Operating Cash Flows, Board Characteristics and Adoption of IR 4.0 Technologies

Shu-Fen Chuah, Char-Lee Lok* and Chee-Wooi Hooy

ABSTRACT

Manuscript type: Research paper
Research aims: This study examines the effect of operating cash flows (OCF) on firm innovation, as represented by the adoption of fourth industrial revolution (IR4.0) technologies. Board characteristics that act as corporate governance mechanisms are introduced as moderators.
Design/Methodology/Approach: The study sample consists of 954 publicly listed firms traded on Bursa Malaysia in 2019. The logistic and linear regression models are employed.
Research findings: Our study found that increasing OCF encourages firm innovation. Both logistic and linear regressions show that board size and board independence are positive moderators, while multiple directorships and busy boards are negative. Chairman-CEO duality has a direct negative impact on firm innovation and negatively moderates the relationship between OCF and IR4.0 adoption in linear regression.
Theoretical contribution/Originality: This study proposed that the adoption of IR4.0 technologies could be observed via (i) the hiring of key personnel with IR4.0 experience, (ii) the appointment of a chief information officer (CIO), (iii) the establishment of the technology committee, and (iv) the acquisition of IR4.0 technology. The positive

* Corresponding author. Char-Lee Lok is a Senior Lecturer at the School of Management, Universiti Sains Malaysia, 11800, Pulau Pinang, Malaysia. Email: lokcl@usm.my.
Shu-Fen Chuah is an Academic Fellow at the Faculty of Business, Economics and Social Development, Universiti Malaysia Terengganu, 21030, Kuala Nerus, Terengganu, Malaysia. She is also the Ph.D. candidate at the School of Management, Universiti Sains Malaysia, 11800, Pulau Pinang, Malaysia. Email: chuah@umt.edu.my / shufen.chuah@student.usm.my.
Chee-Wooi Hooy is a Professor at the School of Management, Universiti Sains Malaysia, 11800, Pulau Pinang, Malaysia. Email: cwhooy@usm.my.

https://doi.org/10.22452/ajba.vol17no1.2

findings highlight the importance of "quantity" within the board—having a larger board size and more independent directors establishes a stronger connection between the firm and additional resources, reinforcing the positive association between operating cash flows and firm innovation. Conversely, the "quality" of the board is equally vital. Chairman-CEO duality, multiple directorships, and busy boards are shown to reduce monitoring quality, thereby exerting a negative influence on the relationship between operating cash flows and firm innovation.
Practitioner/Policy implication: This study reveals approaches firms could undertake to welcome IR4.0 and improve firms' corporate governance policies, particularly those related to board-level policies such as board size, board independence, chairman-CEO duality, multiple directorships and busy board.
Research limitation: It is challenging to quantify firm innovation. The mentioned approaches may only partially reflect the firms' adoption of IR4.0 technologies.

Keywords: Adoption of IR 4.0 Technologies, Agency Theory, Board Characteristics, Firm Innovation, Operating Cash Flows, Resource Dependence Theory
JEL Classification: G30, G31, G32, G41

1. Introduction

In the ASEAN region, Malaysia's economy is growing rapidly, encouraging technological advancements in many industries (Suki et al., 2022). Malaysia's government recognised the benefits of the fourth industrial revolution (IR4.0). Therefore, the government provides various tax incentives, including zero corporate tax rates for up to ten years for companies adapting IR4.0 technology and digitalisation (Ministry of Finance Malaysia, 2021). Despite many government initiatives to promote IR4.0, the Malaysian economy is still in the early stages of transitioning to the IR4.0 ecosystem, lacking knowledge about the norms, standard specifications and the concept of smart manufacturing as demanded by IR4.0 (Tay et al., 2021). According to Backhaus and Nadarajah (2019), Malaysian manufacturing technology will likely remain mainly at the mass production and automation levels of Industry 2.0 and 3.0. In developing countries like Malaysia, digital innovation is mainly through imitation, foreign direct investment, or foreign technology transfer (Bekhet & Latif, 2018). IR4.0 is expected to deliver a high degree of digitalisation, automation, virtualisation, and decentralisation across all industry sectors (Bordeleau et al., 2020).

Digital transformation requires significant amounts of investment; therefore, the ability of a firm to generate cash flows from its

operations is crucial in transitioning to the IR4.0 system. Ghobakhloo et al. (2021) found that financial resource availability is the most frequently mentioned barrier to digital transformation for developing countries. In addition to external loans, a positive operating cash flow resulting from sales growth is an internal resource for a firm's innovation (Ding et al., 2022). A favourable operating cash flow represents increased asset productivity and is unaffected by depreciation and goodwill while the firm maintains its capital expenditure (Healy et al., 1992). According to Lewellen and Lewellen (2016), internal funds cost less than external funds, so companies tend to invest more when cash flow is high. Beladi et al. (2021) found that R&D investment decisions tend to be more conservative and cautious due to the precautionary effect of cash flow uncertainty. Similarly, Pham et al. (2018) suggest that liquid assets mitigate the harmful impact of cash-flow uncertainty and decrease the cost of raising external capital. As a result, positive operating cash flows allow a manager to be more flexible in making investment decisions related to technological innovation.

In adopting IR4.0 technologies, internal managers are better informed than outside investors about the distribution of the new project's future cash flows. They should operate in the best interest of current shareholders (Dionne & Ouederni, 2011). However, managers can exceed spending internally, especially if the firms are exposed to significant market flaws. Agency theory suggests internal corporate governance mechanisms to mitigate agency conflicts between management and shareholders (Sharma, 2011). Thus, board independence is mandatory by market regulators, where at least half of the board members must be independent (Malaysian Code on Corporate Governance, 2017).

This paper extends the existing empirical literature on firms' financial constraints and adoption of IR 4.0 technologies, a form of firm innovation. There is no exact definition for innovation, but generally, innovation involves activities such as generating, adopting, implementing and incorporating new ideas, practices or objects in the organisation (Wan et al., 2005; Van de Ven et al., 1989). This paper proves that internal funds relax firms' financial constraints through positive operating cash flows for firms to invest in IR4.0 technologies, using the sample of 954 publicly listed firms in Malaysia in 2019. As an emerging economy, Malaysia differs from many other countries that have been widely considered in the extant literature. Therefore, policymakers in Malaysia should analyse the possible threat of IR4.0 adoption (Abdul-Hamid et al., 2021). Moreover, the Eleventh

Malaysia Plan rolled out by Malaysia in 2015 has been recognised as one of the most influential public policies related to the fourth industrial revolution policy" (Liao et al., 2018); hence the research context is relevant to the issue IR4.0 adoption. While there is ample research on the effect of operating cash flows on financial indicators such as debt level, firm performance, earnings management, and R&D investment decision (Al-Debi'e, 2011; Beladi et al., 2021; Hastuti et al., 2018; Jang & Kim, 2017; Liman & Mohammed, 2018; Martani & Dini, 2010; Soet et al., 2018), little has studied the relationship between operating cash flows and firm innovations, and this forms an area to be explored. This paper exploits the interaction between the operating cash flows and effective board monitoring in adopting IR4.0. We argue that while positive operating cash flow provides an internal source of capital, the board is a vital resource that connects the firms with external contingencies (following resource dependence theory). In contrast, effective board monitoring alleviates agency costs in adopting technologies (following agency theory). The empirical results show that positive operating cash flows significantly promote firms' innovation, and the positive impact is more pronounced for firms with lower agency costs.

