Original Research Article

Gender diversity, education diversity and big data analytics investments - A test of moderation

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Abstract

Purpose: This study examines the influence of education diversity in moderating the association between gender diversity and big data analytics investments. **Design/methodology/approach:** A multimethod approach is employed where the data (161 responses) are drawn from two quantitative data sources. The primary data are obtained from the questionnaire survey, and the secondary data are gathered from the annual reports. Multiple linear regression analysis is used as the analytical method. **Findings:** This study finds that gender diversity is positively and significantly associated with big data analytics investments. Next, the association between gender diversity and big data analytics investments is negatively moderated by education diversity. The association between gender diversity and big data analytics investments is weakened when the education diversity is higher. **Originality:** This study is one of the first to examine the intervening processes of how gender diversity affects big data analytics investments using education diversity as a moderating variable. This study is novel in its approach to providing empirical evidence and examining the moderating effect of education diversity. **Practical implications:** This study shows that gender diversity facilitates big data analytics investments. The findings help policymakers encourage the female director's role in strategic decision-making. The negative moderating effect of education diversity on gender diversity and big data analytics investments association implies that firms may face challenges accessing resources. The findings help firms promote open debates and effective communication in strategic decision-making to leverage education diversity.

Keywords

strategic decision, big data analytics investments, education diversity, gender diversity, Malaysia

Introduction

Despite the advances in gender equality in the workplace, female directors' under-representation in managerial and leadership positions continues to be an issue of social and economic concern (Adamson and Kelan, 2019). Over time, societal pressure demanded the female director's role in the strategic decision-making process to compensate for their under-representation on the board (Merendino et al., 2018). In the wake of this, females break the glass ceiling and are appointed to boards previously considered male prerogative (Saggese et al., 2021). The role of female directors on the board is emphasised in the Corporate Governance Blueprint 2011 of the Securities Commission Malaysia, where the Blueprint requires the participation of female directors in bringing different viewpoints to the board and has a bigger perspective on corporate strategy that concerns the stakeholders (Jizi, 2017). The revised Malaysian Code of Corporate Governance (MCCG) 2021 calls for the corporate board to have 30% female representation. If the composition of female directors on a board is less, they should disclose the action it takes to achieve the 30% or more and the timeframe to complete it. The revised MCCG 2021 defines the timeframe as a period that is three years or less (Securities Commission Malaysia, 2012). The presence of female directors on the board responds to the normative pressure to promote gender equality and to benefit from gender diversity (Iseke and Pull, 2019).

The government initiatives remove the main structural barriers that limit females' opportunities to access managerial positions in some settings. However, female directors on board members remain a concern (Saggese et al., 2021), and there is debate about female directors' contribution to corporate strategy (Elmagrhi et al., 2019). Affirmative actions place an additional burden on female directors' equality. The general perception that female directors are appointed for affirmative action reasons or to appease special interest groups may increase existing prejudices and stereotypes (Sarabi and Smith, 2021). Furthermore, gender stereotype biases reduce interpersonal trust, decreasing communication openness among board members (Siddiki et al., 2017). Therefore, the lack of interpersonal trust among board members thus making female directors hesitant to express their concerns about the corporate strategy.

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Nevertheless, female directors' unique values and opinions increase strategic board decision-making and accelerate investment in big data analytics (Shin et al., 2020). They view big data analytics as a strategy change beneficial to the firm's long-term development (Yang et al., 2019). Female directors exercise service roles in strategy to provide helpful advice to encourage investments in big data analytics (Arzubiaga et al., 2018). Hence, female directors promote the firm's strategic investment in big data analytics.

In recent years, Malaysian firms have increasingly invested big data analytics to navigate vast amounts of data, streamline decision-making processes and expedite strategic choices. Big data analytics refers to a cluster of data and technology that integrates, accesses and reports every data by correlating, filtering and reporting values not assessable using traditional data technologies (Association for Supply Chain Management, 2012). Businesses are investing in big data analytics to create value (Chen et al., 2015; Vecchio et al., 2018; Grover et al., 2018), shape digital corporate strategies (Schwertner, 2017; Loebbecke and Picot, 2015; Kache and Seuring, 2017), make data-driven decisions (Eastburn and Boland, 2015; Brynjolfsson and McElheran, 2016; Zhou et al., 2016) and ultimately enhance firm performance (Ji-Fan Ren et al., 2017; Wamba et al., 2017; Muller et al., 2018). It is increasingly recognised that big data can significantly improve the decision-making process and create business value (Raguseo and Vitari, 2018).

Furthermore, the Malaysian government supports the growth of big data analytics investments in firms through initiatives such as Digital Malaysia (MyDIGITAL) and the National Big Data Analytics Centre (NBDAC). The Malaysia Digital Economy Blueprint was introduced in 2021 and outlined the initiatives to achieve the aspirations of MyDIGITAL. The Blueprint aims to transform the Malaysian economy into a digitally driven economy (Economic Planning Unit, 2021). Under MyDIGITAL, initiatives were introduced to foster the growth of various digital sectors, including big data analytics. MyDIGITAL accentuates the importance of leveraging data to drive innovation, increase productivity and generate economic value (Economic Planning Unit, 2021).

Additionally, the NBDAC was established in 2016 to position Malaysia as a regional hub for big data analytics (Jaafar, 2023). The NBDAC focuses on developing the necessary infrastructure, talent and policies to support the growth of the big data analytics industry and become an integrated data collection centre. It aims to drive investment in big data analytics to influence decision-making methods in both government and private sectors (Jaafar, 2023). These initiatives have created a favourable environment for developing data analytics capabilities and have positioned Malaysia as a regional hub for big data analytics.

