical when assessing internal controls, which more than offsets the potential benefits derived from mutual understanding and ease of communication. Bruynseels and Cardinaels (2014) investigate the relations between members of an audit committee and CEO formed through "advice networks" (relating to professional and educational ties) and "friendship networks" (resulting from non-professional activities, such as shared memberships in clubs,

charities or other non-profit associations). Their findings suggest that social ties through "friendship networks" have adverse impacts on audit committee's oversight, evidenced by an increased likelihood of earnings management. However, if the connections are formed through "advice networks", negative consequences are not evident.

With respect to external connections with other directors, both Intintoli et al. (2018) and Omer et al. (2020) find that more connected audit committee members facilitate better monitoring of financial reporting processes as they are more aware of relevant market and industry trends, which enable them to evaluate information related to management decisions.

3. Hypotheses development

3.1. Board centrality and audit outcomes

It is anticipated that well-connected boards help improve the quality of MEEs' pre-audit financial statements. The focus is at the board level, rather than the audit committee level, as the small size of MEE boards results in either: (i) in the same directors serving as board members and audit committee members; or (ii) the absence of an audit committee, leaving the oversight of financial statements to the board.

There are two main reasons that boardroom connections are expected to have positive impacts on MEEs' accounting quality. First, Kandori (1992) suggests that community enforcement mechanisms facilitate cooperation and honesty as misbehaviour against one agent results in sanctions imposed by others. Such punishments are more severe for well-connected directors because of their more reputable and prestigious positions. Consequently, high-centrality directors are motivated to sustain their good reputation. Further, these directors serve on other MEE boards, which *"are in perpetual capital-raising mode"* (Featherstone, 2010). Being involved in various fundraising projects and a participant in the networks of mining investors, who could have provided and/or are currently providing capital to their focal firms, these directors exhibit a strong commitment to reciprocity. Reputation and reciprocity are important attributes of social networks

(Larson, 1992), which strongly motivate directors to uphold their business reputation and act in good faith in return for investors' trust and financial support. Therefore, well-connected directors have reputational and reciprocal incentives to ensure effective monitoring of MEEs' internal control and financial reporting processes.

Further, as suggested by Intintoli et al. (2018), high-centrality boards have access to current market conditions and trends which affect the likelihood of exploration and evaluation (E&E) expenditure to be recouped. It is noteworthy that MEEs' key operating activities are E&E (Bui et al., 2021). The decision to either expense or capitalise such expenditure is subject to management's judgement. The majority of MEEs capitalise their expenditure provided that the accounting choice is consistent with requirements under *AASB 6 Exploration for and Evaluation of Mineral Resources*. As discussed in Chapter 2, macroeconomic and industry conditions have significant impacts on MEEs' operations and consequently management decisions to capitalise their current expenditure and/or write down previously capitalised amount. Therefore, having up-to-date knowledge about market conditions, trends and cycles will enable well-connected directors to understand and make more accurate judgement of management decisions in relation to the capitalised E&E amount and to challenge such decisions if necessary.

According to Defond and Zhang (2014) and Aobdia (2019), audit outcomes are highly dependent on firms' financial reporting quality. That is, higher quality pre-audit financial statements are subject to less adjustments required by auditors, resulting in a lower tendency of issuing a modified audit opinion (MAO). In contrast, entities with lower accounting quality face a greater likelihood of receiving an MAO. Chen et al., (2001) find that opportunistic choices of accounting method to meet the Chinese regulatory requirements lead to a higher frequency of MAOs being issued. In sum, the enhanced quality of pre-audit financial statements facilitated by high board centrality is expected to result in a lower likelihood that auditors would issue an MAO. Therefore, Hypothesis 1 is proposed as follows:

H1: *There is a positive association between MEEs' board centrality and audit outcome.*

3.2. Moderating effect of auditor specialisation

Auditors of MEEs with highly-connected directors have a greater likelihood of being referred by connected directors who serve on another MEE board. Prior studies show that directors use their connections to access relevant information to make them more effective monitors of accounting quality (Intintoli et al., 2018), to reduce costs of financing (Chuluun et al., 2014; Luong et al., 2021), and to advise their firms on R&D and acquisition decisions (Brown et al., 2019). Another board function that benefits from network information is the appointment of a statutory auditor. Johansen and Pettersson (2013) argue that board networks provide directors with information about an auditor's work and reporting quality when they have had experience working with that auditor at other firms. Through direct interactions with the auditor, high-centrality directors are more likely to draw on this experience when selecting an auditor for the focal firm. Consequently, the auditor's client portfolio expands, resulting in greater market share and specialisation. The referral may encourage the auditor's reciprocity, a norm inherent in a social network, that could lead to more favourable audit opinion (Guan et al., 2016).

In contrast, the more connected an MEE board is, the more market scrutiny the firm will attract. As such, auditors of MEEs with better-connected boards face greater reputation risk (Defond et al., 2016). Consequently, these auditors have stronger incentives to maintain high audit quality and manage the associated risk by carrying out more extensive audit work.

While auditors may exhibit reciprocal and/or reputational incentives when engaging with well-connected MEE boards, from the specialist auditors' perspective, their reputation of providing quality audit is more important than reciprocity because of the greater investment in building such reputational capital (Reynolds & Francis, 2001; Defond et al., 2002; Lim & Tan, 2008). Thus, it is posited that specialist auditors would issue more conservative opinions when their clients have stronger board social capital. In other words, the proposed association between board centrality and audit outcomes under H1 could be moderated by the presence of audit

specialisation. This potential unintended consequence of board social capital is proposed under Hypothesis 2 as follows:

H2: *Auditor specialisation moderates the association between clients' board centrality and audit outcomes.*

4. Research design

4.1. Empirical models and variables

The following models are estimated to test Hypotheses 1 and 2, with unique firms denoted by *i* and years by *t*. Models include year fixed-effects ($\boldsymbol{\varphi}$) and firm fixed-effects ($\boldsymbol{\omega}$) to account for yearly economy-wide factors and mitigate endogeneity. Appendix A provides the variable definitions.

Model for H1:

$$\begin{aligned} MAO_{i,t} = {} & \theta_0 + \theta_1 Q5\_Centrality\_Board_{i,t} + \theta_2 Q5\_Centrality\_MD_{i,t} + \theta_3 Specialist\_MS_{i,t} \\ & + \theta_4 LTA_{i,t} + \theta_5 ROA_{i,t} + \theta_6 Liquidity_{i,t} + \theta_7 Big4_{i,t} + \theta_8 Ln\_Cash_{i,t} \\ & + \theta_9 Board\_Size_{i,t} + \theta_{10} Indep\_Ned_{i,t} + \theta_{11} Accounting\_expertise\_board_{i,t} \\ & + \theta_{12} EE\_wo_{i,t} + \theta_{13} EE\_Comb_{i,t} + \boldsymbol{\varphi} + \boldsymbol{\omega} + \epsilon_{i,t} \quad (1) \end{aligned}$$

Model for H2:

$$\begin{aligned} MAO_{i,t} = {} & \theta_0 + \theta_1 Top\_Centrality\_Board_{i,t} \times Specialist\_MS_{i,t} \\ & + \theta_2 Top\_Centrality\_Board_{i,t} + \theta_3 Specialist\_MS_{i,t} \\ & + \theta_4 Q5\_Centrality\_MD_{i,t} + \theta_5 LTA_{i,t} + \theta_6 ROA_{i,t} + \theta_7 Liquidity_{i,t} + \theta_8 Big4_{i,t} \\ & + \theta_9 Ln\_Cash_{i,t} + \theta_{10} Board\_Size_{i,t} + \theta_{11} Indep\_Ned_{i,t} \\ & + \theta_{12} Accounting\_expertise\_board_{i,t} + \theta_{13} EE\_wo_{i,t} + \theta_{14} EE\_Comb_{i,t} + \boldsymbol{\varphi} \\ & + \boldsymbol{\omega} + \epsilon_{i,t} \quad (2) \end{aligned}$$

The dependent variable for Models (1) and (2) is MAO_t, which is an indicator variable coded 1 if an MEE receives a modified audit opinion, including unqualified opinions with emphasis of

matter, qualified opinion, disclaimer, or adverse opinion for the current year *t*, and 0 otherwise. The choice of MAO as a proxy for audit outcomes that are driven by MEEs' financial reporting quality is consistent with the discussions and findings in Chen et al. (2001), Defond and Zhang (2014) and Aobdia (2019).

The key explanatory variable for Model (1), *Q5_Centrality_Board,* measures board social capital. Specifically, this proxy is the quintile rank of the average factor score of degree, betweenness, closeness, and eigenvector centrality of all individual members serving on the board excluding the managing director (MD). In Model (2), the variable of interest is the interaction term between board centrality and the specialist auditor (*Top_Centrality_Board* × *Specialist_MS),* with *Top_Centrality_Board* being an indicator variable coded 1 if $Q5\_Centrality\_Board_t$ is ranked in the top quintile of the composite centrality measure, and 0 otherwise. *Specialist_MS* is a dichotomous variable indicating if an auditor has the largest market share in the capitalising MEE sector, consistent with the specialist definition used by Lim and Tan (2008), Srinidhi et al. (2014) and Chang et al. (2021). Market share is measured as the proportion of the number of clients audited by an audit firm out of the total number of clients in the capitalising MEE sector.

This chapter captures MDs' centrality separately given the potentially different incentives arising from their executive position. Consistent with prior literature, both models control for MEE characteristics, including firm size (*LTA),* accounting performance and profitability (*ROA),* liquidity position (*Liquidity),* and cash holding (*Ln_Cash*). In addition, the models include board characteristics, comprising board size (*Board_Size)*, the proportion of the board with independent directors (*Indep_Ned),* and the proportion of directors with accounting expertise (*Accounting_expertise_board)*. Further, the combined value of current year E&E asset additions and acquisitions (*EE_Comb),* and the amount of previously capitalised E&E expenditure that is impaired or written off (*EE_wo)* during the current period, are considered. This is because the E&E asset is the most important asset account on MEEs' balance sheet, the accounting treatment

of which requires a significant level of management judgement. According to the guidance of the Chartered Accountants Australia and New Zealand on key audit matters (KAMs), auditors need to assess whether the accounting policy for E&E expenditures is appropriate, particularly for those in the exploration phase and that:

> *"In determining whether an exploration and evaluation asset should be recognised or not there are some considerations to be made […] As exploration and evaluation expenditures are often made in the hope (rather than the expectation) that there will be future economic benefits, it is difficult for an entity to demonstrate that the recovery of exploration and evaluation expenditures is probable"* (Chartered Accountants Australia and New Zealand 2015, p.15).

4.2. Sample and descriptive statistics

The initial sample consists of 8,887 firm-year observations of all metal and mining firms from 2004 and 2018. The sampling procedure then excludes: (i) mining firms with operating revenue greater than $1 million (as they are less likely to be in the early-stage exploration phase (Bui et al., 2021)), (ii) service providers, (iii) observations with missing market capitalisation, financial and/or governance data, and (iv) firms recognising E&E expenditure as expense.[41] The final sample includes 5,913 firm-year observations for testing H1 and H2.