The rest of this paper is presented in the following sections. Section 2 shows the literature review and hypotheses development, whereas Section 3 describes the context and data in this study. Section 4 presents the findings and discussion, and lastly, Section 5 shows the conclusion and implications.

2. Review of Literature and Hypotheses Development

2.1 Operating Cash Flows and Adoption of IR4.0 Technologies

Cash flow represents cash transactions moving into and out of a business. Other than an income statement and a balance sheet, a statement of cash flows is one of the major financial statements often being referred and analysed by scholars since it shows how much cash has been generated and spent in the business. Generally, cash flow can be classified into three categories: operating cash flow, investing cash flow and financing cash flow.

Operating cash flow is the cash obtained from sales or services of the business' operations. It is the portion of cash flow to fulfil cash needs internally without external financings, such as bank loans (Black, 1998; Nguyen & Nguyen, 2020). Greater operating cash flows may show the potential capability and flexibility of the firms to pay the debt, maintain operations, distribute dividends,

and invest in projects (Nguyen & Nguyen, 2020). According to Black (1998), operating cash flows are more value relevant than earnings, indicating it has the financial ability to capture and summarise the information which affects share values (Al-Debi'e, 2011; Hellström, 2005). Later researchers supported this finding as they found that operating cash flows positively related to return on assets (Soet et al., 2018), return on equity (Liman & Mohammed, 2018), and future operating cash flows in which operating cash flows prediction ability is better than future stock prices (Al-Debi'e, 2011) as well as negatively related to financial distress (Putri, 2021). Operating cash flows do not only reflect firm performance and earnings quality (Martani & Dini, 2010). Lower operating cash flows are also associated with higher debt levels (Harris & Roark, 2019) and higher discretionary accrual (Hastuti et al., 2018; Jang & Kim, 2017).[1] In other words, the lower the operating cash flows, the higher the tendency for the firms to commit discretionary accruals by overstating earnings (Hastuti et al., 2018). According to Nguyen and Nguyen (2020), operating cash flow also affects the investment decisions of individual investors, especially if the profit growth is negative. Besides that, opaqueness in operating cash flow indicates insufficient information for investors to determine firm value; hence operating cash flow opacity or non-transparency boosts stock price crash risk (Cheng et al., 2020; Jin & Myers, 2006).

Recent research by Liu et al. (2023) disclosed that firms with ample internal financial resources are more likely to embark on proactive research and development (R&D) endeavours which promote exploration innovation, while those with constrained financial resources are more inclined to prioritise earnings over R&D investments. Moreover, scholars such as Lewellen and Lewellen (2016) and Beladi et al. (2021) found that firms prefer to invest more when they have higher cash flows, as it signals better risk defence and greater financing ability. These signifying firms may invest in R&D and technology if they have higher operating cash flows. In contrast, businesses are reserved and very cautious in R&D innovation if there is cash flow uncertainty so that possible losses in the future can be avoided (Beladi et al., 2021). Prior researchers such as Bhagat and Welch (1995) and Ryan and Wiggins (2002) found a negative relationship between the levels of operating cash flows and R&D investment. Ryan and Wiggins (2002) and Brown et al. (2009) explain that the possible reason for this adverse finding is that young firms, particularly high-tech firms, are in a growing stage and often require extensive R&D investment; hence they

exhaust internal financing and are yet to produce positive operating cash flows. Although operating cash flow is the primary source of internal finance, it is highly uncertain, and its support for R&D can be unstable (Liu et al., 2023).

For these reasons, the effects of operating cash flows on various aspects remained an essential scope when many countries have revolved into the era of IR4.0 since the early 2010s. This study examines the relationship between operating cash flows and adopting IR4.0 technologies. We investigate whether the internal financing ability of the firms affects their moves in IR4.0 adoption. The firm requires an enormous amount of funds from the initiation to the completion of the IR4.0 transformation. A positive cash flow mitigates financial uncertainties in developing new technology. Therefore, a firm is more likely to invest in IR4.0 technologies when it obtains positive operating cash flows. Based on the above discussion, our primary hypothesis is as follows:

H_1: Operating cash flows increase the adoption of IR4.0 for the firm.

2.2 *Board Characteristics - Agency Theory and Resource Dependence Theory*

While agency theory is the most widely used theory that explains board of directors' roles, resource dependence theory offers a better understanding of boards (Hillman et al., 2009). To provide a comprehensive argument, both agency theory and resource dependence theory are used in this study to explain the effects of board characteristics on the relationship between operating cash flows and the adoption of IR4.0 technologies.

Agency theorists argue that a firm is based on contracts between self-interested individuals (Jensen & Meckling, 1976; Jensen, 1986; Eisenhardt, 1989). For instance, shareholders (the principal) authorise the managers (the agents) to act on their behalf in managing the firms. While the board of directors prefers business activities that maximise shareholder value, the manager may opt for safer business decisions that reduce employment risk, leading to greater agency cost (Jensen & Meckling, 1976; Jensen, 1986; Wang et al, 2018). *Agency cost* is the costs involved in fulfilling the principal-agent contract, for example, the principal's monitoring expenditures, the agent's bonding expenditures, and other possible residual losses (Jensen & Meckling, 1976).

Resource dependence theory views the firm as an open system which depends on contingencies in the external environment to

acquire resources and stay competitive (Pfeffer & Salancik, 1978; Hillman et al, 2009). Resource dependence theory shows external environment affects the firm behaviour, and it is believed that the way firms respond to and control external resources form the basis of power that will ultimately lead to organisational success (Davis & Cobb, 2010; Hillman et al., 2009; Pfeffer, 1972).

To sum up, agency theory provides perspectives on the contractual relationship within the firms, particularly on the board monitoring roles as the principal. In contrast, resource dependence theory complements the arguments by showing how the firms interact with the external environments, in which boards may enable firms to minimise dependence or gain resources through their resource provision role (Pfeffer, 1972; Wijethilake & Ekanayake, 2020). These will then explain the moderating role of the board of directors on the relationship between operating cash flows and the adoption of IR4.0 technologies in the firm.