Several previous studies have explored the impact of big data analytics on firm performance in Malaysia. For instance, these studies find a positive connection between big data analytics and firm performance (Chen et al., 2015; Wamba et al., 2017; Yadegaridehkordi et al., 2020; Adrian et al., 2018). These studies, among others, have shed light on the importance of big data analytics investments in Malaysia and their potential contributions to firm performance. However, further research is needed to understand how big data analytics investments influence firm performance in the Malaysian context. This study aims to address this gap by examining the association between gender diversity and big data analytics investments, considering how the unique characteristics of female directors on the board can leverage big data analytics to gain profits and competitive advantages (Raguseo and Vitari, 2018). Female directors are crucial in driving firm strategy and providing resources for big data analytics investments (Bommaraju et al., 2019).

In Malaysia, the Asian Financial Crisis in 1997 and The Global Financial Crisis in 2008 caused a severe recoil in the managerial regimes as the firms struggled for survival of firms during the period of recurring crises (Fligstein and Roehrkasse, 2016). To sustain the firms during the financial crisis, firms use short-term strategies with bad management practices (Jain and Zaman, 2020). These bad management practices resulting from ineffective monitoring of managerial discretion are the causes of weak corporate governance in firms (Chari and Dixit, 2020). The female directors on the board steer the firm's strategic direction (Hamzah et al., 2020). The female director's strategic role has been receiving greater attention, for instance, the influence of female directors on sustainable investment (Atif et al., 2020), environmental investment (Wei et al., 2017) and R&D investments (Firmialy and Adhiutama, 2020; Saggese et al., 2021). The paucity of research in these areas merited further investigation regarding the association between gender diversity and big data analytics investments. This study directs greater attention to the strategic function of female directors and the effects of gender diversity.

Evidence on gender diversity and corporate strategy shows mixed results suggesting that gender diversity can positively or negatively influence corporate strategy or may have no effect (Wei et al., 2017; Atif et al., 2020; Firmialy and Adhiutama, 2020; Saggese et al., 2021). These studies focused on board gender diversity but neglected the other equally essential gender aspects, such as board educational level, and therefore, this offers a fertile area for further research (Elmagrhi et al., 2019). Moreover, the big data literature has been primarily investigated conceptually, not empirically (Merendino et al., 2018). As a result, understanding the influence of gender diversity on big data analytics is incomplete. This study aims to fill this knowledge gap by assessing the moderating role of education diversity on the association between gender diversity and big data analytics investments.

This study employs the resource dependence theory by Pfeffer and Salancik (1978) to examine big data analytics investments and their association with gender diversity. Resource dependence theory suggests that organisations depend on external resources to achieve strategic objectives and that controlling resources is critical to organisational survival and success (Pfeffer and Salancik, 1978). In this context, the board of directors is crucial in ensuring the organisation has access to the necessary resources. The board of directors sets the firm strategy because they can discover critical information and essential resources that reduce uncertainty for strategic decision-making (Hernandez-Lara and Gonzales-Bustos, 2020).

From the resource dependence theory perspective, the board is seen as a resource for managing a firm's external environmental dependencies and uncertainties (Hillman et al., 2000). Pfeffer and Salancik (1978) outline four benefits of the board in terms of (i) advice and counsel; (ii) legitimacy; (iii) channels for communicating information between external organisations and the firm; and (iv) preferential access to commitments or support from essential elements outside the firm. To this end, a firm has to have the right mix of directors, particularly female directors who can bring the diversity of knowledge, skills, experience, expertise and ties to carry out their duties of monitoring, provision of resources and steering the strategic direction of the firm (Fama and Jensen, 1983). Gender diversity can influence the board's ability to acquire and control resources effectively. Gender diversity can bring diverse perspectives and experiences to the board, which may help to identify new opportunities and strategies for acquiring and controlling resources. Consistent with such arguments, studies tend to find a positive association between the proportion of female directors and corporate strategy (Amorelli and Garcia-Sanchez, 2020).

Consequently, the current study seeks to contribute to the existing literature. First, this study posits the critical types of resources for the firms and extends the understanding of co-optation and organisation performance in resource dependence theory by proposing that female directors form social connections with external organisations to ensure favourable resource exchanges and, in turn, contribute to big data analytics investments. Female directors link the firm with the external environment through network ties and contribute different perspectives, cultures and methods of working to the firms (Kamran et al., 2022).

Second, this study responds to different gender diversity scholars, such as Liao et al. (2019) and Elmagrhi et al. (2019), to further understand and gather new insights regarding female directors' roles. Liao et al. (2019) urge future researchers to concomitantly continue to understand other characteristics of female directors, such as the educational background of firms' operations and output. Similarly, Elmagrhi et al. (2019) document that studies examining the influence of unique female directors' characteristics, such as their level of education, on corporate strategy is scarce. Therefore, by examining the moderating effect of education diversity in the association between gender diversity and big data analytics investments, this study contributes to the existing body of knowledge by better understanding the association between female directors on the board and strategic decision-making.

Third, since investing in big data analytics is perceived as a strategy, this study explores how board processes, particularly decision-making processes concerning big data analytics, occur in an organisation. This study provides insights into whether and how female directors contribute to strategic decision-making to invest in big data analytics. Lastly, this study encourages policy formulation and emphasises the female directors' role in deciding the firm's strategic direction and ensuring that resources are available. Therefore, the outcomes of this study offer practical insights to the Malaysian government and policymakers, such as Bursa Malaysia and the Securities Commission Malaysia, in advocating gender diversity to improve corporate strategy.

The rest of the paper provides the theoretical framework and literature review leading to the development of hypotheses, explains the research methodology adopted in the paper, reports the empirical findings of the paper, discusses the findings of the paper, and concludes the paper.

Literature review and hypotheses development

Resource dependence theory

Big data analytics investments are explained using resource dependence theory, developed initially by Pfeffer and Salancik (1978). Resource dependence theory is fundamental to studying the influences of environments on corporate relations (Drees and Heugens, 2013). The organisation's survival depends on acquiring essential resources such as big data analytics. Hagstrom (2012) stated that big data analytics is a 'new paradigm of knowledge assets' and the upcoming innovative, competitive and productive frontier.