Table 1 presents descriptive statistics for the dependent variable, key explanatory variable, and control variables used to test the relation between board centrality and audit outcome. For comparison, the left-hand panel of Table 1 reports statistics for capitalising MEEs while the right-hand panel for non-MEEs which are typically larger producers (based on the $1 million revenue threshold discussed above) or those provide mining services. The table shows no statistically

[41] Less than 10% of the original sample are expensers. Due to different incentives underlying the accounting choice for recording E&E expenditure, this chapter excludes all expensers and focuses on capitalisers only.

significant difference between MEEs and non-MEEs in relation to auditors' tendency to issue an MAO (11% for capitalising MEEs and 10% for non-MEEs). This implies there is no evidence of a material difference in audit outcome between these two types of firms. However, only 25% of the MEE sample are audited by Big 4 auditors, on average, as opposed to 52% of the non-MEE sample. With respect to audit fees, the median (mean) annual audit fees paid by MEEs is $33,000 ($40,000), which is consistent with the fees paid to auditors reported by Ferguson et al. (2014). In terms of non-audit service fees, MEEs paid on average $9,000. In contrast, non-MEEs paid a significantly higher amount of audit fees and non-audit fees to their auditors, with a median (mean) of $116,000 ($628,000) and $20,000 ($275,000), respectively.

[Insert Table 1 here]

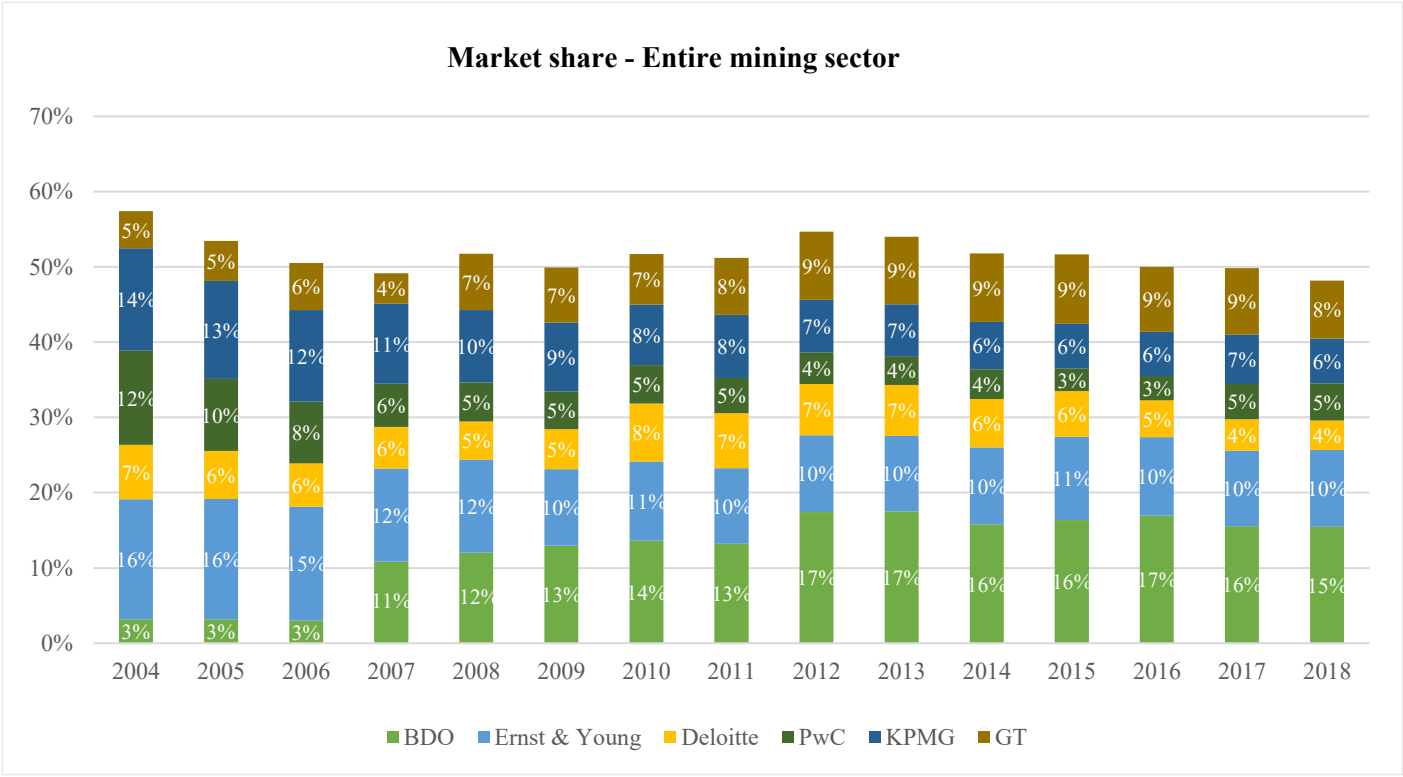
The considerable differences in choosing Big 4 auditors and audit and non-audit fees between MEEs and non-MEEs reflect the differences in firm size, financial position and performance. Table 1 shows that MEEs are smaller in firm size with a median (mean) total assets of $10.2 million ($25.7 million) in contrast to $161.4 million ($3.2 billion) for non-MEEs. MEEs are typically loss-making with a median (mean) ROA of −16% (−53%) and cash-constrained given their lower level of cash balance. These distinguished attributes also drive the differences in governance characteristics. Specifically, MEEs have a smaller board of four members instead of five reported for non-MEEs. MEE boards are made up of 35% independent non-executive directors as opposed to 41% for non-MEEs, on average. The only board feature that seems to exhibit no significant difference is the proportion of the board having accounting expertise, with both types of firms reporting 13% on average.

Table 2 presents the market share information of the top 10 audit firms in the entire mining sector and for the sample of capitalising MEEs only. Based on the average market share, calculated as the proportion of the number of clients audited by an audit firm out of the total number of audit clients in the mining sector, BDO, Ernst & Young and KPMG have the largest market share of

15.0%, 11.6% and 8.7%, respectively. Focusing on the MEEs sector, there is a bigger gap between BDO (16.5%) and Ernst & Young (9.7%). The third largest market share is captured by another non-Big 4 auditor, Grant Thornton (GT) (9.3%).

[Insert Table 2 here]

Figure 1 depicts temporal changes to market share of the six leading auditors over the sample period 2004–2018 for the entire mining sector and the capitalising MEEs sample. Figure 1 clearly shows that the two non-Big 4 firms experienced considerable increases in their market share, particularly BDO, with a significant jump in 2007, which resulted in the sharp decrease in the market share of KPMG and PwC. Ernst & Young's market share also followed a downward trend but with a lesser magnitude between 2004 and 2018.



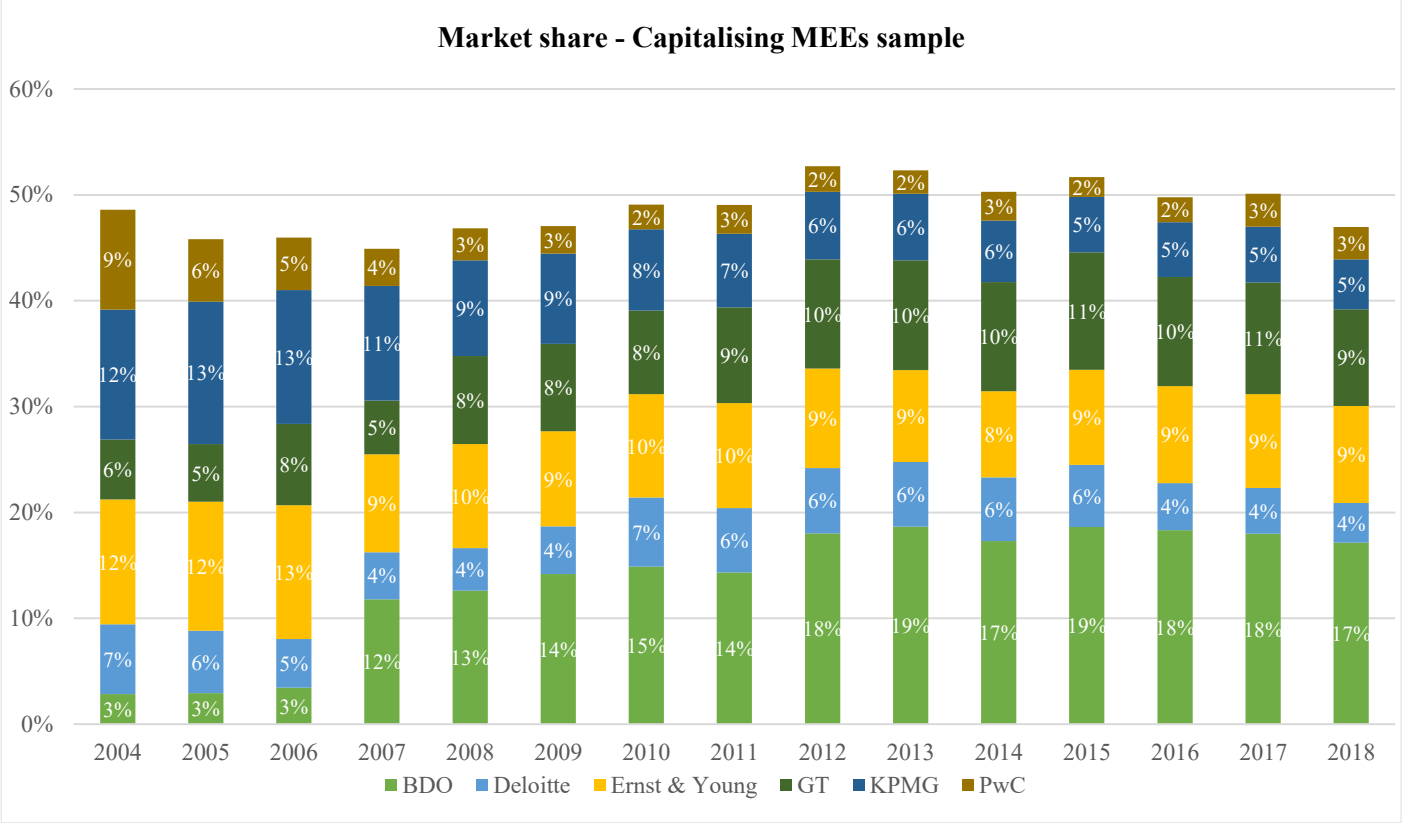


Figure 1: Market share between 2004 and 2018

Table 3 reports leading audit partners' market share. The three audit partners with the greatest number of clients, based on both samples of all mining firms and capitalising MEEs, are John Peter van Dieren (Stantons International), Vern Tidy (Ernst & Young), and Peter James Toll (Horwath, which merged with BDO in 2007).

[Insert Table 3 here]

Table 4, Panel A and Figure 2 report the name of the specialist auditor (determined as the leader in terms of client market share) by year. Big 4 auditors were the leading audit firms for the entire mining sector and for the MEE sample up to 2008 and 2006, respectively, until BDO took over the leadership.