2.3 Board Size

Board size represents the number of directors sitting on the board. Generally, the size of the board varies with business nature, board culture and firm size. Some CEOs who hold the chairman position at the same time intentionally boost the board size to showcase their status (Abidin et al., 2009; Dehaene et al., 2001). Agency theory commonly argues that a larger board has greater communication problems and group incoordination, hence a decrease in the board's ability to monitor the top management, and resulted in overpowered CEO, rising agency problems and adverse effects on the firms (Abidin et al., 2009; Eisenberg et al., 1998; Jensen, 1993; Wang et al., 2018; Yermack, 1996). Moreover, communication in the form of a willingness to exchange ideas leads to greater firm innovation (Wan et al., 2005). In short, a smaller board size is more efficient and favoured (Abidin et al., 2009; Wang et al., 2018). In contrast, resource dependence theory highlights the positive effects of having additional board members as more members allow more significant connections to external resources (Pfeffer, 1972; Goodstein et al., 1994; Wang et al., 2018), indicating more directors working toward the interest of stakeholders. That is to say; board size is not merely a number; it signals a pool of talents, skills, experience, and resources of the firm as well as the response of the firm to external challenges (Dalton & Dalton, 2005; Hidalgo et al., 2011; Hillman et al., 2009; Pfeffer, 1972; Wang et al., 2018). With diverse members, backgrounds and perspectives, boards have a more remarkable ability to monitor

and improve the firms (Adams et al., 2005). They can function with greater effectiveness and efficiency (Gandía, 2008). Both theories render plausible arguments regarding the pros and cons of having a greater board size. For instance, greater board size may lead to poor board monitoring and thus misuse of operating cash flow or overinvestment by the firm (following agency theory), or more resources working towards adopting IR4.0 technology so that the firm stays competitive and succeed in the era IR4.0 (following resource dependence theory). In the context of firm innovation and in line with resource dependence theory, greater board size may lead to more resources and ideas exchanged (Wan et al., 2005). With these, we deduce that board size is an important board element which affects the relationship between the operating cash flow and IR4.0 adoption, and it is hypothesised that:

> H_2: *Board size positively moderates the relationship between operating cash flows and the adoption of IR4.0.*

2.4 Board Independence

A literature survey shows that the discussion on board size is often accompanied by further discussion on board independence. As an illustration, Pfeffer (1972) stated that board size relates to the external environmental needs of the firms, and those with greater interdependence require a greater ratio of outside directors (Hillman et al, 2009). In a corporate governance context, more independent non-executive directors indicate greater board independence. Given their relatively neutral role compared to the executive directors, they are also known as outside or external directors (Dehaene et al., 2001). To be exact, except for their directorships, they have no ties with the firm, are not directly involved in the business activity, and can provide unbiased opinions to the board and management (Abidin et al., 2009; Clifford & Evans, 1997; de Villiers et al., 2011; Liao et al., 2015; Vitolla et al., 2019). Moreover, past literature showed that they have a greater interest in guaranteeing the achievement of objectives and more incentives to correct the firm behaviour (Chen et al., 2016; Fama & Jensen, 1983; García-Sanchez et al., 2011), henceforth a higher board independence ratio enable more effective monitoring by the firms (Liao et al., 2015; Vitolla et al., 2019). Viewing from the agency theory lens, independent directors monitor and ensure the functionality of the board and the directors to achieve the firm objective, mitigate management and shareholders' agency conflicts and minimise agency problems (Abidin et al., 2009; Bathala & Rao,

1995; García-Sanchez et al., 2011). However, close monitoring from the board may increase the task complexity of the managers and slow down the firm innovation as managers may need more time and effort to persuade the board to agree to the investment decision (Li & Yang, 2019). In relation to resource dependence theory, compared to executive directors, who are often the shareholders that manage the firms, independent directors are hired from the "outside". Their varied background forms an essential resource to the firms, connecting them to the outside world and acting as the resource provider who brings in the resources that match the firms' needs (Chen et al., 2016; Pfeffer, 1972). Following resource dependence theory, it is hypothesised that:

H_3: *Board independence positively moderates the relationship between operating cash flows and the adoption of IR4.0.*

2.5 Chairman-CEO Duality

The effects of board chairman-CEO have been empirically ambiguous. Chairman-CEO duality happens when a chairman of the board holds the CEO position at the same time. As aforementioned, close monitoring from the board may increase the task complexity of the managers in persuading the board to approve the investment decision (Li & Yang, 2019) and hence restrict innovation. However, Li and Yang (2019) further explained that if the CEO is a board chairman, this chairman-CEO would face less employment risk and experience less stress for short-term financial performance, so more freely and comfortable in pursuing exploration and innovation. While non-chairman CEO requires more time and effort to convince the chairman and the board members for decisions, a chairman-CEO has less task complexity in persuading and more freedom in making and implementing technology decisions (Li & Yang, 2019). The unity of command by a single leader, chairman-CEO, is more efficient in responding to external events (Boyd, 1995; Peng et al., 2007), and more efficiently and effectively in managing internal and external resources. As Wan et al. (2005) argued, flexibility and openness of organisational structure helps encourage new idea generation. In this case, the chairman-CEO face lesser restriction from the board for innovation. In line with agency theory, separating the chairman and CEO position is beneficial because separation in monitoring and controlling ensure the stakeholders' best interest (Peng et al., 2007). When the chairman is not the CEO, the CEO will face more pressure from the boards, pushing the CEO to be involved in exploitative

innovation and increase patent applications (Valencia, 2018; Li & Yang, 2019). Further supported by Wijethilake and Ekanayake (2020), when the CEO is equipped with additional informal power by holding the chairman-CEO position simultaneously, there is a negative effect on firm performance. Based on the literature, compared to non-chairman CEOs, the chairman-CEO faces lesser employment risk, task complexity in persuading and implementing technology decisions, and restriction from the board for innovation; hence, the chairman-CEO is more flexible in utilising operating cash flows for firm innovation. With these, we hypothesise that:

> H_4: *Chairman-CEO duality positively moderates the relationship between operating cash flows and the adoption of IR4.0.*

2.6 Multiple Directorship

The event when directors serve on the board and hold directorship in different firms is known as multiple directorships. While board size gives information about the number of directors who works towards the firm objectives, multiple directorships suggest the number of external resources that could be channelled to the firms, as highlighted by Boyd (1990) regarding the role of directors who have multiple directorships as "resource-rich" directors. Boyd (1990) further argues that as the number of other directorships each director holds (board interlock) is beneficial, the type of the director matters more than the number (Hillman et al., 2009). Supported by Pfeffer and Salancik (1978) and Chen et al. (2016), using resource dependence theory, the authors explain that there is a strong positive relationship between interlocking and competitiveness in the industrial and international market, thanks to the quality information obtained and board social capital formed through the directors' ability to access resources via the interlocking directorate ties (Chen et al., 2016; Hillman & Dalziel, 2003; Tian et al., 2011). This implies that interlocking directors may enhance firm innovation by bringing knowledge, technology or practice from their networks. However, agency theory has the opposite perspective. According to agency theory, multiple directorships harm the firms as they may not fully commit to monitoring the firm, resulting in high agency costs (Latif et al., 2013) and negative implications on firm performance (Haniffa & Hudaib, 2006). In addition, Sarkar and Sarkar (2009) evidenced that multiple independent directorships positively correlated with firm value while multiple directorships by inside directors have the opposite effect, supporting both resource dependence theory and

agency theory. This research suggests that directors with multiple directorship may not fully commit to monitoring the firm activities such as firm innovation. In line with agency theory, we hypothesise that:

H_5: *Multiple directorships negatively moderates the relationship between operating cash flows and the adoption of IR4.0.*