The basic assumption of resource dependence theory is the female directors' responsibility to ensure the firm's survival. Grounded in this theory, the firm's ability to acquire and maintain resources is the key to ensuring the firm's survival (Pfeffer and Salancik, 1978). Female directors are the primary linkage mechanism for connecting a firm with a source of external dependency. The firm can reduce dependence and gain valuable resources by utilising the female director's valuable knowledge, skills, influence or networks to external dependency sources.

Resource dependence theory explains the impact of gender diversity on big data analytics investments. A mix of expertise, experience and board knowledge can influence corporate decision-making. The ability of the female directors to provide resources to the firm by linking the firm with its external environment is essential. Female directors help to connect firms with the external environment through network ties. Female directors can build and maintain interpersonal relationships (Choi, 2019). Despite the minority status, female directors use their previous experience on other boards or network ties to create a perception of similarity with the majority and thus engage effectively in board work (Kamran et al., 2022).

In addition, female directors bring a different perspective to the boardroom, which can help to identify and respond to external changes or opportunities. For example, female directors are more attuned to issues related to innovation, which can help the firm to understand better and respond to changing social norms and expectations (Glass and Cook, 2018). Therefore, the resource dependence theory suggests that female directors can help link the firm with the external environment by providing access to different external resources and bringing a different perspective to the board. This can help to enhance the firm's ability to acquire and control external resources, which is critical to organisational success. Resource dependence theory is used in this study to explain big data analytics investments and their association with gender diversity.

Gender diversity, big data analytics investments and education diversity

In recent years, corporate board structure and its impact on firm behaviour have been global issues. The following subsections discuss literature in formulating hypotheses relating gender diversity to big data analytics investments in Malaysia, moderated by education diversity.

Gender diversity and big data analytics investments. The board of directors play a crucial role in strategic decision-making, as they oversee the firm's long-term direction and ensure that its strategy aligns with its goals and objectives. The board of directors are expected to provide strategic guidance and monitor the implementation of the firm's strategy. Accordingly, the directors fulfil strategic tasks to prepare strategic proposals and make decisions on long-term strategies and goals, putting those strategies and goals into action and controlling follow-up decisions on those strategies and goals (Torchia et al., 2011; Arzubiaga et al., 2018).

In particular, a diverse range of skills, experiences and perspectives in the boardroom is vital to help the directors to identify and evaluate a broader range of strategic options and to ensure that the firm's strategy is responsive to changing environment and stakeholder needs. Thus a diversified opinion enhances the decision-making of the board (Amorelli and Garcia-Sanchez, 2020).

Female directors contribute different perspectives, cultures and approaches to the firm (Hernandez-Lara and Gonzales-Bustos, 2020). Female directors bring different features and skills to the boardroom, which can help to identify and respond to external changes or opportunities (Abdelazim et al., 2022; Rakia et al., 2023). For example, Munir et al. (2020) state that female directors differ from male directors in handling tasks, analysing and processing information. Female directors encourage creativity and innovation in formulating firms (Katmon et al., 2017).

Female directors are more engaged in strategic change than male directors (Glass and Cook, 2018). The female directors are curious about the underlying values and actively raise their concerns about big data analytics in board discussions (Mikhailenko et al., 2021). The presence of female directors on the board improves decision-making quality and induces investments in big data analytics.

Gender has been empirically investigated regarding strategic decision-making, for instance, the influence of female directors on sustainable investment (Atif et al., 2020), environmental investment (Wei et al., 2017) and R&D investments (Firmialy and Adhiutama, 2020; Saggese et al., 2021). From a resource dependence theory perspective, female directors provide different perspectives and approaches to working for the firm (Hernandez-Lara and Gonzales-Bustos, 2020). Thus, a diversified opinion improves the decision-making of the board (Amorelli and Garcia-Sanchez, 2020).

According to Pfeffer and Salancik (1978), resource dependence theory asserts that directors help to decrease dependency between the firm and the external entities and the pertinent uncertainty by giving related to strategic change. Integrating female and male directors' heterogeneous knowledge and experience is essential in strategic change. In line with the empirical studies and the theoretical foundation, this study proposes that female directors on the corporate board positively affect the strategic decision-making that leads to investment in big data analytics. Hence, it can be hypothesised that:

H1: There is a positive association between gender diversity and big data analytics investments.

The moderating effect of education diversity. The effect of gender diversity on investments in big data analytics may vary depending on the educational level of the board members. The presence of female directors on the board promotes the firm strategic investment in big data analytics. Female directors' unique resources, expertise and advice enhance strategic board decision-making and improve investment efficiency in big data analytics (Shin et al., 2020). Firms with more gender-diverse boards are open to new ideas and perspectives, which leads to a greater willingness to invest in big data analytics (Glass and Cook, 2018).

However, the effect of gender diversity on investments in big data analytics may be moderated by education diversity. Resource dependence theory posits that firms rely on external resources to survive and thrive (Pfeffer and Salancik, 1978). Education diversity provides access to a diverse range of knowledge, skills and expertise, which can help firms to acquire and control external resources more effectively. In addition, the board of directors with different knowledge and experiences consider the implications of strategic decisions for a broader range of corporate stakeholders (Karim, 2021).

In contrast, when a board has a high education diversity, the effect of gender diversity on investments in big data analytics may be weaker. The diversified perspectives and backgrounds of the directors may hinder the board processes in formulating and implementing strategies (Merendino et al., 2018). The ineffective board processes cause poor communication and conflict of interest, which delay the information transfer among board members (Nordback and Espinosa, 2019). The shortcoming of having diversified educational levels is that the time required to compromise for a consensus is longer with diversified opinions from different areas of expertise.