[Insert Table 4 here]

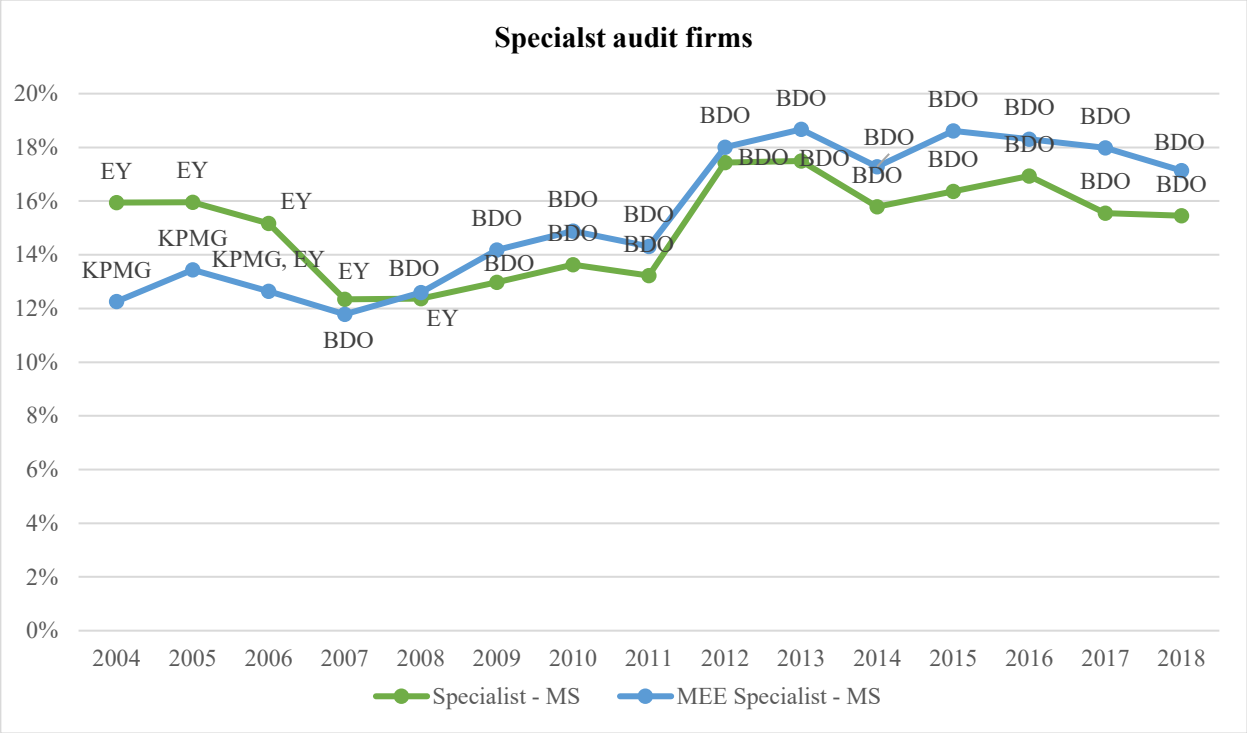


Figure 2: Specialist audit firms between 2004 and 2018.

Table 4, Panel B and Figure 3 report information on mining specialist audit partners. Until 2012, John Peter van Dieren (Stantons International) had the greatest number of clients in the mining sector, except for 2008 when he tied with Vern Tidy (Ernst & Young). As for the MEE sample, Mr. van Dieren was also the lead specialist up until 2011, except for 2008. From 2013 onwards, partners from Stantons International (Martin Michalik and Samir Tirodkar) continued to dominate the leadership, except for 2015 when Phillip William Murdoch (BDO) took over the leadership for that year and financial years 2017 and 2018 when Danny Buckley (HLB Mann Judd) shared the leadership with Martin Michalik.

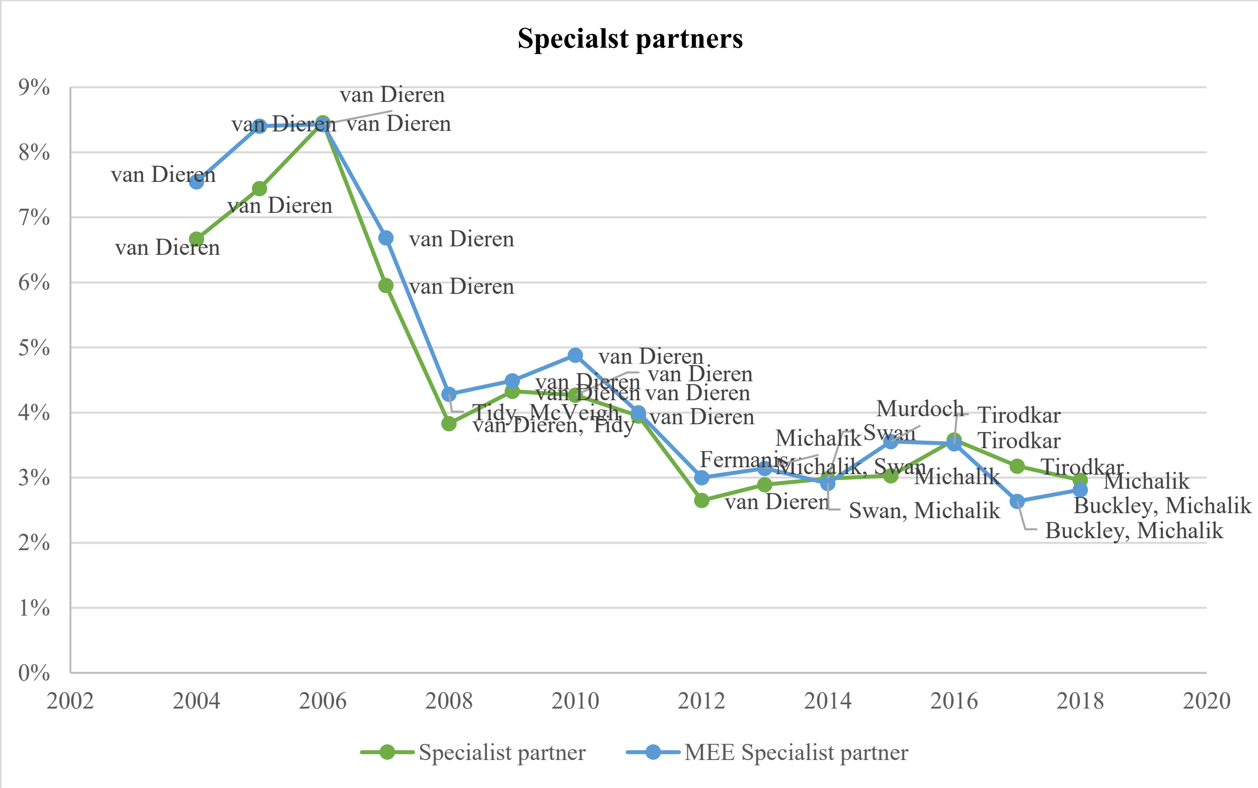


Figure 3: Specialist audit partner between 2004 and 2018.

Table 5 reports the Pearson's correlation matrix for all variables used for testing H1 and H2. As Table 5 shows, board centrality is negatively correlated with modified audit opinion ($r = -0.0370$, $p < 0.01$), which supports H1. There is also evidence that specialist auditors are more likely to issue MAOs ($r = 0.0261$, $p < 0.05$). Similar trends can be observed when the auditor is one of the Big 4 firms. However, specialist partners do not appear to be significantly correlated with audit opinion. In terms of MEEs' key assets, the value of E&E impairment and combined E&E additions and acquisitions is found to be positively ($r = 0.0296$, $p < 0.05$) and negatively ($r = -0.0437$, $p < 0.01$) correlated, respectively, with the likelihood of MEEs receiving an MAO. Finally, the presence of accounting-expert directors on the board is not significantly correlated with audit outcomes.

[Insert Table 5 here]

5. Main results

5.1. Board centrality and audit outcomes

Tables 6 and 7 present logit regression results for testing H1 before and after controlling for auditor specialisation, respectively. A proxy for audit outcomes, MAO_t, is regressed on board centrality and the control variables. Table 6 presents three sets of results (estimated coefficients and odds ratios) of the logit regression: (i) without any fixed-effects (Columns 1 and 2), (ii) with year fixed-effects (Columns 3 and 4), and (iii) with both firm and year fixed-effects (Columns 5 and 6). Overall, the results across the columns consistently show that MEE boards with higher centrality are less likely to receive an MAO (coefficient = –0.1581, $p < 0.01$ in Column (1); coefficient = –0.1644, $p < 0.01$ in Column (3); coefficient = –0.1788, $p < 0.01$ in Column (5)). These results support H1 which predicts that high-centrality boards have greater reputational incentives and are more informed of relevant industry information to monitor the financial reporting processes and ensure high reporting quality, resulting in a lower likelihood of receiving a modified audit opinion. The odds ratio of 0.8363 reported in Column (6) suggests that an increase in the quintile rank of board centrality by one is associated with 16.37% lower probability of MEEs receiving an MAO.

[Insert Table 6 here]

In addition, the insignificant coefficient estimated for *Accounting_expertise_board* in Table 6 suggests that boards with accounting expertise do not appear to reduce the likelihood of MEEs receiving an MAO. This may imply that accounting expertise has less relevance in a setting where the financial statements are relatively simple, with E&E assets being the most important asset account. The results also show that the amount of E&E assets is negatively associated with the likelihood of receiving an MAO (coefficient = –0.0401, $p < 0.05$ in Column (3); coefficient = –0.0351, $p < 0.05$ in Column (5)). These findings suggest that while managerial judgement is required to determine if E&E expenditures are eligible to be deferred/capitalised under AASB 6, such judgement seems justifiable, leading to a 5% reduction in the likelihood of receiving an MAO

as inferred from Column (6). On the other hand, there is some evidence in Columns (5) and (6) that the E&E impairment amount prompts the auditor to issue an MAO (coefficient = 0.0184, $p <$ 0.1 in Column (5)).

When audit firms' specialisation is taken into consideration, findings in Table 7 continue to provide strong support for the positive impacts of board centrality on audit outcomes. Nevertheless, auditor specialisation (as determined by market share) does not seem to have a significant association with audit opinion.

[Insert Table 7 here]

In summary, Tables 6 and 7 provide significant evidence of the positive relation between boards' social capital and financial reporting quality as reflected in audit outcomes, which is consistent with findings documented in Intintoli et al. (2018).

5.2. Moderating effect of auditor specialisation

Table 8 examines whether specialist auditors moderate the significant association between board centrality and audit opinion. Results from Columns (1)−(3) show evidence of the moderating effect given the positive and significant interaction terms, $Top\_Centrality\_Board_t \times Specialist\_MS_t$ (coefficient = 1.1000, $p < 0.01$ in Column (1); coefficient = 1.1727, $p < 0.01$ in Column (2); coefficient = 1.2203, $p < 0.05$ in Column (3)), thus lending support for H2. It is inferred that while firms with high-centrality boards are less likely to receive an MAO, their greater public exposure is perceived to increase specialist auditors' reputational risk, which results in a more conservative audit opinion.

[Insert Table 8 here]

These results can be reconciled with findings in Lim and Tan (2008) who examine specialist auditors' reputational incentives when being engaged by audit clients to perform non-

audit services. The authors argue that the concerns of reputational loss due to failure to remain independent and provide quality audit services give specialist auditors sufficient motivation to mitigate monetary incentives arising from the provision of non-audit services. In sum, there is consistent evidence that specialist auditors are motivated to preserve their reputation in providing quality audit, demonstrated by an increased probability of issuing an MAO.