2.7 Busy Board

The multiple directorship variable measures the total board appointments of all individual directors, whereas the busy board variable considers the directors' busyness level and board involvement intensity. In this study, busy board ratio is defined as the total number of board members who hold at least three directorships divided by the total number of board members. Given that board of directors is equipped with experience, skills, knowledge and social capital, which may contribute to the firms, it is common for directors, especially outside directors, to be appointed by different companies (Latif et al., 2013; Haniffa & Cooke, 2002). Since multiple directorships are unavoidable, holding less than three directorships at one time is often considered the best practice (Latif et al., 2013) so that their monitoring roles is not compromised and agency problem would not arise, as argued in agency theory. Generally, successful firm innovation requires time, money, and leadership (Delbecq & Mills, 1985), so busy boards that put inadequate time, money, and effort could hurt firm innovation. Moreover, looking from the resource dependence theory point of view, Pfeffer and Salancik (1978) stated that directors could access external information and resources and bridge the firms to environmental contingencies. Eventually, their control over external resources will provide a basis of power for the firms to stay competitive in the market (Davis & Cobb, 2010; Hillman et al., 2009; Pfeffer, 1972). Without sufficient board involvement, none of these could be achieved. As innovation requires enthusiasm in information exchange and knowledge sharing (Wan et al., 2005), satisfactory board involvement and interactions are particularly essential. Hence, it is deduced that boards that are too busy may affect the relationship between operating cash flows and the adoption of IR4.0 and the last hypothesis is presented as follows:

H_6: *Busy board negatively moderates the relationship between operating cash flows and the adoption of IR4.0.*

3. Context and Data

In answering the question, "What are the most influential public policies related to the fourth industrial revolution?" Liao et al. (2018) stated that the "Eleventh Malaysia Plan" released by the Economic Planning Unit (EPU) Malaysia in May 2015, together with the other ten countries and one region had topped the list.[2] In fact, in preparing the nation to revolve into the era of IR4.0, the Malaysian government then rolled out an eight-year policy (2018-2025), National Policy on Industry 4.0 (Industry4WRD), on 31 October 2018. This study examines the relationship between operating cash flow and adopting IR 4.0 technologies.

Despite the lack of a clear definition, firm innovation could be interpreted as the generation, adoption, implementation and incorporation of new ideas, practices or artefacts in the organisation (Wan et al., 2005; Van de Ven et al., 1989). In this study, we argue that adopting IR 4.0 technologies is a form of firm innovation, as it involves introducing revolutionary technology, practice and culture that may immensely change the firm. Likewise, there is no exact definition for adopting IR 4.0 technologies. Hence, in this study, we propose that firm innovation regarding the adoption of IR4.0 technology could be observed via four categories:

(i) the hiring of key personnel with IR4.0 experience,
(ii) the appointment of a chief information officer (CIO),
(iii) the establishment of the technology committee, and
(iv) the acquisition of IR4.0 technology. All these data are downloaded and compiled from S&P Capital IQ before being filtered and identified. For example, we download all the key personnel profiles from S&P Capital IQ using People Screening Function. Then, the raw data is filtered using keywords, which results in a dummy variable DPROFILE takes value one if the key personnel profiles show relevant experience with blockchain, machine learning (ML), robotic, industry 4.0, Internet of things (IoT), artificial intelligence (AI), business intelligence (BI), big data and analytics, zero otherwise. Similarly, from the data available in S&P Capital IQ, we check if the firms have appointed Chief Information Officer (CIO) or established a technology-related committee. For instance, our sample shows that technology-related committee include the technology committee, information technology committee, information technology management committee, and information and communications technology

committee. If the firm appointed a CIO or established the committee as mentioned earlier, dummy variables DCIO and DCOMMITTEE take the value of one, respectively, and zero otherwise. Lastly, we check the customer list of the IR4.0 business solution company; then dummy variable DCUSTOMER equals one if the firm has acquired the IR4.0 business solution. Similar to DPROFILE which identify key personnel's IR4.0 background, for DCUSTOMER, we check the firms's IR4.0 background and identify whether the firms acquire business solution or technology related to blockchain, ML, robotic, industry 4.0, IoT, AI, BI, big data and analytics. To examine the total effect of these four categories, dummy variable adoption of IR 4.0 technologies (IR4.0) equals one if DPROFILE, DCIO, DCOMMITTEE or DCUSTOMER equals one, zero otherwise. These four efforts prepare the firms to be competitive players during the era of IR4.0.

On the other hand, for independent variable - operating cash flows (CASH) and control variables - Tobin's Q (TOBINQ), return on assets (ROA), market capitalisation (SIZE), firm age (FIRMAGE), payout ratio (PAYOUT) and revenue (REVENUE), they were obtained from S&P Capital IQ. The equation for the baseline model for this study is as follows:

$$ln\frac{P}{1-P} = \beta_0 + \beta_1 TOBINQ_i + \beta_2 ROA_i + \beta_3 SIZE_i + \beta_4 FIRMAGE_i + \beta_5 PAYOUT_i + \beta_6 REVENUE_i + \beta_7 CASH_i + INDUSTRY_i + \varepsilon_i$$

where $ln\frac{P}{1-P}$ represents the probability of the adoption of IR 4.0 technologies; β_x are the coefficients estimated by the model for Tobin's Q (TOBINQ) is the natural logarithm of the sum of market capitalisation and the book value of total liabilities, divided by book value of total assets, winsorised at 0.5 per cent to 99.5 per cent level. Return on assets is the earnings before interest and taxes divided by the average of the total assets year 2019 and total assets year 2018, winsorised at 0.5 per cent to 99.5 per cent level. Market capitalisation (SIZE) is the multiplication of the last close market price of the company's share with the last close outstanding shares. Firm age (FIRMAGE) is the difference between the year of study (2019) and the year founded. The payout ratio is the common and preferred stock dividends paid divided by the net income. Revenue (REVENUE) is the natural logarithm of the absolute value of total revenues. Operating cash flows (CASH) is the natural logarithm of cash from

operations. INDUSTRY represents industry dummy in the model for controlling industry-specific effects; ε represents the error term while i is the indice for individuals.

Using 954 public listed firms traded on Bursa Malaysia main market in 2019 and the final sample size of 642 firms for logistic regression,[3] we estimate the relationship between operating cash flows (CASH) and the adoption of IR 4.0 technologies (IR4.0), while controlling the effects of Tobin's Q, return on assets, firm size, payout ratio and revenue. Following the literature review, the moderating effects of board characteristics, namely board size (BOARDSIZE), board independence (INDEPENDENT), chairman-CEO duality (DUALITY), multiple directorships (MULTI) and busy board (BUSY), on the relationship between operating cash flows and the adoption of IR 4.0 technologies are being examined. We have converted the continuous variables data of board size (BOARDSIZE), board independence (INDEPENDENT), multiple directorships (MULTI) and busy board (BUSY), into dummy variables, as shown as DBSIZE, DINDEP, DMULTI and DBUSY respectively.[4] For the moderator DUALITY, no conversion has been done as it is in binary form.[5] All the board characteristics data is obtained from the company annual report. The logistic regression models with the moderator (i.e. dummy variable of board size, DBSIZE) are represented as follows:

$$\ln \frac{P}{1-P} = \beta_0 + \beta_1 TOBINQ_i + \beta_2 ROA_i + \beta_3 SIZE_i + \beta_4 FIRMAGE_i + \beta_5 PAYOUT_i + \beta_6 REVENUE_i + \beta_7 CASH_i + \beta_8 DBSIZE_i + \beta_9 (CASH * DBSIZE)_i + INDUSTRY_i + \varepsilon_i$$

In the further analysis involving other moderators, we substitute DBSIZE with DINDEP, DUALITY, DMULTI and DBUSY, each at a time, into the above equation. For robustness test, we employ linear regression in the last part of the data analysis and compare the logistic regression and linear regression results. The definitions of all the variables are presented in Appendix I.