Past literature establishes a relationship between gender and education diversity (Yang et al., 2019; Ramon-Llorens et al., 2019). Yet, few studies empirically test how education diversity moderates strategic organisational outcomes. This study suggests education diversity as a moderating variable that acts as a catalyst for the effect of gender diversity on big data analytics investments. Education diversity affects the direction and/or strength of the association between gender diversity and big data analytics investments. Previous studies indicate that education diversity catalyses organisational change (Ahmad and Yaseen, 2018; Triana et al., 2019).

Regarding moderating effect, limited evidence exists examining education diversity in certain relationships. Ahmad and Yaseen (2018) found a negative significant moderating impact of education diversity on business strategies and customer-focus management. The negative moderating effect may be due to the potential for education diversity to increase group conflict, contending that greater diversity may be adverse for firms if diversification reduces

group cohesion and hinders effective decision-making. Based on this presumption, this study also expects a negative moderating effect of education diversity on the association between gender diversity and big data analytics investments due to conflicts raised between board members.

Education diversity weakens the positive influence of gender diversity. This study suggests that when a board has a high education diversity, the effect of gender diversity on investments in big data analytics is weakened. Hence, it can be hypothesised that:

H2: Higher education diversity weakens the positive influence of gender diversity on big data analytics investments.

Conceptual schema

The two hypotheses are developed to examine the significance of the association between gender diversity and big data analytics investment, moderated by education diversity. The conceptual schema, including the direct effect and the moderated effect between the variables, is shown in Figure 1.

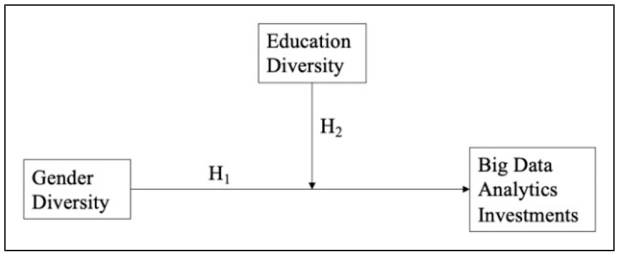

Figure 1. Conceptual schema.

Research methodology

The multimethod approach is used in this study because it contributes to the reliability and validity of the data and lessens the risk of common method bias. The data sources include primary data from the questionnaire survey to measure the dependent variable (big data analytics investments) and secondary data gathered from the annual reports to measure the independent variable (gender) and moderating variable (education), and the control variables (firm performance, firm age and board size). The year 2019 was chosen because of the introduction of Corporate Strategic Priorities (2017–2020) and the revised MCCG 2017. This study adopts multiple linear regression analysis as the statistical method to assess the research model.

Using the G*Power 3.1 software, a minimum sample size of 77 responses is needed to proceed with the data analysis. The expected response rate of 20% (158 responses) from the population is selected in this study using G*Power post hoc analysis. In this study, the sampling technique employed is the census method, which involves encompassing all elements of the population as the sample size (Cantwell, 2008; Ibrahim, 2020). In a census, no sampling is performed, and the goal is to collect information from every element of the population. This study focuses on all the 788 firms listed on the Main Market of Bursa Malaysia as the targeted population. The sample includes both adopters and non-adopters of big data analytics. A total of 161 responses are recorded.

This study adopts the survey as the data collection method for the dependent variable, big data analytics investments, for the following reasons. This study investigates the association between gender diversity and big data analytics investments, with education diversity as the moderator. Hence, the responses should be quantified into measurable variables for further analysis, which justifies the survey's adoption as the data collection method.

This study opts for the latter as the main vehicle for data collection between the paper survey and online questionnaire survey. Online questionnaire survey is selected because it takes advantage of the internet's ability to provide access to groups and individuals who would be difficult, if not impossible, to reach through other channels (Wright, 2005). According to Pugliese et al. (2014), the board of directors are busy professionals. The online questionnaire survey gives the board control over completing the survey to increase the engagement response rate. The online questionnaire survey is sent through email due to the cost-effectiveness, fast transmission and response turnaround (Dibb et al., 2001; Kent and Brandal, 2003). The respondents are chief executive officers or the managing directors of the firm. If the chief executive officer is unavailable, an additional request to complete the online questionnaire survey is sent to the chairman and executive directors.

The dependent variable, big data analytics investments, is measured for each firm, and the measurement item is adopted from a previously validated dimension used in Raguseo et al. (2020). The big data analytics investments construct refers to the use of at least one of the five big data analytics solutions, namely: (i) visual analytics software, (ii) in-memory analytics software, (iii) MapReduce and Hadoop software, (iv) social media analytics software and (v) predictive analytics software to determine whether the firms have invested a big data analytics solution and establish their experience over the years, which is measured with the following question: 'For the current fiscal year (e.g. 1 January 2020–31 December 2020), how many years ago did you first started using big data analytics that is structured as – 1. Visual analytics software, 2. In-memory analytics software, 3. MapReduce and Hadoop software, 4. Social media analytics software and 5. Predictive analytics software'. This construct equals 1 if the firm used at least one of the five big data analytics solutions in 2020 and 0 otherwise. Using the binary variable can result in losing information and power (Farrington and Loeber, 2000). However, the big data analytics investments construct is condensed into a binary variable because the responses should be quantified into measurable variables for further analysis, which justifies the survey's adoption as one of the data collection methods.

The average time to answer the survey questionnaire is 1 hour and 17 seconds. The survey questionnaires were dispatched to 788 firms listed on the Main Market of Bursa Malaysia from 11 January 2021 to 15 September 2021.