6. Additional tests

6.1. Specialist audit partners

This section further investigates industry specialisation at the audit partner level. *Specialist_partner*$_t$ is included in model (1) to replace auditor specialist, *Specialist_MS*$_t$. A specialist partner is defined as an audit partner who is the market leader based on their share of MEE clients. Results in Table 9 show no evidence to suggest that specialist partners are more likely to issue an MAO than non-specialist partners (coefficient = 0.3483, $p > 0.1$ in Column (1); coefficient = 0.3555, $p > 0.1$ in Column (2); coefficient = 0.4567, $p > 0.1$ in Column (3)). However, the positive impact of board centrality in reducing MEEs' probability of receiving an MAO continues to be evident. Untabulated findings also reveal no systematic difference between partners who work for Big 4 firms versus non-Big 4 firms. Overall, it can be inferred that in the MEE setting, the role of specialist audit partners in driving audit outcomes is not evident.

[Insert Table 9 here]

6.2. Robustness tests

This section performs robustness tests of the main findings presented in Section 5.

6.2.1. Endogeneity concerns

To address endogeneity concerns which may arise due to omission of variables or self-selection, this chapter follows Hauser (2018) and uses M&As as an exogenous shock to board centrality. This quasi-natural experiment provides a joint test of changes to board busyness and board social capital (resulting from the loss of external board seats). If, a treated firm's board member (treated director) who loses their external board seat due to an acquisition (thus becomes

less busy) can spend more time monitoring the treated firm's financial reporting procedures, better accounting quality may be realised. However, if the loss of connections makes the treated director less informed of industry practices and trends, which could hinder effective oversight of accounting practices, the treated firm's auditor may be more likely to issue an MAO.

Table 10 reports results comparing the audit outcomes of treated firms whose directors lost their external board seats following successful M&As and those firms which do not have directors losing external board seats (control firms). Column (1) presents the results with *Treated* representing the number of cases in which a firm has a director whose role was terminated at a target firm, while Column (2) separately investigates if such treated director is the MD (*Treated_MD*) or other board member (*Treated_Board*). Results from Columns (1) and (2) find no differences between treated and control firms in terms of the likelihood of receiving an MAO. The insignificant findings imply no overwhelming evidence of an adverse impact of busyness which may be associated with high-centrality directors such that it could offset the benefits of gaining industry information and conditions through boardroom connections. An alternative interpretation is that while treated directors lost connections with target firms' boards, they aim to sustain their established reputation of being effective monitors. Therefore, no negative impacts on their oversight are observed following the M&A shocks.

[Insert Table 10 here]

Table 11 further examines the potential consequences borne by treated firms whose board members (excluding the MD) lost their directorships at target firms. The coefficient of *Q5_Centraity_Target* in Column (1) is significantly positive (coefficient = 1.0481, $p < 0.1$), which indicates that treated firms whose boards lost the connections with the most connected targets' boards (board centrality ranked in the top quintile) experience an increased likelihood of receiving an MAO. This could be attributable to the loss of industry information and trends necessary to facilitate effective monitoring of accounting quality. Taken together, findings in Table 10 and Table 11 provide some evidence of the positive impact of board centrality and no evidence that

the adverse impact of board busyness outweighs the benefits of board social capital in affecting audit outcomes.

[Insert Table 11 here]

6.2.2. Alternative measure and additional tests

Models 1 and 2 use the natural logarithm of total assets to control for firm size. According to Ferguson et al. (2014), market capitalisation reflects not only firm size but also MEEs' life cycle stages. Therefore, to check the robustness of the main results, these models are re-estimated using market capitalisation as an alternative proxy for firm size. Very similar results (untabulated) are documented for both H1 and H2 when market capitalisation is used.

MAO may not be a perfect proxy for financial reporting quality. A more direct measure would be a residual from the estimation of discretionary accruals by Dechow and Dechev (2002), which have been commonly used by prior studies, such as Intintoli et al. (2018) and Brown et al. (2019). The idea is to detect large estimation errors in accruals which may indicate intentional earnings management. However, for MEEs that are in their early development phase, they have yet reached the stage to generate earnings and their operating cash flow is predominantly outflows. As a result, the correlations between earnings and accruals, and between accruals and cash flow are almost non-existent in this setting. Technical calculations aside, from MEEs' management perspective, given the non-revenue generating status, their motivation to manipulate earnings through accruals is limited. This explains why abnormal accruals are not chosen and only MAO is used to proxy for MEEs' financial reporting quality.

The interpretation of a lower likelihood of MAOs being issued can be tricky. On the one hand, it may indicate better quality accounting. On the other hand, it may suggest auditors' independence is compromised (Guan et al., 2016). However, as discussed under section 3.2 and demonstrated in the findings presented in Table 8, because of reputational concerns resulting from the association with highly-connected boards, specialist auditors are more likely to issue an MAO.

This is consistent with prior audit literature citing market-based incentives as the motivation for auditors to maintain their reputation of being independent from their clients.

To further demonstrate that the documented findings reflect improved financial reporting quality instead of independence concerns, an additional robustness test is performed. Specifically, if auditors' independence is adversely impacted due to their financial dependence on the client firms through, for example, delivering non-audit services (NAS) (Frankel et al., 2002; Gaynor et al., 2006), a negative association between MAO and NAS fees paid to the auditors is expected. NAS is measured two ways: (1) the natural logarithm of fees paid for NAS, and (2) the ratio of NAS fees to audit fees.

The findings are presented in Tables 12 and 13. Both tables show no evidence of a negative link between non-audit fees and a lower likelihood of receiving an MAO, which is consistent with the empirical findings by Defond et al. (2002). The authors suggest that the insignificant impact of non-audit service fees on audit opinion reflects the auditor's incentives to protect their reputation and avoid litigation.

[Insert Table 12 here]

[Insert Table 13 here]

Lastly, if the concern is about high-centrality directors being too busy because of their many boardroom connections to appropriately monitor the financial reporting process, which overweighs the benefit of gaining industry knowledge to challenge management decisions, this will be most evident for the busiest boards. However, as Table 14 shows, the interaction term between $Q5\_Centrality\_Board_t$ and $Busy_t$ (an indicator variable coded 1 if the percentage of directors on the board holding two or more board seats other than the current board is in the top quintile) is not statistically significant, suggesting no evidence that the negative effect of director busyness is so severe that it cancels out the benefits of director social capital in affecting audit

outcomes. These findings are consistent with those in Tables 10 and 11 above which fail to document overwhelming evidence of the adverse impact of director busyness when employing M&As as an exogeneous shock.

[Insert Table 14 here]

7. Conclusion

In conclusion, this chapter finds that highly-connected MEE boards, with access to relevant industry and technical knowledge, have strong reputational and reciprocal incentives to monitor the financial reporting quality of their firms, leading to a lower likelihood of receiving a modified audit opinion. However, their greater social capital and visibility also indirectly expose specialist auditors to higher reputational risk, rendering the auditors more conservative as evidenced by a higher probability of issuing an MAO. This chapter also documents some evidence suggesting the capitalisation and impairment of exploration assets are considered by auditors when issuing an audit opinion.

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Chapter 4 Tables

Table 1: Descriptive statistics

	Capitalising MEEs					*Non-MEEs*					
Variables	**Obs**	**Min**	**Mean**	**Median**	**Max**	**Obs**	**Min**	**Mean**	**Median**	**Max**	***T-test***
Audit statistics											
MAO	5,913	0.00	0.11	0.00	1.00	1,752	0.00	0.10	0.00	1.00	–1.0351
Big4	5,913	0.00	0.25	0.00	1.00	1,752	0.00	0.52	1.00	1.00	22.2009***
Audit_fees ($000)	5,875	0.00	40.11	33.00	182.25	1,578	0.00	627.92	115.99	41,969.15	18.0568***
Other_fees ($000)	5,881	0.00	8.99	0.00	137.67	1,578	0.00	274.61	20.24	25,574.31	14.7364***
Firm and board characteristics											
Total_asset ($000)	5,913	155.72	25,698.89	10,213.78	357,184.90	1,602	733.26	3,157,287.00	161,408.60	161,000,000.00	16.2477***
LTA	5,913	11.96	16.15	16.14	19.69	1,602	13.51	18.98	18.90	25.80	64.3364***
ROA	5,913	-10.42	-0.53	-0.16	0.21	1,590	-4.40	-0.14	0.01	1.22	11.1725***
Liquidity	5,913	0.02	10.95	5.11	100.55	1,510	0.01	2.89	1.69	50.58	18.6868***
Ln_Cash	5,913	8.48	14.24	14.41	18.20	1,510	8.48	16.49	16.54	23.31	41.1979***
EE_wo_t	5,913	0.00	7.71	11.00	16.83	1,434	0.00	6.19	0.00	18.30	–7.6769***
EE_Comb_t	5,913	0.00	12.37	14.06	17.27	1,435	0.00	10.81	14.40	19.28	–9.7781***
Board_Size	5,913	2.00	3.97	4.00	7.00	1,752	1.00	5.30	5.00	15.00	35.7505***
Indep_Ned	5,913	0.00	0.35	0.33	1.00	1,752	0.00	0.41	0.44	1.00	8.5451***
Accounting_expertise_board	5,913	0.00	0.13	0.00	0.67	1,752	0.00	0.13	0.13	0.67	–0.5590
Q5_Centrality_Board	5,913	1.00	3.00	3.00	5.00	1,752	1.00	2.97	3.00	5.00	
Q5_Centrality_MD	5,913	1.00	2.88	3.00	5.00	1,752	1.00	2.94	3.00	5.00	

This table compares audit, firm and board governance statistics between capitalising MEEs and non-MEEs for the period 2004–2018. *MAO* is an indicator variable coded 1 if firms receive modified audit opinions including unqualified opinions with emphasis of matter, qualified opinions, disclaimers or adverse opinions, and 0 otherwise. *Big4* is an indicator variable coded 1 if statutory auditors are one of the Big4 auditors, and 0 otherwise. *Audit_fees ($000)* and *Other_fees ($000)* are the value in thousands of audit fees and non-audit service fees, respectively. *Total_assets ($000)* and *LTA* are the value in thousands and the natural logarithm of total assets, respectively. *ROA* is return on assets measured as earnings before interest and tax divided by total assets. *Liquidity* is the ratio of current assets to current liabilities. *Ln_Cash* is the natural logarithm of the amount of cash balance. *EE_wo* and *EE_Comb* are the natural logarithm of the amount of exploration and evaluation (E&E) assets written off or impaired, and combined E&E asset additions and acquisitions, respectively. *Board_Size* is the number of directors sitting on the board. *Indep_Ned* is the percentage of independent non-executive directors on the board. *Accounting_expertise_board* is the proportion of board members excluding the MDs who possess expertise in accounting. *Q5_Centrality_Board* and *Q5_Centrality_MD* are the quintile rank of the average factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 2: Top 10 auditors by market share