4. Findings and Discussions

4.1 Descriptive Statistics and Correlation Analysis

Panel A Table 1 presents the descriptive statistics for the variables in this study, whereas Panel B gives information about the details of the dummy variables used. Our dependent variable is the adoption of IR 4.0 technologies (IR4.0), and its subcategories are DPROFILE, DCIO, DCUSTOMER and DCOMMITTEE. As can be seen in Panel B Table

1, out of the 954 firms, there are 133 (13.94 per cent) firms adopted IR4.0 technologies (IR4.0), with a majority of them being the clients of IR4.0 business solutions (DCUSTOMER), followed by appointing the chief information officer (DCIO), hiring key personnel with IR4.0 experience (DPROFILE), and lastly establishing the technology-related committee (DCOMMITTEE). In Panel A, the average board size in this study is 7, which is relatively consistent with the average board size of 7.84 by Abidin et al. (2009), who also studied the board size in Malaysia. On average, about half of the board (49 per cent) in publicly listed firms in Malaysia consist of independent directors (INDEPENDENT), and about a quarter of the firms (29 per cent) favoured chairman-CEO duality (DUALITY). The directors' average number of board appointments are 1.53, and there are boards with no director holding directorship in other firms as the minimum number of appointments is 1 (refer MULTI). For busy board (BUSY), the maximum of 1 indicates that there are firms with all the directors holding at least three directorships. Operating cash flow (CASH) is defined as the natural logarithm of cash from operations. There are 691 firms with positive operating cash flow and 263 with zero or negative operating cash flow. The natural logarithm of zero and negative value of operating cash flows would result in undefined numbers, leaving 691 firm observations for logistic regression. Operating cash flows range from 0.036 to 19457.7 million Malaysian ringgit. The natural logarithm resulted in a minimum of -3.32 and a maximum of 9.88, respectively.

Table 2 displays the correlation analysis of the variables. In general, the correlation figures are less than 0.5, except DCIO and IR4.0 (0.55), DCUSTOMER and IR4.0 (0.80), ROA and TOBINQ (0.56), SIZE and CASH (0.82), REVENUE and CASH (0.70), REVENUE and SIZE (0.68), DBSIZE and BSIZE (0.74), DINDEP and INDEP (0.53), DMULTI and MULTI (0.80), DMULTI and BUSY (0.72), DBUSY AND MULTI (0.67), DBUSY and BUSY (0.74), and DBUSY and DMULTI (0.61).

Table 1: Descriptive Statistics

Panel A:	N	Mean	S.D.	Min	0.25	Mdn	0.75	Max
IR4.0	954	0.14	0.35	0.00	0.00	0.00	0.00	1.00
DPROFILE	954	0.04	0.19	0.00	0.00	0.00	0.00	1.00
DCIO	948	0.04	0.21	0.00	0.00	0.00	0.00	1.00
DCUSTOMER	948	0.01	0.11	0.00	0.00	0.00	0.00	1.00
DCOMMITTEE	954	0.09	0.29	0.00	0.00	0.00	0.00	1.00

Panel A:	N	Mean	S.D.	Min	0.25	Mdn	0.75	Max
CASH	691	3.37	1.97	-3.32	2.19	3.30	4.57	9.88
TOBINQ	941	-0.06	0.59	-1.63	-0.40	-0.14	0.18	2.50
ROA	954	2.12	6.03	-20.99	-0.31	1.71	4.54	27.95
SIZE	905	5.46	1.73	2.35	4.20	5.13	6.29	11.51
FIRMAGE	954	34.34	21.55	0.00	20.00	30.00	44.00	191.00
PAYOUT	954	0.34	1.14	0.00	0.00	0.00	0.42	26.18
REVENUE	914	1.55	2.46	-6.91	-0.08	1.56	3.16	9.28
BOARDSIZE	954	7.13	2.10	3.00	6.00	7.00	8.00	13.00
INDEPENDENT	954	0.49	0.13	0.20	0.40	0.50	0.60	0.80
DUALITY	954	0.29	0.45	0.00	0.00	0.00	1.00	1.00
MULTI	948	1.53	0.49	1.00	1.17	1.40	1.75	4.25
BUSY	948	0.13	0.17	0.00	0.00	0.10	0.20	1.00
DBSIZE	954	0.58	0.49	0.00	0.00	1.00	1.00	1.00
DINDEP	954	0.07	0.26	0.00	0.00	0.00	0.00	1.00
DMULTI	954	0.26	0.44	0.00	0.00	0.00	1.00	1.00
DBUSY	954	0.13	0.33	0.00	0.00	0.00	0.00	1.00

	Dummy = 0		Dummy = 1		Total
Panel B:	**Frequency**	**Percentage (%)**	**Frequency**	**Percentage (%)**	**observations**
IR4.0	821	86.06	133	13.94	954
DPROFILE	920	96.44	34	3.56	954
DCIO	906	95.57	42	4.43	948
DCUSTOMER	868	90.99	86	9.01	954
DCOMMITTEE	936	98.73	12	1.27	948
DUALITY	682	71.49	272	28.51	954
DBSIZE	403	42.24	551	57.76	954
DINDEP	885	92.77	69	7.23	954
DMULTI	710	74.42	244	25.58	954
DBUSY	833	87.32	121	12.68	954

Notes: Appendix I provides the definition for all the variables.