Concerning the independent variable, gender diversity is measured based on the proportion of female directors on the board (Erhardt et al., 2003; Levi et al., 2014; Luo et al., 2017; Bommaraju et al., 2019). Next, the moderating variable, education diversity, is measured by reference to the proportion of directors possessing Master degree, MBA degree,

Juris Doctor degree and PhD degree qualifications on board (Dalziel et al., 2011; Chen, 2012, 2014; Chen et al., 2013; Beji et al., 2020).

The control variables comprising firm performance, firm age and board size are measured for each firm. Firm performance is controlled as firms invest in big data analytics to gain a competitive advantage and improve firm performance. (Corte-Real et al., 2017). Firm performance is measured by Tobin's Q, defined as the sum of the market value of equity (share price multiplied by the number of ordinary shares in issue at fiscal year-end) and the book value of debt divided by the book value of total assets. Tobin's Q is used in prior studies as a proxy for firm performance, for example, Isidro and Sobral (2015), Green and Jame (2013), and Carter et al. (2010). The firm age is controlled as firms may become more bureaucratic and inert over time, thus unable to adapt to changing circumstances efficiently (Richard et al., 2019). The firm age is measured by the number of years that a firm has been established (Chen, 2014; Coad et al., 2016; Richard et al., 2019). A board with an optimum number of directors is crucial to advise and monitor the management and make decision-making to invest in big data analytics (Bhimani, 2009). Board size is measured by the number of directors sitting on the board of an individual firm (Ruigrok et al., 2006; Husnain et al., 2021; Khan et al., 2021).

Before data collection, a pre-test is conducted. Sekaran and Bougie (2003) stated that a questionnaire survey must conduct a pre-test to confirm that there is no ambiguity in the questions and that respondents can fully understand the questions the way they are designed and intended. The pre-test survey was carried out in October 2020.

The pre-test is important to establish the instrument's content validity (Straub, 1989). Establishing content validity is important as it represents the items' appropriateness on the instrument for measuring constructs (Straub, 1989; Straub et al., 2004; Lewis et al., 2005). Each item should be representative of the construct and comprehensively cover all aspects of the construct. This study follows the suggestions of Lewis et al. (2005) on establishing content validity by conducting pre-tests and a preliminary test.

For this study, two groups of experts were consulted. The first group consisted of a chairman and an executive director from two public listed firms in Malaysia. They were approached for their expertise, opinions and the questionnaire's design. Meanwhile, the second group consisted of four senior lecturers and one postgraduate student from Curtin University Malaysia, who were asked to comment on the questionnaire's design and research methodology.

This study requires a preliminary analysis to ensure the usefulness, reliability and validity before testing the proposed model (Hair et al., 2009). The data screening for missing data and normality checks are conducted in this study.

Estimates of the regression equation are as follows:

$$\begin{aligned} &BIG\ DATA\ ANALYTICS\ INVESTMENTS \\ &= \beta_0 + \beta_1 GENDER + \beta_2 FIRM\ PERFORMANCE \\ &\quad + \beta_3 FIRM\ AGE + \beta_4 BOARD\ SIZE \\ &\quad + \beta_5 GENDER * EDUCATION + \varepsilon \end{aligned}$$

where

BIG DATA ANALYTICS INVESTMENTS	Big data analytics investments
GENDER	Gender
FIRM PERFORMANCE	Firm performance
FIRM AGE	Firm age
BOARD SIZE	Board size
GENDER * EDUCATION	Interaction between gender and education
β_0	Constant
$\beta_1 - \beta_5$	Regression coefficient
ε	Error term

Results

Descriptive statistics

Table 1 presents the descriptive statistics. The mean value of big data analytics investments is 0.910, with a standard deviation of 0.292. The findings reflect that 146 out of 161 firms have used at least one of the five big data analytics solutions, namely: (i) visual analytics software, (ii) in-memory analytics software, (iii) MapReduce and Hadoop software, (iv) social media analytics software and (v) predictive analytics software in the year 2020.

The table indicates the average of female directors on board is 19.6%. Hence, the involvement of female directors on boards of Malaysian public listed firms is considered low, below the recommended 30.0%. The results reveal an inadequate representation of females on the board. The mean value of Tobin's Q of public listed firms in Malaysia is 2.365. Besides, the mean values of the firm age, board size and education diversity are 30.630, 7.940 and 34.4%, respectively.

Common method bias

Harman's single-factor test in SPSS to identify common method variance. In exploratory factor analysis (EFA), a significant amount of common variance in the process is

Table 1. Descriptive Statistics (n = 161).

Variables	Minimum	Maximum	Mean	Standard deviation
Big data analytics investments	0.000	1.000	0.910	0.292
Gender	0.000	0.500	0.196	0.135
Firm performance	0.050	66.910	2.365	7.731
Firm age	2.000	113.000	30.630	20.197
Board size	4.000	15.000	7.940	2.098
Education	0.000	0.880	0.344	0.200

assumed to exist when a single factor emerges or one general factor accounts for most of the measure. In the total variance explained results, the percentage of variance under extraction sums of squared loadings should be less than 50% (Podsakoff et al., 2003). The test is performed on all 6 items to assess the research model. The percentage of variance in the extraction sums of squared loadings is only 16.1%, far below the recommended 50%; hence, common method bias may not be a concern in this study.

Pearson's correlation test

Table 2 presents the Pearson's correlation. Pearson's correlation measures the linear relationship between two continuous random variables. It does not assume normality, although it assumes finite variances and covariance. When the variables are bivariate normal, Pearson's correlation provides a complete description of the association (Hotelling and Pabst, 1936). The highest correlation of 0.317 between big data analytics investments and education is reported. According to Gujarati (2003), multicollinearity is a problem when the correlation coefficient between two variables is more than 0.800. None of the variables is correlated at 0.800 and above, indicating that multicollinearity may not be a concern in this study (Gujarati, 2003; Hair et al., 1998).