Entire mining industry			Capitalising MEEs		
Auditors	**Average client numbers**	**Average market share (%)**	**Auditors**	**Average client numbers**	**Average market share (%)**
BDO	95	15.0	BDO	75	16.5
Ernst & Young	64	11.6	Ernst & Young	39	9.7
KPMG	47	8.7	Grant Thornton	42	9.3
HLB Mann Judd	51	8.0	HLB Mann Judd	40	9.0
Grant Thornton	50	7.9	KPMG	31	8.2
Stantons International	36	6.3	Stantons International	26	6.4
Deloitte	37	6.2	PKF	22	5.9
PricewaterhouseCoopers	30	6.0	Deloitte	24	5.5
PKF	27	5.0	RSM Australia Partners	21	5.1
RSM Australia Partners	26	4.5	Bentleys	18	4.0

Table 3: Top 10 audit partners by market share

	Entire mining industry			Capitalising MEEs	
Audit partners	**Average client numbers**	**Average market share (%)**	**Audit partners**	**Average client numbers**	**Average market share (%)**
John Peter van Dieren	25	5.17	John Peter van Dieren	18	5.44
Vern Tidy	18	4.29	Vern Tidy	12	4.20
Peter James Toll	16	2.69	Peter James Toll	13	2.88
Samir Tirodkar	16	2.55	Bradley Graham McVeigh	12	2.82
Martin Michalik	16	2.53	Christopher Walter Watts	12	2.79
Bradley Graham McVeigh	14	2.33	Martin Michalik	13	2.78
Jarrad Prue	12	2.18	Phillip William Murdoch	11	2.44
Phillip William Murdoch	14	2.15	Samir Tirodkar	11	2.40
Graham Rothesay Swan	13	2.15	Norman Gary Neill	10	2.38
Christopher Richard Burton	14	2.06	Christopher Richard Burton	12	2.33

Table 4: Audit specialists by year

Panel A: Audit firm specialisation

	Specialist – Entire mining industry			Specialist – Capitalising MEEs		
Year	**Client numbers**	**Market share (%)**	**Auditors**	**Client numbers**	**Market share (%)**	**Auditors**
2004	55	16	EY	26	12	KPMG
2005	60	16	EY	32	13	KPMG
2006	61	15	EY	33	13	KPMG, EY
2007	58	12	EY	37	12	BDO
2008	71	12	EY	50	13	BDO
2009	78	13	BDO	60	14	BDO
2010	83	14	BDO	64	15	BDO
2011	87	13	BDO	68	14	BDO
2012	125	17	BDO	96	18	BDO
2013	127	17	BDO	101	19	BDO
2014	111	16	BDO	89	17	BDO
2015	108	16	BDO	89	19	BDO
2016	104	17	BDO	78	18	BDO
2017	93	16	BDO	75	18	BDO
2018	94	15	BDO	73	17	BDO

Panel B: Audit partner specialisation

	Entire mining industry			
Years	**Client numbers**	**Market share (%)**	**Partner**	**Audit firms**
2004	23	7	John Peter van Dieren	Stantons International
2005	28	7	John Peter van Dieren	Stantons International
2006	34	8	John Peter van Dieren	Stantons International
2007	28	6	John Peter van Dieren	Stantons International
2008	22	4	John Peter van Dieren, Vern Tidy	Stantons International, Ernst & Young

2009	26	4	John Peter van Dieren	Stantons International
2010	26	4	John Peter van Dieren	Stantons International
2011	26	4	John Peter van Dieren	Stantons International
2012	19	3	John Peter van Dieren	Stantons International
2013	21	3	Martin Michalik, Graham Rothesay Swan	Stantons International, Rothsay Chartered Accountants
2014	21	3	Graham Rothesay Swan	Rothsay Chartered Accountants
2015	20	3	Martin Michalik	Stantons International
2016	22	4	Samir Tirodkar	Stantons International
2017	19	3	Samir Tirodkar	Stantons International
2018	18	3	Martin Michalik	Stantons International
Capitalising MEEs				
2004	16	8	John Peter van Dieren	Stantons International
2005	20	8	John Peter van Dieren	Stantons International
2006	22	8	John Peter van Dieren	Stantons International
2007	21	7	John Peter van Dieren	Stantons International
2008	17	4	Vern Tidy, Bradley Graham McVeigh	Ernst & Young, BDO
2009	19	4	John Peter van Dieren	Stantons International
2010	21	5	John Peter van Dieren	Stantons International
2011	19	4	John Peter van Dieren	Stantons International
2012	16	3	Simon Spero Fermanis	PKF
2013	17	3	Martin Michalik	Stantons International
2014	15	3	Graham Rothesay Swan, Martin Michalik	Rothsay Chartered Accountants, Stantons International
2015	17	4	Phillip William Murdoch	BDO
2016	15	4	Samir Tirodkar	Stantons International
2017	11	3	Danny Buckley, Martin Michalik	HLB Mann Judd, Stantons International
2018	12	3	Danny Buckley, Martin Michalik	HLB Mann Judd, Stantons International

Table 5: Pearson's correlation matrix

	MAO_t	$Q5\_Centrality\_Board_t$	$Q5\_Centrality\_MD_t$	$Specialist\_MS_t$	$Specialist\_partner_t$	LTA_t
MAO_t	1					
$Q5\_Centrality\_Board_t$	–0.0370***	1				
$Q5\_Centrality\_MD_t$	–0.0019	0.3678***	1			
$Specialist\_MS_t$	0.0261**	–0.0239*	0.0073	1		
$Specialist\_partner_t$	–0.0026	0.0333**	–0.0150	–0.0348***	1	
LTA_t	–0.0212	0.1338***	0.2514***	0.0220*	–0.0528***	1
ROA_t	–0.1029***	–0.0104	0.0183	–0.0043	–0.0158	0.4899***
$Liquidity_t$	–0.1233***	0.0221*	–0.0623***	–0.0179	0.0042	0.0325**
$Big4_t$	0.0216*	0.1109***	0.1182***	–0.1354***	–0.1050***	0.2731***
Ln_Cash_t	–0.1840***	0.1874***	0.2200***	0.0014	0.0147	0.5941***
$Board\_Size_t$	0.0039	0.2353***	0.3840***	0.0095	–0.0214*	0.4259***
$Indep\_Ned_t$	–0.0015	0.0748***	0.0244*	–0.0555***	–0.0292**	0.0564***
$Accounting\_expertise\_board_t$	–0.0023	0.0383***	–0.0967***	–0.0519***	0.0485***	–0.1037***
EE_wo_t	0.0296**	0.0262**	0.0499***	–0.0242*	–0.0132	–0.0559***
EE_Comb_t	–0.0437***	0.0657***	0.1202***	0.0132	–0.0368***	0.2960***

	ROA_t	$Liquidity_t$	$Big4_t$	Ln_Cash_t	$Board\_Size_t$	$Indep\_Ned_t$	$Accounting\_expertise\_board_t$	EE_wo_t	EE_Comb_t
ROA_t	1								
$Liquidity_t$	0.1225***	1							
$Big4_t$	0.0611***	–0.0077	1						
Ln_Cash_t	0.3197***	0.3419***	0.1918***	1					
$Board\_Size_t$	0.1139***	–0.0268**	0.1831***	0.3384***	1				
$Indep\_Ned_t$	0.0006	0.0252*	0.0285**	0.0606***	0.0529***	1			
$Accounting\_expertise\_board_t$	–0.0488***	0.0010	–0.0330**	–0.0553***	–0.1323***	–0.0283**	1		
EE_wo_t	–0.1610***	–0.0572***	–0.0376***	–0.0676***	–0.0135	–0.0205	–0.0007	1	
EE_Comb_t	0.1878***	–0.0401***	0.0181	0.2014***	0.1510***	–0.0191	–0.0697***	0.2311***	1

This table presents the correlation for all variables used for testing the hypotheses. *MAO* is an indicator variable coded 1 if firms receive modified audit opinions including unqualified opinions with emphasis of matter, qualified opinions, disclaimers or adverse opinions, and 0 otherwise. *Q5_Centrality_Board* and *Q5_Centrality_MD* are the quintile rank of the average factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively. *Specialist_MS* is an indicator variable coded 1 if an auditor is the leader within the MEE sector by market share, and 0 otherwise. *Specialist_partner* is an indicator variable coded 1 if an audit partner is the leader in the MEE sector based on market share, and 0 otherwise. *LTA* is the natural logarithm of total assets. *ROA* is the return on assets. *Liquidity* is the ratio of current assets to current liabilities. *Big4* is an indicator variable coded 1 if statutory auditors are one of the Big4 auditors, and 0 otherwise. *Ln_Cash* is the natural logarithm of the cash balance. *Board_Size* is the number of directors sitting on the board. *Indep_Ned* is the percentage of independent non-executive directors on the board. *Accounting_expertise_board* is the proportion of board members excluding the MDs who possess expertise in accounting. *EE_wo* and *EE_Comb* are the natural logarithm of the amount of exploration and evaluation (E&E) assets written off or impaired, and combined E&E asset additions and acquisitions, respectively. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively

Table 6: Association between board centrality and audit outcomes

	MAO_t					
	Coeff	**Odds ratio**	**Coeff**	**Odds ratio**	**Coeff**	**Odds ratio**
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
$Q5\_Centrality\_Board_t$	–0.1581***	0.8537***	–0.1644***	0.8484***	–0.1788***	0.8363***
	(0.0576)	(0.0492)	(0.0585)	(0.0496)	(0.0592)	(0.0495)
$Q5\_Centrality\_MD_t$	0.0348	1.0354	0.0495	1.0508	0.0356	1.0362
	(0.0550)	(0.0569)	(0.0570)	(0.0599)	(0.0558)	(0.0579)
LTA_t	0.3518***	1.4216***	0.2998***	1.3496***	0.1316	1.1406
	(0.0924)	(0.1313)	(0.0961)	(0.1297)	(0.0873)	(0.0996)
ROA_t	–0.1714***	0.8425***	–0.1511***	0.8598***	–0.0850*	0.9185*
	(0.0463)	(0.0390)	(0.0487)	(0.0419)	(0.0484)	(0.0444)
$Liquidity_t$	–0.0247***	0.9756***	–0.0302***	0.9703***	–0.0268***	0.9736***
	(0.0073)	(0.0071)	(0.0082)	(0.0079)	(0.0069)	(0.0067)
$Big4_t$	0.1941	1.2142	0.2004	1.2219	0.0849	1.0887
	(0.2055)	(0.2495)	(0.2124)	(0.2595)	(0.2388)	(0.2599)
Ln_Cash_t	–0.3449***	0.7083***	–0.3801***	0.6838***	–0.2835***	0.7532***
	(0.0534)	(0.0378)	(0.0575)	(0.0393)	(0.0506)	(0.0381)
$Board\_Size_t$	0.0758	1.0787	0.0092	1.0092	–0.0926	0.9115
	(0.0797)	(0.0859)	(0.0852)	(0.0859)	(0.0775)	(0.0706)
$Indep\_Ned_t$	0.0229	1.0232	0.3410	1.4064	0.2219	1.2484
	(0.2701)	(0.2764)	(0.2809)	(0.3951)	(0.2559)	(0.3194)
$Accounting\_expertise\_board_t$	0.2376	1.2682	0.1620	1.1759	0.3985	1.4896
	(0.4925)	(0.6245)	(0.5243)	(0.6165)	(0.5067)	(0.7548)
EE_wo_t	0.0249**	1.0252**	0.0150	1.0151	0.0184*	1.0186*
	(0.0100)	(0.0102)	(0.0103)	(0.0105)	(0.0108)	(0.0110)
EE_Comb_t	–0.0240	0.9762	–0.0401**	0.9607**	–0.0351**	0.9655**
	(0.0161)	(0.0157)	(0.0162)	(0.0156)	(0.0152)	(0.0147)
Constant	–4.0645***	0.0172***	–2.6812**	0.0685**		
	(1.2445)	(0.0214)	(1.3094)	(0.0897)		
Observations	5,913	5,913	5,913	5,913	2,159	2,159
Year fixed-effects	No	No	Yes	Yes	Yes	Yes
Firm fixed-effects	No	No	No	No	Yes	Yes
Pseudo R-squared	6.0%	6.0%	11.5%	11.5%	19.3%	19.3%