Table 2: Correlation analysis

	Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
1.	IR4.0	1.00																				
2.	DPROFILE	0.46	1.00																			
3.	DCIO	0.55	0.13	1.00																		
4.	DCOMMITTEE	0.22	0.08	0.06	1.00																	
5.	DCUSTOMER	0.80	0.21	0.26	0.03	1.00																
6.	CASH	0.26	0.12	0.29	0.09	0.19	1.00															
7.	TOBINQ	0.16	0.05	0.08	0.00	0.16	0.16	1.00														
8.	ROA	0.05	0.00	0.07	-0.02	0.04	0.25	0.56	1.00													
9.	SIZE	0.29	0.11	0.30	0.10	0.21	0.82	0.41	0.36	1.00												
10.	FIRMAGE	0.05	-0.02	0.10	0.07	0.05	0.19	-0.07	0.03	0.22	1.00											
11.	PAYOUT	-0.03	-0.01	0.02	-0.01	-0.03	0.08	0.14	0.14	0.15	0.01	1.00										
12.	REVENUE	0.19	0.06	0.27	0.07	0.10	0.70	0.15	0.18	0.68	0.20	0.02	1.00									
13.	BOARDSIZE	0.19	0.10	0.19	0.06	0.13	0.43	0.08	0.08	0.46	0.18	0.02	0.40	1.00								
14.	INDEPENDENT	0.01	0.01	0.04	-0.03	-0.01	0.05	0.02	-0.03	0.04	0.06	0.00	-0.01	-0.26	1.00							
15.	DUALITY	-0.12	-0.04	-0.10	-0.06	-0.07	-0.04	-0.08	-0.06	-0.09	-0.04	0.01	-0.02	0.00	-0.13	1.00						
16.	MULTI	0.07	0.03	0.04	0.03	0.03	0.09	-0.07	-0.09	0.11	0.06	0.00	0.04	-0.05	0.19	-0.07	1.00					
17.	BUSY	0.07	0.01	0.03	0.03	0.05	0.07	-0.10	-0.09	0.07	0.07	0.02	0.05	-0.04	0.17	-0.08	0.89	1.00				
18.	DBSIZE	0.15	0.07	0.12	0.07	0.10	0.31	0.00	0.06	0.31	0.13	0.03	0.28	0.74	-0.25	-0.01	-0.05	-0.03	1.00			
19.	DINDEP	0.05	0.03	0.04	0.05	0.03	-0.03	0.03	-0.10	-0.01	0.03	0.05	-0.06	-0.14	0.53	-0.02	0.12	0.10	-0.10	1.00		
20.	DMULTI	0.04	0.02	0.02	-0.01	0.01	0.07	-0.05	-0.07	0.07	0.05	0.00	0.06	-0.09	0.19	-0.03	0.80	0.72	-0.08	0.12	1.00	
21.	DBUSY	0.04	0.02	0.02	-0.03	0.03	0.03	-0.04	-0.07	0.03	0.03	0.06	0.05	-0.11	0.13	-0.05	0.67	0.74	-0.16	0.08	0.61	1.00

Notes: Appendix I provides definition for all the variables.

Multicollinearity occurs when two or more similar variables are presented in the model, and it is difficult to determine which has impacted the dependent variable. It should be noted that for DCIO, DCUSTOMER and IR4.0, they are the dependent variables; hence no multicollinearity issues. For board characteristics (moderating variables) such as BOARDSIZE, DBSIZE, INDEPENDENT, DINDEP, MULTI, DMULTI, BUSY and DBUSY, it should be noted that they are being introduced into logistic regression model separately and not simultaneously, hence there is no multicollinearity issue as well. For control and independent variables such as ROA, TOBINQ, REVENUE, CASH and SIZE, we have conducted the variance inflation factor (VIF) analysis to confirm their relationship. All the variables have a VIF of less than 5, indicating no multicollinearity problem in the logistic regression models.[6]

4.2 The Effect of Operating Cash Flows on the Adoption of IR 4.0 Technologies

Table 3 shows the effect of operating cash flows on adopting IR 4.0 technologies. The operating cash flows used in the analysis are the cash from operations reported in the cash flow statement. Models (1) and (2) show the logistic regression of IR4.0 adoption on the control variables while Models (3) and (4) show the logistic regression of IR4.0 adoption on the control variables and CASH. The industry dummy variable in Model (4) is crucial for controlling industry-specific effects. Industries like healthcare and technology are at the forefront of adopting IR4.0 technologies. It is found that operating cash flows positively relate to the adoption of IR 4.0 technologies and this result is more pronounced when industry-specific effect is controlled. As expected, operating cash flow provides an internal source of capital (Nguyen & Nguyen, 2020), and our finding supports prior literature that opined that operating cash flow is a financial source that represents the ability of the firms to fund the investment internally (Black, 1998; Nguyen & Nguyen, 2020). Regarding control variables, generally, high-growth firms (TOBINQ) and larger firms (SIZE) are positively related to adopting IR 4.0 technologies. This is because in high-growth firms, operating cash flows are often used to invest and fund growth internally (Black, 1998). Similarly, larger firms often have greater resources to invest in innovation. In contrast, dividend payout (PAYOUT) and return on assets (ROA) are negatively related to IR4.0 adoption. The internal resources are limited, and when the firms allocate the resources for dividend distribution, they have lesser resources to invest in innovation.

Moreover, firms with poorer ROA might consider the adoption of IR4.0 as an opportunity to increase their revenue.

Table 3: The effect of operating cash flows on the adoption of IR 4.0 technologies.

DTotal	(1)	(2)	(3)	(4)
TOBINQ	0.6823***	0.3538	0.8075***	0.4251
	(0.0005)	(0.1264)	(0.0054)	(0.2222)
ROA	-0.0590***	-0.0451**	-0.0619**	-0.0563*
	(0.0031)	(0.0365)	(0.0288)	(0.0821)
SIZE	0.5608***	0.5708***	0.3090*	0.3665**
	(0.0000)	0.0000	(0.0534)	(0.0397)
FIRMAGE	-0.0036	0.0035	-0.0006	0.0060
	(0.4332)	(0.4830)	(0.9060)	(0.2764)
PAYOUT	-0.9316***	-0.8404**	-0.8677**	-0.8068**
	(0.0077)	(0.0235)	(0.0252)	(0.0324)
REVENUE	-0.0491	0.0243	-0.0893	-0.1015
	(0.3915)	(0.7359)	(0.2208)	(0.2805)
CASH			0.2763**	0.3628**
			(0.0475)	(0.0171)
Constant	-4.5439***	-6.8928***	-4.2005***	-6.9777***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Industry dummy	No	Yes	No	Yes
N	876	876	642	642

Notes: Appendix I provides definition for all the variables. Parentheses report p values. ***, **, * indicate 1, 5, and 10 percent levels of significance, respectively. Model (1) and (2) are models without independent variables. Model (3) and (4) with added CASH variable is the baseline model without and with industry effect.

Model (4) with the industry dummy is the baseline model and further analysis in this research is extended from this model. As aforementioned, there are four subcategories under the adoption of IR 4.0 technologies, namely DPROFILE, DCIO, DCUSTOMER and DCOMMITTEE. Using the baseline model in Table 3, we further analyse the effect of operating cash flows on these subcategories, and the results are presented in Table 4. In the depiction of Model (1) in Table 4, operating cash flows positively relate to hiring key personnel with IR4.0 experience (DPROFILE). Similarly, in Model (4), operating cash flows increase the acquisition of IR4.0 business solutions and

technologies. Investment in human capital equipped with IR4.0 experience and advanced IR4.0 technologies for the best interest of firm innovation requires sufficient financial ability. Our results show that internal funds relax firms' financial constraints through the positive operating cash flows for firms to invest in IR4.0 technologies.

Table 4: The effect of operating cash flow on subcategory of the adoption of IR 4.0 technologies.