Hypothesis testing Procedures

Multiple linear regression analysis is a statistical method utilised to determine the relationship between one dependent variable and one or more independent variables (Hair et al., 1998). Multiple linear regression, specifically Ordinary Least Squares (OLS) regression, is used as the primary statistical method for data analysis. Before undertaking the regression analysis, this study examines whether the regression assumption is fulfilled.

Testing the assumptions of multiple linear regression

Before carrying out a multiple regression analysis, it is essential to note that some general assumptions are required for this analysis. These assumptions are related to the residual terms that must be independent and identically normally distributed with a uniform variance.

First, the normality of the variables is examined using the Shapiro-Wilk test. The results report a significant effect ($p < .05$) thus indicating that the research data is not normally distributed. The variables, firm performance, firm age and education are transformed using mathematical functions such as the natural logarithm and square root to make it more approximately normal. This can help stabilise the variance and make the residuals more normally distributed.

Second, the scatterplot is used to check the homogeneity of variance of the residuals (homoscedasticity). A horizontal line with equally spread points shows homoscedasticity. The variance of the error is constant. This indicates that heteroscedasticity may not be a concern in the regression model.

Lastly, all variables have variance inflated factor (VIF) values below 10, indicating multicollinearity may not be a concern in the regression model.

Multiple linear regression analysis

In testing the study's hypotheses, the multiple linear regression analysis uses big data analytics investments as the dependent variable and gender diversity as the independent variable. Education diversity is moderating variable. The firm performance, firm age and board size are control variables.

Table 3 presents the results of the regression analysis. Based on the regression results, the model is valid, meaning that at least one of the variables is a significant determinant of the big data analytics investments (F value= 3.954, $p = .003$). In addition, the variables included in the model can explain 13.8% of the variance in the big data analytics investments, as shown by the Adjusted R Squared.

The results reveal a significant positive relationship between board gender diversity and big data analytics investments ($\beta = 0.380$, $p < .001$), controlling for firm performance ($\beta = -0.014$, $p = .895$), firm age ($\beta = 0.127$, $p = .223$) and board size ($\beta = -0.039$, $p = .702$). The coefficients reported are standardised, indicating that a one-unit change in the independent variable corresponds to a change in the dependent variable in the same units. Therefore, a one-unit increase in board gender diversity is associated with 0.380 units increase in big data analytics investments, holding constant, firm performance, firm age and board size. Hence, H1 is supported. The results are consistent with the positive association between gender diversity and strategic decision-making reported by Hsu et al. (2019), Shin et al. (2020), and Atif et al. (2020). From a resource dependence theory perspective, female directors give different views and approaches to working for the firm (Hernandez-Lara and Gonzales-Bustos, 2020). Thus, a diversified opinion

Table 2. Pearson's correlation test.

Variables	1	2	3	4	5	6
1. Gender	1					
2. Firm performance	−.190**	1				
3. Firm age	.166*	−.139*	1			
4. Board size	.181*	−0.095	0.030	1		
5. Education	.193**	−0.086	−0.009	.213**	1	
6. Big data analytics investments	.227**	−0.117	−0.001	.175*	.317**	1

Note: Association of ** represents correlation is significant at the 0.01 level, and * represents correlation is significant at the 0.05 level. The result is based on a one-tailed test.

Table 3. Multiple linear regression analysis results.

	Coefficients				
Variables	Unstandardised	Standardised	Standard error	t-value	*p*-value
(Constant)	−0.543		0.365	−1.486	0.141
Gender	1.859	0.380	0.503	3.698	<0.001
Firm performance	−0.014	−0.014	0.105	−0.133	0.895
Firm age	0.264	0.127	0.215	1.228	0.223
Board size	−0.012	−0.039	0.031	−0.383	0.702
Education	−0.391	−0.289	0.137	−2.865	0.005
Adjusted R squared	0.138				
F-value	3.954				
p-value	0.003				
Durbin Watson	2.057				
No. of Observations	161				

Note: Associations ** and * denote 0.01 and 0.05 significance levels, respectively. One-tailed probabilities are used for the tests of the variables since the associated hypothesis are directional.

Table 4. Moderation results.

	Relationship	Path coefficient	Standard deviation	t-value	*p*-value	Decision
	Gender diversity -> big data analytics investments	0.196	0.173	7.282	<.001	
H2	Gender diversity*Education diversity -> big data analytics investments	−0.217	0.020	−2.885	0.004	Supported

Note: One-tailed t-values are used for the tests of the variables since the associated hypothesis are directional.

improves strategic decision-making to invest in big data analytics (Amorelli and Garcia-Sanchez, 2020).

Test for moderation

The outcomes of the moderation analysis for hypothesis H2 are provided in Table 4. The interaction term, Gender Diversity*Education Diversity, shows a negative effect on big data analytics investments of −0.217, while the simple effect of gender diversity is 0.196. The average gender diversity level is 0.196, whereas the higher education diversity level is 0.217. Kenny (2018), 0.005, 0.01 and 0.025 represent small, medium and large effect sizes. In this study, the effect size of 0.040 is considered large. The interaction effect is statistically significant ($t = -2.885$, $p = .004$), indicating that education diversity moderates with a negative (−0.217) moderation. Higher education diversity weakens the positive association between gender diversity and big data analytics investments.

Education and gender diversity can complement each other in influencing big data analytics investments, as per the resource dependence theory (Pfeffer and Salancik, 1978). According to the resource dependence theory, firms effectively manage external dependencies. The diversity in education and gender among directors provides a broader array of resources and perspectives, enabling firms to navigate complex situations (Merendino et al., 2018; Nieto et al., 2019).

However, the result shows that when boards have high education diversity, the positive influence of gender diversity on big data analytics investments appears to diminish. The significant negative effect of the interaction term ($\beta = -0.217$, $t = 2.885$, $p = .004$) suggests that high education diversity weakens the positive impact of gender diversity on big data analytics investments. The findings support H2 as the result aligns with the negative significant moderating effect of education diversity on business strategies and customer-focus management reported by Ahmad and Yaseen (2018). Diverse perspectives and backgrounds of directors may lead to communication issues and hinder consensus-building due to differing opinions from various areas of expertise (Merendino et al., 2018; Nordback and Espinosa, 2019).