This table presents the association between board centrality and audit outcomes over the period 2004–2018 using the following model:

$$MAO_{i,t} = \theta_0 + \theta_1 Q5\_Centrality\_Board_{i,t} + \theta_2 Q5\_Centrality\_MD_{i,t} + \theta_3 LTA_{i,t} + \theta_4 ROA_{i,t} + \theta_5 Liquidity_{i,t} + \theta_6 Big4_{i,t} + \theta_7 Ln\_Cash_{i,t} + \theta_8 Board\_Size_{i,t} + \theta_9 Indep\_Ned_{i,t} + \theta_{10} Accounting\_expertise\_board_{i,t} + \theta_{11} EE\_wo_{i,t} + \theta_{12} EE\_Comb_{i,t} + \varphi + \omega + \epsilon_{i,t} \quad (1A)$$

MAO is an indicator variable coded 1 if firms receive modified audit opinions including unqualified opinions with emphasis of matter, qualified opinions, disclaimers or adverse opinions, and 0 otherwise. *Q5_Centrality_Board*$_t$ and *Q5_Centrality_MD*$_t$ are the quintile rank of the average factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively.
LTA is the natural logarithm of total assets. *ROA* is the return on assets. *Liquidity* is the ratio of current assets to current liabilities. *Big4* is an indicator variable coded 1 if statutory auditors are one of the Big4 auditors, and 0 otherwise. *Ln_Cash* is the natural logarithm of the cash balance. *Board_Size* is the number of directors sitting on the board. *Indep_Ned* is the percentage of independent non-executive directors on the board. *Accounting_expertise_board* is the proportion of board members excluding the MDs who possess expertise in accounting. *EE_wo* and *EE_Comb* are the natural logarithm of the amount of exploration and evaluation (E&E) assets written off or impaired, and combined E&E asset additions and acquisitions, respectively. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 7: Association between board centrality and audit outcomes, controlling for auditor specialisation

				MAO_t		
Variables	**Coeff (1)**	**Odds ratio (2)**	**Coeff (3)**	**Odds ratio (4)**	**Coeff (5)**	**Odds ratio (6)**
Q5_Centrality_Board$_t$	–0.1597***	0.8524***	–0.1667***	0.8464***	–0.1797***	0.8355***
	(0.0576)	(0.0491)	(0.0585)	(0.0495)	(0.0593)	(0.0496)
Q5_Centrality_MD$_t$	0.0343	1.0349	0.0487	1.0499	0.0352	1.0359
	(0.0547)	(0.0566)	(0.0565)	(0.0593)	(0.0559)	(0.0579)
Specialist_MS$_t$	0.2557	1.2913	0.3049	1.3565	0.0572	1.0589
	(0.2109)	(0.2723)	(0.2292)	(0.3110)	(0.2371)	(0.2510)
LTA$_t$	0.3492***	1.4179***	0.2987***	1.3481***	0.1318	1.1409
	(0.0926)	(0.1312)	(0.0961)	(0.1295)	(0.0873)	(0.0996)
ROA$_t$	–0.1690***	0.8445***	–0.1495***	0.8611***	–0.0848*	0.9187*
	(0.0460)	(0.0389)	(0.0486)	(0.0419)	(0.0484)	(0.0445)
Liquidity$_t$	–0.0246***	0.9757***	–0.0302***	0.9702***	–0.0268***	0.9736***
	(0.0073)	(0.0071)	(0.0082)	(0.0080)	(0.0069)	(0.0067)
Big4$_t$	0.2303	1.2590	0.2451	1.2777	0.0930	1.0974
	(0.2045)	(0.2575)	(0.2136)	(0.2729)	(0.2410)	(0.2644)
Ln_Cash$_t$	–0.3467***	0.7070***	–0.3840***	0.6811***	–0.2844***	0.7525***
	(0.0535)	(0.0378)	(0.0578)	(0.0394)	(0.0508)	(0.0382)
Board_Size$_t$	0.0771	1.0802	0.0111	1.0112	–0.0918	0.9123
	(0.0796)	(0.0860)	(0.0851)	(0.0860)	(0.0776)	(0.0708)
Indep_Ned$_t$	0.0316	1.0321	0.3549	1.4261	0.2221	1.2487
	(0.2703)	(0.2789)	(0.2814)	(0.4013)	(0.2559)	(0.3196)
Accounting_expertise_board$_t$	0.2653	1.3038	0.1972	1.2180	0.4037	1.4974
	(0.4954)	(0.6460)	(0.5264)	(0.6411)	(0.5069)	(0.7591)
EE_wo$_t$	0.0254**	1.0257**	0.0157	1.0158	0.0186*	1.0188*
	(0.0100)	(0.0103)	(0.0104)	(0.0105)	(0.0108)	(0.0110)
EE_Comb$_t$	–0.0241	0.9762	–0.0404**	0.9604**	–0.0351**	0.9655**
	(0.0161)	(0.0157)	(0.0162)	(0.0156)	(0.0152)	(0.0147)
Constant	–4.0566***	0.0173***	–2.6588**	0.0700**		
	(1.2461)	(0.0216)	(1.3079)	(0.0916)		
Observations	5,913	5,913	5,913	5,913	2,159	2,159
Year fixed-effects	No	No	Yes	Yes	Yes	Yes
Firm fixed-effects	No	No	No	No	Yes	Yes
Pseudo R-squared	6.0%	6.0%	11.6%	11.6%	19.3%	19.3%

This table presents the association between board centrality and auditor specialisation and audit outcomes over the period 2004–2018 using the following model:

$$MAO_{i,t} = \theta_0 + \theta_1 Q5\_Centrality\_Board_{i,t} + \theta_2 Q5\_Centrality\_MD_{i,t} + \theta_3 Specialist\_MS_{i,t} + \theta_4 LTA_{i,t} + \theta_5 ROA_{i,t} + \theta_6 Liquidity_{i,t} + \theta_7 Big4_{i,t} + \theta_8 Ln\_Cash_{i,t} + \theta_9 Board\_Size_{i,t} + \theta_{10} Indep\_Ned_{i,t} + \theta_{11} Accounting\_expertise\_board_{i,t} + \theta_{12} EE\_wo_{i,t} + \theta_{13} EE\_Comb_{i,t} + \varphi + \omega + \epsilon_{i,t} \quad (1B)$$

MAO is an indicator variable coded 1 if firms receive modified audit opinions including unqualified opinions with emphasis of matter, qualified opinions, disclaimers or adverse opinions, and 0 otherwise. *Q5_Centrality_Board$_t$* and *Q5_Centrality_MD$_t$* are the quintile rank of the average factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively. *Specialist_MS* is an indicator variable coded 1 if an auditor is the leader within the MEE sector by market share, and 0 otherwise. *LTA* is the value in natural logarithm of total assets. *ROA* is the return on assets. *Liquidity* is the ratio of current assets to current liabilities. *Big4* is an indicator variable coded 1 if statutory auditors are one of the Big4 auditors, and 0 otherwise. *Ln_Cash* is the natural logarithm of the amount of cash balance. *Board_Size* is the number of directors sitting on the board. *Indep_Ned* is the percentage of independent non-executive directors on the board. *Accounting_expertise_board* is the proportion of board members excluding the MDs who possess expertise in accounting. *EE_wo* and *EE_Comb* are the natural logarithm of the amount of exploration and evaluation (E&E) assets written off or impaired, and combined E&E asset additions and acquisitions, respectively. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 8: Moderating effect of auditor specialisation on audit outcomes

Variables	MAO_t		
	(1)	(2)	(3)
$Top\_Centrality\_Board_t \times Specialist\_MS_t$	1.1000***	1.1727***	1.2203***
	(0.4131)	(0.3966)	(0.4503)
$Top\_Centrality\_Board_t$	-0.4142**	-0.4684**	-0.4388**
	(0.2103)	(0.2088)	(0.2072)
$Specialist\_MS_t$	0.0411	0.0682	-0.1944
	(0.2249)	(0.2438)	(0.2518)
$Q5\_Centrality\_MD_t$	0.0002	0.0154	0.0002
	(0.0515)	(0.0536)	(0.0545)
LTA_t	0.3421***	0.2900***	0.1132
	(0.0924)	(0.0955)	(0.0873)
ROA_t	-0.1631***	-0.1448***	-0.0801*
	(0.0459)	(0.0484)	(0.0480)
$Liquidity_t$	-0.0254***	-0.0313***	-0.0280***
	(0.0073)	(0.0083)	(0.0070)
$Big4_t$	0.2267	0.2474	0.0942
	(0.2042)	(0.2133)	(0.2407)
Ln_Cash_t	-0.3482***	-0.3847***	-0.2836***
	(0.0535)	(0.0572)	(0.0506)
$Board\_Size_t$	0.0676	0.0034	-0.1000
	(0.0798)	(0.0854)	(0.0773)
$Indep\_Ned_t$	0.0185	0.3310	0.1870
	(0.2699)	(0.2804)	(0.2563)
$Accounting\_expertise\_board_t$	0.2200	0.1309	0.3988
	(0.4928)	(0.5231)	(0.5062)
EE_wo_t	0.0253**	0.0157	0.0183*
	(0.0100)	(0.0103)	(0.0107)
EE_Comb_t	-0.0243	-0.0405**	-0.0341**
	(0.0158)	(0.0160)	(0.0152)
Constant	-4.1446***	-2.7555**	
	(1.2471)	(1.3054)	
Observations	5913	5913	2159
Year fixed effects	No	Yes	Yes
Firm fixed effects	No	No	Yes
Pseudo R-squared	6.0%	11.6%	19.3%

This table presents the moderating effect of specialist auditors on the association between board centrality and audit outcomes over the period 2004–2018 using the following model:

$$MAO_{i,t} = \theta_0 + \theta_1 Top\_Centrality\_Board_{i,t} \times Specialist\_MS_{i,t} + \theta_2 Top\_Centrality\_Board_{i,t} + \theta_3 Specialist\_MS_{i,t} + \theta_4 Q5\_Centrality\_MD_{i,t} + \theta_5 LTA_{i,t} + \theta_6 ROA_{i,t} + \theta_7 Liquidity_{i,t} + \theta_8 Big4_{i,t} + \theta_9 Ln\_Cash_{i,t} + \theta_{10} Board\_Size_{i,t} + \theta_{11} Indep\_Ned_{i,t} + \theta_{12} Accounting\_expertise\_board_{i,t} + \theta_{13} EE\_wo_{i,t} + \theta_{14} EE\_Comb_{i,t} + \varphi + \omega + \epsilon_{i,t} \quad (2)$$