	DPROFILE (1)	DCIO (2)	DCOMMITEE (3)	DCUSTOMER (4)
TOBINQ	0.5253	-1.1016	-0.9111	0.7730*
	(0.4012)	(0.1410)	(0.5673)	(0.0571)
ROA	-0.0680	0.0605	-0.0886	-0.0717*
	(0.2118)	(0.3892)	(0.5284)	(0.0510)
SIZE	-0.0090	0.3759	1.0144	0.3534*
	(0.9791)	(0.2553)	(0.2048)	(0.0920)
FIRMAGE	-0.0041	0.0054	0.0271	0.0109*
	(0.7314)	(0.4822)	(0.1422)	(0.0772)
PAYOUT	-0.4391	-0.0129	-2.1708	-0.9774*
	(0.4319)	(0.9724)	(0.4113)	(0.0517)
REVENUE	-0.1538	0.2227	-0.5462	-0.2095**
	(0.3720)	(0.2770)	(0.2377)	(0.0487)
CASH	**0.5424***	0.2571	0.3114	**0.3489****
	(0.0682)	(0.3655)	(0.6129)	(0.0403)
Constant	-5.1345***	-9.4466***	-10.8042***	-6.1520***
	(0.0041)	(0.0000)	(0.0019)	(0.0000)
N	500	642	224	622

Notes: Appendix I provides definition for all the variables. Parentheses report p values. ***, **, * indicates 1, 5, and 10 percent levels of significance, respectively. Industry dummy has been included and the industry-specific effects are controlled in all regressions.

4.3 The Moderating Effect of Board Characteristics

In general, positive operating cash flow is the primary source of capital for firms, and it can fulfil a firm's cash needs internally (Black, 1998; Nguyen & Nguyen, 2020). Our result suggests it relaxes tight financial constraints and positively relates to firm innovation, as represented by IR4.0 adoption. In this study, we argue that the relationship between operating cash flows and adopting IR4.0 technologies might be affected by board characteristics

such as board size, board independence, chairman-CEO duality, multiple directorship and busy board. Viewing from corporate governance context, board characteristics are an essential corporate governance mechanism in which the board of directors has unique responsibilities. As discussed in the hypotheses development, we expect these board characteristics can moderate the positive relationship between operating cash flows and the adoption of IR4.0.

Table 5 presents the logistic regression results of the moderating effect of the board characteristics. Model (1) shows that board size has a direct positive impact on the adoption of IR4.0 adoption. Moreover, Model (2) and (4) show that board size and board independence positively moderate the relationship between operating cash flows and the adoption of IR4.0 technologies. In contrast, in Models (8) and (10), multiple directorships and busy board have a negative moderating effect. However, chairman-CEO duality is not a significant moderator (as shown in Model (6)), but it has a significant direct negative impact on the adoption of IR4.0 technologies in Model (5).

All in all, the positive findings are supported by the resource dependence theory, while the agency theory explains the negative findings. In Models (1) and (2), board size is said to have both direct and moderating effects. In line with resource dependence theory, when more members are sitting on the board, they bring more resources to the firms directly or indirectly, improving the process of utilising operating cash flows to fund innovation activities such as IR4.0 adoption. Similarly, independent or outside directors connect the board to external resources while monitoring the management's decisions on business operations, including the operating cash flow. In contrast, multiple directorships and busy board negatively moderate this relationship, indicating that board busyness weakens monitoring roles, leads to potential agency problems, and decreases firm innovation. This finding is in line with Latif et al. (2013), who argue that agency costs may incur if directors fail to commit to monitoring roles fully.

It should be well noted that the proxies of DProfile, DCIO, DComm, and DCustomer are not mutually exclusive and overlap as a firm that has appointed a CIO may have established the technology committee as well. Hence in the robustness test (Table 6), we sum up the DProfile, DCIO, DComm, and DCustomer and convert it to a continuous variable (0-4) to examine if the results differ if the proxies overlap. A score of 0 indicates that the firm has not hired key personnel with IR4.0 experience, appointed a CIO, established

Table 5: The effect of operating cash flow on the adoption of IR 4.0 technologies: The moderating role of board characteristics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
TOBINQ	0.4648	0.4488	0.4156	0.4489	0.5130	0.5150	0.4281	0.3979	0.4251	0.4648
	(0.1926)	(0.2052)	(0.2341)	(0.2103)	(0.1516)	(0.1508)	(0.2186)	(0.2521)	(0.2224)	(0.1878)
ROA	-0.0560	-0.0410	-0.0549*	-0.0525	-0.0617*	-0.0618*	-0.0559*	-0.0547*	-0.0560*	-0.0569*
	(0.1014)	(0.2325)	(0.0940)	(0.1128)	(0.0614)	(0.0612)	(0.0849)	(0.0944)	(0.0844)	(0.0855)
SIZE	0.3207*	0.2900	0.3674**	0.3756**	0.3016*	0.2993*	0.3656**	0.3502*	0.3676**	0.3324*
	(0.0723)	(0.1069)	(0.0392)	(0.0377)	(0.0909)	(0.0953)	(0.0399)	(0.0507)	(0.0392)	(0.0643)
FIRMAGE	0.0046	0.0030	0.0060	0.0056	0.0057	0.0057	0.0060	0.0061	0.0060	0.0061
	(0.4206)	(0.6012)	(0.2822)	(0.3270)	(0.3113)	(0.3099)	(0.2838)	(0.2760)	(0.2802)	(0.2816)
PAYOUT	-0.8564**	-0.9041**	-0.8236**	-0.9002**	-0.8672**	-0.8650**	-0.8079**	-0.7380**	-0.8064**	-0.7499**
	(0.0243)	(0.0247)	(0.0299)	(0.0236)	(0.0245)	(0.0247)	(0.0316)	(0.0468)	(0.0325)	(0.0458)
REVENUE	-0.1110	-0.1065	-0.0998	-0.1050	-0.0798	-0.0796	-0.1026	-0.0946	-0.1026	-0.0868
	(0.2477)	(0.2693)	(0.2884)	(0.2704)	(0.4026)	(0.4038)	(0.2749)	(0.3196)	(0.2769)	(0.3630)
CASH	0.3688**	-0.1094	0.3608**	0.3161**	0.4065***	0.4045***	0.3630**	0.4784***	0.3625**	0.4518***
	(0.0156)	(0.6020)	(0.0178)	(0.0393)	(0.0081)	(0.0088)	(0.0169)	(0.0034)	(0.0172)	(0.0043)
DBSIZE	**0.8394****	-1.1090*								
	(0.0121)	(0.0986)								
CASH*DBSIZE		**0.6138*****								
		(0.0020)								
DINDEP			**0.1614**	-3.1114						
			(0.7617)	(0.1191)						

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
CASH*DINDEP				**0.7823***						
				(0.0754)						
DUALITY					**-0.8346****	-0.9236				
					(0.0143)	(0.2771)				
CASH*DUALITY						0.0204				
						(0.9087)				
DMULTI							0.0782	1.4559**		
							(0.7906)	(0.0271)		
CASH*DMULTI								**-0.3240****		
								(0.0226)		
DBUSY									0.0537	1.9907**
									(0.8918)	(0.0102)
CASH*DBUSY										**-0.4881*****
										(0.0073)
Constant	-7.2692***	-6.0586***	-6.9812***	-6.8752***	-6.6487***	-6.6194***	-6.9909***	-7.6178***	-6.9901***	-7.2963***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
N	642	642	642	642	642	642	642	642	642	642

Notes: Appendix I provides definition for all the variables. Parentheses report p values. ***, **, * indicates 1, 5, and 10 percent levels of significance, respectively. Industry dummy has been included and the industry-specific effects are controlled in all regressions.

a technology committee, or acquired IR4.0 technology. In contrast, a score of 4 indicates that the firms have completed all four proxies in adopting IR4.0 technologies. The descriptive statistics of the continuous variable of IR4.0 adoption is available in Appendix II. We repeat the analysis using linear regression and compare the results in Table 6 with the logistic regression results in Table 5. Overall, the results are consistent, except for the moderating effect of chairman-CEO duality. In the linear regression model, we found that when the chairman also acts as the company CEO, the CEO with this informal power deteriorates the monitoring power of the rest of the board members (Wijethilake & Ekanayake, 2020). Valencia (2018) and Li and Yang (2019) argue that the separation of the chairman and CEO imposes greater pressure on the CEO to undertake more exploitative innovation and patent applications.