On a side note, this study compares the marginal effects on big data analytics investments to assess the significance of the interaction effect compared to the coefficient of the moderating variable (education diversity). The interaction effect's coefficient (−0.217) is statistically significant but smaller than the coefficient of the moderating variable (education diversity) (0.313). This implies that the direct effect of education diversity is more influential in explaining the variation in big data analytics investments than the interaction effect.

The simple effect of education diversity on big data analytics investments ($\beta = -0.289$, $t = -2.865$, $p = .005$) indicates a significant positive association. The educational backgrounds of directors play a crucial role in supporting strategic changes (Bernile et al., 2018; Aberg et al., 2019). Scientific knowledge acquired through higher education is vital for solving complex tasks. The directors' educational backgrounds reflect the quality of advice they provide, influencing the calibre of initiatives undertaken to invest in big data analytics.

However, when education diversity is used as a moderating variable in the association between gender diversity and big data analytics investments, the benefits of education diversity among female directors may not materialise as expected. A small number of female directors may lead to marginalisation, with their voices and contributions receiving inadequate attention or influence (Sarabi and Smith, 2021). This situation may limit the influence of their diverse educational backgrounds on board strategic decision-making, including big data analytics investments.

Token female directors may face challenges and gender stereotype biases, reducing their effectiveness in advocating for strategic decision-making in big data analytics investments. The appointment of female directors for affirmative action or appeasing special interest groups may perceive them as less valuable board members (Sarabi and Smith, 2021). Gender stereotype biases can inhibit trust and communication among board members (Siddiki et al., 2017), leading to hesitancy among female directors to express their concerns about a firm's strategy. Consequently, this can impede big data analytics investments.

To optimise the benefits of education and gender diversity, firms should establish an inclusive boardroom environment where all directors, regardless of gender and educational background, have equal opportunities to contribute and have their voices heard. Increasing gender diversity on boards and promoting a culture valuing diverse perspectives can lead to better decision-making, including big data analytics investments. This approach unlocks the full potential of education diversity among all directors, while efforts to ensure the involvement of female directors can mitigate marginalisation and enhance the effectiveness of gender diversity initiatives.

Robustness test on education diversity

The additional analysis is conducted to examine the robustness of the results to different assumptions about the level of education diversity on the board. The additional analysis excludes firms with no education diversity on the board. The association between gender diversity and big data analytics investments are examined separately for firms with diverse educational levels.

The results in Table 5 illustrate a significant positive relationship between board gender diversity and big data analytics investments ($\beta = 0.315$, $p = .005$), thus supporting H1.

Additionally, the results in Table 6 show education diversity negatively moderates the association between gender diversity and big data analytics investments ($\beta = -0.186$, $t = 2.219$, $p = .028$), supporting H2.

The results of the above are consistent with the main analysis results, proving that the results from the additional analysis have passed the robustness test and the regression results are reliable.

Discussions

The results indicate that a higher proportion of female directors on board enhances big data analytics investments. Female directors are more relational and emphasise novelty and innovation than male directors (Glass and Cook, 2018). Female directors exercise service roles in strategy to provide resources and influence big data analytics investments (Arzubiaga et al., 2018). From a resource dependence theory perspective, female directors are an essential resource to firms based on their contributions to bringing new ideas and expertise to the board for strategic decision-making (Walt and Ingley, 2003). Female directors' knowledge, commitment and enthusiasm to explore new ideas lead to better board strategic decision-making to invest in big data analytics (Nahum and Carmeli, 2020). The results are consistent with Rejeb et al. (2020), Beji et al. (2020), and Leyva-Townsend et al. (2021), which found a positive association between female directors on the board and strategic board decision-making.

As technological changes reshape industries, firms call for gender diversity in their strategy (Veile et al., 2021). The board deals with these competitive and social conditions (Cucari et al., 2018). The Malaysian government introduced Corporate Governance Strategic Priorities (2021–2023) to leverage technology to monitor corporate governance practices. Female directors recognise big data analytics as leverage to improve corporate strategy and promote business growth. Subsequently, big data analytics is included in the board's agenda. With female directors on board, investment in big data analytics is accelerated.

The results support the resource dependence theory that female directors offer resources and expertise to invest in big data analytics (Castellanos and George, 2020). The findings are consistent with past studies by Atif et al. (2020), Wei et al. (2017), Firmialy and Adhiutama (2020), and Hernandez-Lara and Gonzales-Bustos (2020) that report female directors contribute to work related to long-term strategies and overall goals.

Additionally, education diversity negatively moderates the association between gender diversity and big data analytics investments. The negative effect points to ineffective board discussions due to potential miscommunication and conflicts between board members. The board's divergent educational levels and ideas may interfere with and create complicated decision-making (Merendino et al., 2018). Furthermore, consensus and uniformity among the board of directors matter in supporting strategic changes in investing in big data analytics. Reiterating in another way, the board of directors make strategic decision-making in a complex and uncertain nature when supporting firms with strategic advice and providing a resource. However, such conditions favour uniform, not diverse, perspectives.

Moreover, the time-consuming decision-making is another possible reason that negatively moderates the relationship. Poor communication and conflict of interests delay the information transfer among board members (Nordback and Espinosa, 2019). The time required to compromise for a consensus might be longer with diversified opinions from different areas of expertise.

Conspicuously, education diversity can create communication barriers and group conflict, hindering effective decision-making, including strategic investment in big data analytics. While board gender diversity is positively associated with big data analytics investments, education diversity negatively moderates this association. The negative moderating effect reflects that with the increase in education diversity, the positive association between board gender diversity and big data analytics is weakened. This finding is

Table 5. Multiple linear regression analysis results (robustness test).