MAO is an indicator variable coded 1 if firms receive modified audit opinions including unqualified opinions with emphasis of matter, qualified opinions, disclaimers or adverse opinions, and 0 otherwise. *Top_Centrality_Board*$_t$ is an indicator coded 1 if *Q5_Centrality_Board*$_t$ is ranked in the top quintile of the average factor score of board member centrality measures, and 0 otherwise.*Q5_Centrality_Board*$_t$ and *Q5_Centrality_MD*$_t$ are the quintile rank of the average factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively. *Specialist_MS* is an indicator variable coded 1 if a statutory auditor is the leader within the MEE sector by market share, and 0 otherwise. *LTA* is the value in natural logarithm of total assets. *ROA* is the return on assets. *Liquidity* is the ratio of current assets to current liabilities. *Big4* is an indicator variable coded 1 if statutory auditors are one of the Big4 auditors, and 0 otherwise. *Ln_Cash* is the natural logarithm of the cash balance. *Board_Size* is the number of directors sitting on the board. *Indep_Ned* is the percentage of independent non-executive directors on the board. *Accounting_expertise_board* is the proportion of board members excluding the MD who possess expertise in accounting. *EE_wo* and *EE_Comb* are the natural logarithm of the amount of exploration and evaluation (E&E) assets written off or impaired, and combined E&E asset additions and acquisitions, respectively. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 9: Association between board centrality and audit outcomes, controlling for specialist partners

		MAO_t	
Variables	**(1)**	**(2)**	**(3)**
$Q5\_Centrality\_Board_t$	–0.1618***	–0.1683***	–0.1843***
	(0.0576)	(0.0585)	(0.0593)
$Q5\_Centrality\_MD_t$	0.0371	0.0519	0.0399
	(0.0547)	(0.0566)	(0.0560)
$Specialist\_partner_t$	0.3483	0.3555	0.4567
	(0.2526)	(0.2649)	(0.3122)
LTA_t	0.3550***	0.3022***	0.1377
	(0.0925)	(0.0960)	(0.0872)
ROA_t	–0.1728***	–0.1524***	–0.0898*
	(0.0463)	(0.0486)	(0.0485)
$Liquidity_t$	–0.0246***	–0.0301***	–0.0266***
	(0.0072)	(0.0082)	(0.0069)
$Big4_t$	0.2205	0.2283	0.1377
	(0.2062)	(0.2124)	(0.2419)
Ln_Cash_t	–0.3475***	–0.3820***	–0.2859***
	(0.0532)	(0.0574)	(0.0506)
$Board\_Size_t$	0.0750	0.0081	–0.0948
	(0.0796)	(0.0852)	(0.0776)
$Indep\_Ned_t$	0.0286	0.3412	0.2212
	(0.2702)	(0.2810)	(0.2558)
$Accounting\_expertise\_board_t$	0.2313	0.1547	0.4046
	(0.4928)	(0.5247)	(0.5062)
EE_wo_t	0.0247**	0.0147	0.0175
	(0.0100)	(0.0104)	(0.0108)
EE_Comb_t	–0.0239	–0.0398**	–0.0349**
	(0.0161)	(0.0162)	(0.0152)
Constant	–4.1031***	–2.7196**	
	(1.2460)	(1.3092)	
Observations	5,913	5,913	2,159
Year fixed-effects	No	Yes	Yes
Firms fixed-effects	No	No	Yes
Pseudo R-squared	6.0%	11.6%	19.5%

This table presents the association between board centrality and audit partner specialisation and audit outcomes over the period 2004–2018. *MAO* is an indicator variable coded 1 if firms receive modified audit opinions including unqualified opinions with emphasis of matter, qualified opinions, disclaimers or adverse opinions, and 0 otherwise. $Q5\_Centrality\_Board_t$ and $Q5\_Centrality\_MD_t$ are the quintile rank of the average factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively. *Specialist_partner* is an indicator variable coded 1 if an audit partner is the leader in the MEE sector based on market share, and 0 otherwise. *LTA* is the natural logarithm of total assets. *ROA* is the return on assets. *Liquidity* is the ratio of current assets to current liabilities. *Big4* is an indicator variable coded 1 if statutory auditors are one of the Big4 auditors, and 0 otherwise. *Ln_Cash* is the natural logarithm of the cash balance. *Board_Size* is the number of directors sitting on the board. *Indep_Ned* is the percentage of independent non-executive directors on the board. *Accounting_expertise_board* is the proportion of board members excluding the MDs who possess expertise in accounting. *EE_wo* and *EE_Comb* are the natural logarithm of the amount of exploration and evaluation (E&E) assets written off or impaired, and combined E&E asset additions and acquisitions, respectively. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 10: Impact of exogenous shock on the association between board centrality and audit outcomes

Variables	*Δ_MAO* (1)	*Δ_MAO* (2)
Treated	0.0837	
	(0.1962)	
Treated_Board		–0.0078
		(0.2208)
Treated_MD		0.6076
		(0.5945)
Δ_LTA	–0.0656	–0.0665
	(0.1018)	(0.1017)
Δ_ROA	–0.0154	–0.0156
	(0.0351)	(0.0352)
Δ_Liquidity	–0.0028	–0.0027
	(0.0029)	(0.0029)
Δ_Big4	–0.2955	–0.2849
	(0.2751)	(0.2764)
Δ_Ln_Cash	–0.2810***	–0.2812***
	(0.0529)	(0.0530)
Δ_Board_Size	–0.1454**	–0.1454**
	(0.0691)	(0.0689)
Δ_Indep_Ned	0.2909	0.2920
	(0.2513)	(0.2511)
Δ_Accounting_expertise_board	0.1560	0.1622
	(0.5328)	(0.5319)
Δ_EE_wo	–0.0028	–0.0028
	(0.0091)	(0.0091)
Δ_EE_Comb	0.0290*	0.0290*
	(0.0151)	(0.0151)
Constant	–3.2918***	–3.2903***
	(0.3772)	(0.3777)
Observations	4,805	4,805
Year fixed-effects	Yes	Yes
Pseudo R-squared	8.10%	8.14%

This table presents the impact of exogeneous shocks on the association between board centrality and audit outcomes by exploiting a quasi-natural experiment over the period 2004–2018. *Treated* is the number of cases in which the board has a director whose role at the target firm was terminated following an M&A shock (shocked director). In Column (2), *Treated* is separated into *Treated_Board* and *Treated_MD* which are the number of cases in which the board has a member who is *not* the MD and is the MD whose role at the target firm was terminated following an M&A shock, respectively. Shocked directors must maintain their role at the board of treated firms in year *t*+1 where *t* is the financial year when target firms were delisted from the stock exchange following a successful M&A, causing directors to lose board seats (Hauser, 2018).

All other dependent and independent variables are in change form which captures the changes over the *t*–1 to *t*+1 window. *Δ_MAO* is an indicator variable coded 1 if firms received a clean audit opinion in year *t*–1 and modified audit opinions in year *t*+1, and 0 otherwise. *LTA* is the natural logarithm of total assets. *ROA* is the return on assets. *Liquidity* is the ratio of current assets to current liabilities. *Big4* is an indicator variable coded 1 if statutory auditors are one of the Big4 auditors, and 0 otherwise. *Ln_Cash* is the natural logarithm of the cash balance. *Board_Size* is the number of directors sitting on the board. *Indep_Ned* is the percentage of independent non-executive directors on the board. *Accounting_expertise_board* is the proportion of board members excluding the MDs who possess expertise in accounting. *EE_wo* and *EE_Comb* are the natural logarithm of the amount of exploration and evaluation (E&E) assets written off or impaired, and combined E&E asset additions and acquisitions, respectively. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 11: Impact of exogenous shock on the association between board centrality and audit outcomes – Treated sample

Variable	*Δ_MAO* *(1)*
Q5_Centrality_Target	1.0481*
	(0.5889)
Δ_LTA	0.0145
	(0.3635)
Δ_ROA	–0.0879
	(0.2140)
Δ_Liquidity	0.0066
	(0.0127)
Δ_Big4	0.0168
	(0.6782)
Δ_ Ln_Cash	–0.4764**
	(0.1884)
Δ_Board_Size	0.1915
	(0.2099)
Δ_Indep_Ned	1.6828
	(1.0574)
Δ_Accounting_expertise_board	–0.1592
	(1.5651)
Δ_EE_wo	0.0324
	(0.0330)
Δ_EE_Comb	0.0322
	(0.0549)
Constant	–3.6812***
	(1.0119)
Observations	235
Year fixed-effects	No
Pseudo R-squared	14.3%

This table examines the impacts of losing board connections on audit outcomes on treated samples over the period 2004–2018. *Q5_Centrality_Target* is an indicator variable coded 1 if the factor score of four key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of the target firm board measured one year prior to M&A shock is in the top quintile, and 0 otherwise. All other dependent and independent variables are in a change form which captures the changes over the *t*–1 to *t*+1 window. *Δ_MAO* is an indicator variable coded 1 if firms received a clean audit opinion in year *t*–1 and a modified audit opinions in year *t*+1, and 0 otherwise.

LTA is the natural logarithm of total assets. *ROA* is the return on assets. *Liquidity* is the ratio of current assets to current liabilities. *Big4* is an indicator variable coded 1 if statutory auditors are one of the Big auditors, and 0 otherwise. *Ln_Cash* is the natural logarithm of the cash balance. *Board_Size* is the number of directors sitting on the board. *Indep_Ned* is the percentage of independent non-executive directors on the board. *Accounting_expertise_board* is the proportion of board members excluding the MDs who possess expertise in accounting. *EE_wo* and *EE_Comb* are natural logarithm of the amount of exploration and evaluation (E&E) assets written off or impaired, and combined E&E asset additions and acquisitions, respectively. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 12: The association between board centrality and audit outcomes, controlling for non-audit service fees

		MAO_t	
Variables	**(1)**	**(2)**	**(3)**
$Q5\_Centrality\_Board_t$	-0.1564***	-0.1625***	-0.1744***
	(0.0578)	(0.0586)	(0.0596)
$Q5\_Centrality\_MD_t$	0.0349	0.0518	0.0413
	(0.0552)	(0.0571)	(0.0561)
LTA_t	0.3524***	0.3004***	0.1394
	(0.0933)	(0.0965)	(0.0895)
ROA_t	-0.1835***	-0.1635***	-0.1004**
	(0.0466)	(0.0494)	(0.0494)
$Liquidity_t$	-0.0247***	-0.0301***	-0.0268***
	(0.0072)	(0.0082)	(0.0069)
$Big4_t$	0.1520	0.1544	0.0420
	(0.2040)	(0.2106)	(0.2415)
Ln_Cash_t	-0.3578***	-0.3962***	-0.2975***
	(0.0547)	(0.0582)	(0.0515)
$Board\_Size_t$	0.0724	0.0010	-0.1016
	(0.0800)	(0.0857)	(0.0785)
$Indep\_Ned_t$	-0.0546	0.2611	0.1129
	(0.2664)	(0.2798)	(0.2590)
$Accounting\_expertise\_board_t$	0.2341	0.1735	0.3879
	(0.4870)	(0.5130)	(0.5087)
EE_wo_t	0.0239**	0.0141	0.0161
	(0.0101)	(0.0104)	(0.0109)
EE_Comb_t	-0.0280*	-0.0441***	-0.0402***
	(0.0162)	(0.0161)	(0.0154)
NAS_t	0.0212	0.0238	0.0081
	(0.0161)	(0.0165)	(0.0169)
Constant	-3.8899***	-2.4859*	
	(1.2682)	(1.3319)	
Observations	5,881	5,881	2145
Year fixed effects	No	Yes	Yes
Firm fixed effects	No	No	Yes
Pseudo R-squared	6.2%	11.8%	19.8%

This table presents the association between board centrality and audit outcomes, controlling for the provision of non-audit service, over the 2004 to 2018 period.