	Coefficients				
Variables	Unstandardised	Standardised	Standard error	t-value	*p*-value
(Constant)	−0.431		0.331	−1.304	0.196
Gender	1.316	0.315	0.459	2.870	0.005
Firm performance	−0.072	−0.083	0.095	−0.757	0.452
Firm age	0.266	0.149	0.197	1.345	0.182
Board size	−0.019	−0.072	0.028	−0.666	0.508
Education	−0.259	−0.219	0.128	−2.024	0.046
Adjusted R squared	0.099				
F-value	2.830				
p-value	0.021				
Durbin Watson	1.943				
No. of Observations	148				

Note: Associations ** and * denote 0.01 and 0.05 significance levels, respectively. One-tailed probabilities are used for the tests of the variables since the associated hypothesis are directional.

Table 6. Moderation results (robustness test).

	Relationship	Path coefficient	Standard deviation	t-value	*p*-value	Decision
	Gender diversity -> big data analytics investments	0.191	0.151	2.268	0.025	
H2	Gender Diversity*Education diversity -> big data analytics investments	−0.186	0.018	−2.219	0.028	Supported

Note: One-tailed t-values are used for the tests of the variables since the associated hypothesis are directional.

consistent with Ahmad and Yaseen (2018) arguing that education diversity negatively moderates business strategies and customer-focus management.

Implications and conclusion

The findings from this study are essential for improving the stock of knowledge on corporate strategy and providing theoretical and practical implications.

One of the important functions of the board is the provision of resources. This study extends the understanding of co-optation and organisation performance in resource dependence theory. This study states that female directors contribute linkage to acquiring sufficient support from the external environment for resource exchanges. Female directors link the firm with the external environment by giving access to various types of external resources through network ties and by bringing different ideas, values and perspectives to the board.

Furthermore, the resource dependence theory suggests that firms depend on external resources to achieve their goals and that the availability and accessibility of these resources can influence their behaviour. The findings of this study imply that firms may face challenges in accessing and utilising external resources due to the negative moderating effect of education diversity on the association between gender diversity and investments in big data analytics. The findings suggest that firms must consider the board composition, expertise and skills needed to pursue strategic initiatives in big data analytics investments. The findings that indicate that higher education diversity weakens gender diversity and big data analytics investments association highlight the importance of effective communication and collaboration among board members (Nordback and Espinosa, 2019). Firms must ensure that directors with different educational levels can effectively work together to leverage their expertise and knowledge in strategic board decision-making.

The findings of this study have several practical implications for firms, policymakers, regulators and investors. From the regulator's perspective, the findings of this study are of interest to policymakers such as Bursa Malaysia and the Securities Commission Malaysia. Securities Commission Malaysia should provide a more extended transition period for fully adopting the quota regulation to enhance females' participation in the workforce so they can diligently perform their strategic roles on the corporate boards. Nonetheless, policymakers should continue advocating and enforcing gender diversity to enhance corporate strategy.

From a firm perspective, the results would be helpful to the board of directors, especially the nomination committee, which oversees directors' selection and assessment (Securities Commission Malaysia, 2012). The findings will serve as a point of reference to the nomination committee in advocating annual board reviews to raise awareness of the contribution of female directors to a firm's strategy. Moreover, the nominating committee should ensure the recruitment exercise includes female candidates. The nominating committee should facilitate various female training to create a larger pool of eligible female candidates for board positions. Board structure and composition recognising the role of female directors as active and responsible fiduciaries should be strengthened.

Besides, the results would be helpful to the board committee in improving how meetings are conducted and information is disseminated. The board failed to benefit from

the directors' educational level in investing in big data analytics because of the communication barriers and group conflict. Relatedly, solutions should be in place to cope with obstacles that limit the directors' potential and may focus on facilitating or encouraging the directors' active, open and accessible approaches in strategic board decision-making. Firms need third parties, for instance, a board committee, to facilitate the flow of all required information to directors before board meetings. Likewise, to facilitate open debates. The board committee should review how board members interact and participate and how decision-making is made.

The findings would benefit the firms investing in big data analytics on the board processes, particularly decision-making processes and investment outputs. This study reveals that the participation of female directors facilitates big data analytics investments. Firms can leverage these findings to shape their business strategies, recognising gender diversity as a driver for driving big data analytics investments. The different perspectives of female directors contribute to the effectiveness of strategic changes related to big data analytics investments.

The findings would be useful to the investors on how boards should engage in strategic issues. This study offers insights that the gender diversity of the board of directors can contribute to big data analytics investments. This study implies that leveraging big data analytics investments requires the board's strategic role. The finding of this study suggests that female directors are an essential resource to firms in bringing new ideas and expertise to the board for strategic decision-making to invest in big data analytics.

Meanwhile, this study has some limitations for considering only one year, which is the year 2019. The selection of one year may not be generalisable to other periods. This limited period allows only particular conclusions that are limited by the context. Future research could extend the analysis by increasing the time horizon to evaluate the revised MCCG 2017 impact within the Malaysian context. Moreover, the study uses online questionnaire surveys and annual reports as the main sources for data collection. As other reporting mediums such as media, websites and interviews show another viewpoint of the firm, future studies can include media, websites and interviews as the source of information.

Finally, the results indicate that a higher proportion of female directors on board enhances big data analytics investments. This study provides references for future studies. The results imply that policy reforms aimed at improving the participation of female directors on the board should be directed at enhancing the female director's strategic role in the firm. It also highlights the need for continued research for a deeper understanding of the intervening processes and better insights into how education diversity affects Malaysian firms' corporate strategy. The moderating effect of education diversity on this association provides empirical evidence and fetches theoretical support from existing literature.

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