MAO is an indicator variable coded 1 if firms receive modified audit opinions including unqualified opinions with emphasis of matter, qualified opinions, and disclaimers or adverse opinions, and 0 otherwise. $Q5\_Centrality\_Board_t$ and $Q5\_Centrality\_MD_t$ are quintile rank of the average of factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively.

LTA is the value in natural logarithm of total assets. *ROA* is return on assets. *Liquidity* is the ratio of current assets to current liabilities. *Big4* is an indicator variable coded 1 if statutory auditors are one of the Big4 auditors, and 0 otherwise. *Ln_Cash* is natural logarithm of the amount of cash balance. *Board_Size* is the number of directors sitting on the board. *Indep_Ned* is the percentage of independent non-executive directors on the board. *Accounting_expertise_board* is the proportion of board members excluding the MDs who possess expertise in accounting. *EE_wo* and *EE_Comb* are natural logarithm of the amount of exploration and evaluation (E&E) assets written off or impaired and combined E&E assets additions and acquisitions, respectively. *NAS* is natural logarithm

of the amount of non-audit service fees paid to the auditor. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 13: The association between board centrality and audit outcomes, controlling for non-audit service fees – Alternative measure

		MAO_t	
Variables	**(1)**	**(2)**	**(3)**
$Q5\_Centrality\_Board_t$	-0.1649***	-0.1701***	-0.1832***
	(0.0588)	(0.0595)	(0.0602)
$Q5\_Centrality\_MD_t$	0.0431	0.0584	0.0479
	(0.0556)	(0.0575)	(0.0567)
LTA_t	0.3481***	0.3104***	0.1308
	(0.0938)	(0.0976)	(0.0901)
ROA_t	-0.1789***	-0.1649***	-0.0984**
	(0.0470)	(0.0499)	(0.0492)
$Liquidity_t$	-0.0234***	-0.0293***	-0.0257***
	(0.0074)	(0.0083)	(0.0070)
$Big4_t$	0.1740	0.1654	0.0829
	(0.2056)	(0.2120)	(0.2449)
Ln_Cash_t	-0.3490***	-0.3896***	-0.2977***
	(0.0557)	(0.0595)	(0.0525)
$Board\_Size_t$	0.0821	0.0093	-0.0868
	(0.0820)	(0.0870)	(0.0795)
$Indep\_Ned_t$	-0.1417	0.1888	0.0471
	(0.2720)	(0.2851)	(0.2607)
$Accounting\_expertise\_board_t$	0.2753	0.1939	0.3759
	(0.4891)	(0.5167)	(0.5115)
EE_wo_t	0.0225**	0.0122	0.0143
	(0.0102)	(0.0105)	(0.0109)
EE_Comb_t	-0.0277*	-0.0445***	-0.0409***
	(0.0164)	(0.0165)	(0.0155)
NAS_AF_t	-0.1355	-0.1521	-0.2583
	(0.1397)	(0.1470)	(0.1635)
Constant	-3.8882***	-2.5824*	
	(1.2823)	(1.3584)	
Observations	5770	5770	2087
Year fixed effects	No	Yes	Yes
Firm fixed effects	No	No	Yes
Pseudo R-squared	5.9%	11.5%	19.7%

This table presents the association between board centrality and audit outcomes, controlling for the provision of non-audit service, over the 2004 to 2018 period.

MAO is an indicator variable coded 1 if firms receive modified audit opinions including unqualified opinions with emphasis of matter, qualified opinions, and disclaimers or adverse opinions, and 0 otherwise. $Q5\_Centrality\_Board_t$ and $Q5\_Centrality\_MD_t$ are quintile rank of the average of factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively.

LTA is the value in natural logarithm of total assets. *ROA* is return on assets. *Liquidity* is the ratio of current assets to current liabilities. *Big4* is an indicator variable coded 1 if statutory auditors are one of the Big4 auditors, and 0 otherwise. *Ln_Cash* is natural logarithm of the amount of cash balance. *Board_Size* is the number of directors sitting on the board. *Indep_Ned* is the percentage of independent non-executive directors on the board. *Accounting_expertise_board* is the proportion of board members excluding the MDs who possess expertise in accounting. *EE_wo* and *EE_Comb* are natural logarithm of the amount of exploration and evaluation (E&E) assets written off or impaired and combined E&E assets additions and acquisitions, respectively. NAS_AF_t is the ratio of non-audit service fees to the audit fees paid to the auditor. ***, ** and *

denote statistical significance at the 1%, 5% and 10% levels, respectively. Robust standard errors are reported in parentheses.

Table 14: The association between board centrality and audit outcomes, controlling for director busyness

Variables	MAO_t		
	(1)	(2)	(3)
$Q5\_Centrality\_Board_t \times Busy_t$,	0.0217	0.1025	0.2201
	(0.1565)	(0.1589)	(0.1650)
$Q5\_Centrality\_Board_t$	-0.1518**	-0.1703***	-0.2012***
	(0.0623)	(0.0633)	(0.0632)
$Busy_t$,	-0.1843	-0.4418	-0.8353
	(0.6454)	(0.6562)	(0.6799)
$Q5\_Centrality\_MD_t$	0.0325	0.0486	0.0358
	(0.0555)	(0.0573)	(0.0562)
LTA_t	0.3516***	0.3013***	0.1391
	(0.0924)	(0.0960)	(0.0875)
ROA_t	-0.1699***	-0.1504***	-0.0846*
	(0.0461)	(0.0486)	(0.0485)
$Liquidity_t$	-0.0245***	-0.0299***	-0.0262***
	(0.0072)	(0.0081)	(0.0069)
$Big4_t$	0.1934	0.1945	0.0792
	(0.2055)	(0.2124)	(0.2387)
Ln_Cash_t	-0.3454***	-0.3813***	-0.2863***
	(0.0536)	(0.0574)	(0.0509)
$Board\_Size_t$	0.0699	0.0063	-0.0899
	(0.0808)	(0.0860)	(0.0786)
$Indep\_Ned_t$	0.0210	0.3427	0.2199
	(0.2701)	(0.2814)	(0.2564)
$Accounting\_expertise\_board_t$	0.2390	0.1555	0.3511
	(0.4930)	(0.5233)	(0.5087)
EE_wo_t	0.0251**	0.0153	0.0188*
	(0.0100)	(0.0103)	(0.0108)
EE_Comb_t	-0.0241	-0.0405**	-0.0364**
	(0.0161)	(0.0161)	(0.0153)
Constant	-4.0320***	-2.6422**	
	(1.2430)	(1.3088)	
Observations	5913	5913	2159
Year fixed effects	No	Yes	Yes
Firm fixed effects	No	No	Yes
Pseudo R-squared	6.0%	11.6%	19.4%

This table presents the association between board centrality and audit outcome, controlling for director busyness, over the 2004 to 2018 period.

MAO is an indicator variable coded 1 if firms receive modified audit opinions including unqualified opinions with emphasis of matter, qualified opinions, and disclaimers or adverse opinions, and 0 otherwise. $Q5\_Centrality\_Board_t$ and $Q5\_Centrality\_MD_t$ are quintile rank of the average of factor score of key centrality measures (degree, betweenness, closeness, and eigenvector centrality) of individual board members excluding the MD, and of the MD, respectively.

Busy is an indicator variable coded 1 if the measure of director busyness, which is the percentage of NEDs on the board who hold two or more board positions in industry peers other than the current board, is in the top quintile of each year sample, and 0 otherwise.

LTA is the value in natural logarithm of total assets. *ROA* is return on assets. *Liquidity* is the ratio of current assets to current liabilities. *Big4* is an indicator variable coded 1 if statutory auditors are one of the Big4 auditors, and 0 otherwise. *Ln_Cash* is natural logarithm of the amount of cash balance. *Board_Size* is the number of directors sitting on the board. *Indep_Ned* is the percentage of independent non-executive directors on the board.

Accounting_expertise_board is the proportion of board members excluding the MDs who possess expertise in accounting. *EE_wo* and *EE_Comb* are natural logarithm of the amount of exploration and evaluation (E&E) assets written off or impaired and combined E&E assets additions and acquisitions, respectively. Robust standard errors are reported in parentheses.

Appendix A: Variable definitions

Variable	Definition	Data sources
Dependent variables:		
MAO_t	An indicator variable coded 1 if firms receive modified audit opinions including unqualified opinions with emphasis of matter, qualified opinions, disclaimers or adverse opinions for the current year, and 0 otherwise.	Connect4
Explanatory variables:		
$Q5\_Centrality\_Board_t$	Quintile rank of the average factor score of individual board members excluding the MD. Factor score is based on four key centrality measures (degree, betweenness, closeness, and eigenvector centrality) measured at the individual director level for the current year.	Connect4/igraph
$Q5\_Centrality\_MD_t$	Quintile rank of the factor score of the MD. Factor score is based on the MD's four key centrality measures (degree, betweenness, closeness, and eigenvector centrality) for the current year.	Connect4/igraph
Board characteristics:		
$Board\_Size_t$	Number of directors sitting on the board for the current year.	Connect 4
$Indep\_Ned_t$	Percentage of non-executive directors (NEDs) on the board who are independent for the current year.	Connect 4
$Accounting\_expertise\_board_t$	Percentage of NEDs on the board who have accounting expertise (based on their past employment in the accounting profession of at least 10 years) for the current year.	Hand collected
Control variables:		
LTA_t	Natural logarithm of total assets for the current year.	DatAnalysis
ROA_t	Return on assets, measured as earnings before interest and tax divided by total assets for the current year.	DatAnalysis
$Liquidity_t$	The ratio of current assets to current liabilities for the current year.	DatAnalysis
$Big4_t$	An indicator variable coded 1 if statutory auditors are one of the Big auditors, and 0 otherwise.	Connect 4
Ln_Cash_t	Natural logarithm of the cash balance for the current year.	DatAnalysis
EE_wo_t	Natural logarithm of the amount of previously capitalised exploration and evaluation (E&E) expenditures which are impaired/written off in the current year.	Hand collected

Variable	Definition	Data sources
EE_Comb_t	Natural logarithm of the combined amount of E&E asset additions and acquisitions for the current year.	Hand collected