Table 6: The effect of operating cash flow on the adoption of IR 4.0 technologies: The moderating role of corporate governance dimension using linear regression

	(1)	(2)	(3)	(4)	(5)	(6)
TOBINQ	0.0434	0.0458	0.0422	0.0406	0.0395	0.0539
	(0.3244)	(0.2914)	(0.3390)	(0.3550)	(0.3656)	(0.2172)
ROA	-0.0085**	-0.0059	-0.0082**	-0.0086**	-0.0082**	-0.0085**
	(0.0356)	(0.1421)	(0.0439)	(0.0322)	(0.0397)	(0.0328)
SIZE	0.0508**	0.0372*	0.0531**	0.0492**	0.0475**	0.0424*
	(0.0214)	(0.0891)	(0.0161)	(0.0260)	(0.0304)	(0.0536)
FIRMAGE	0.0016*	0.0013	0.0016*	0.0015*	0.0016**	0.0016**
	(0.0505)	(0.1050)	(0.0592)	(0.0686)	(0.0465)	(0.0458)
PAYOUT	-0.0259	-0.0273	-0.0273	-0.0255	-0.0247	-0.0275
	(0.1975)	(0.1669)	(0.1746)	(0.2028)	(0.2156)	(0.1692)
REVENUE	-0.0103	-0.0111	-0.0100	-0.0085	-0.0082	-0.0072
	(0.3700)	(0.3277)	(0.3839)	(0.4614)	(0.4760)	(0.5304)
CASH	**0.0532*****	-0.0113	0.0460***	0.0621***	0.0738***	0.0692***
	(0.0022)	(0.6047)	(0.0093)	(0.0005)	(0.0001)	(0.0001)
DBSIZE		-0.2131***				
		(0.0030)				
CASH*DBSIZE		**0.0959*****				
		(0.0000)				
DINDEP			-0.1937			
			(0.1281)			

	(1)	(2)	(3)	(4)	(5)	(6)
CASH*DINDEP			**0.0702****			
			(0.0314)			
DUALITY				0.0531		
				(0.4930)		
CASH*DUALITY				**-0.0355***		
				(0.0758)		
DMULTI					0.2333***	
					(0.0039)	
CASH*DMULTI					**-0.0688*****	
					(0.0004)	
DBUSY						0.3488***
						(0.0013)
CASH*DBUSY						**-0.0981*****
						(0.0001)
Constant	-0.5201***	-0.3785**	-0.5155***	-0.5229***	-0.5322***	-0.4832***
	(0.0011)	(0.0184)	(0.0012)	(0.0013)	(0.0008)	(0.0023)
N	642	642	642	642	642	642
r2_a	0.2552	0.2823	0.2586	0.2605	0.2678	0.2700
r2	0.2749	0.3035	0.2806	0.2824	0.2895	0.2916

Notes: Appendix I provides definition for all the variables. Parentheses report p values. ***, **, * indicates 1, 5, and 10 percent levels of significance, respectively. Industry dummy has been included and the industry-specific effects are controlled in all regressions.

5. Conclusion, Implication and Limitation

In conclusion, the industrial revolution involves investment in innovation. This study proposes that such innovation investment could be reflected in (1) the hiring of key personnel with relevant experience, (2) the appointment of CIO, (3) the establishment of technology committee in the respected area, and (4) the purchasing of the IR4.0 business solution to solve the massive data and contemporary technology issue. The proposed measurements are in line with Wan et al. (2005) and Van de Ven et al. (1989) in defining "innovation", where innovation involves activities such as generating, adopting, implementing and incorporating new ideas, practices or objects in the organisation. The innovation activities require sufficient funding, and operating cash flows from sales or services of the operations are generally the major revenue which fulfils cash needs internally (Black, 1998; Nguyen & Nguyen, 2020). This study found empirical evidence of the positive relationship between

operating cash flows and adopting IR 4.0 technologies, a type of firm innovation. Out of the four proposed measurements, the findings suggest that internal funds relax firms' financial constraints through the positive operating cash flows for firms to invest in IR4.0 key personnel and IR4.0 business solutions and technologies.

In examining the moderating effects of the board characteristics, using both logistic and linear regression, it is shown that board characteristics as the corporate governance mechanisms significantly moderate the positive relationship between operating cash flows and the adoption of IR 4.0 technologies. Larger board size and independent director ratios have positive moderating impacts as quantitatively they bring greater and various resources to the firms (following resource dependence theory), while increasing multiple directorships and board busyness have the opposite effect as directors could not fully commit to the board monitoring roles (following agency theory), affecting the firms' activities in utilising operating cash flows to fund the firm innovation process. It is suggested that the board should maintain a larger size with more independent directors. Still, the appointment of directors should also consider the directors' commitment and busyness. After all, it is not only about the numbers, but the resources the directors allocate to fulfil their responsibilities. Both logistic and linear regressions suggest that the quantity aspects of the board in terms of board size and the number of outside directors are equally essential to the monitoring quality of the board as measured by multiple directorships and board busyness. We do not reject the hypothesis formed in Section 2, except H4, as chairman-CEO duality negatively moderates the relationship between operating cash flows and the adoption of IR4.0. Though insignificant in logistic regression, linear regression using a continuous form of IR4.0 adoption further reveals that chairman-CEO duality may have a negative moderating impact. This aligns with the findings of Valencia (2018) and Li and Yang (2019), in which the chairman-CEO with informal power has less pressure to engage in more exploitative innovation and pursue patent applications, thus highlighting the importance of the monitoring role of the board.

In terms of the implications and limitations, theoretically, this paper extends the existing literature on firms' financial constraints and adoption of IR4.0 technologies by showing that positive operating cash flows increase firm innovation. In addition, the corporate governance mechanisms that have been introduced proved that board characteristics such as board size, board independence, chairman-CEO duality, multiple directorships and board busyness

also affect firm innovation. The results serve as references to the various parties keen on the firm's IR4.0 adoption agenda by using Malaysia as the sample since Malaysia has one of the most influential public policies related to the fourth industrial revolution (Liao et al., 2018). Our results show that operating cash flows are one possible threat to IR4.0 adoption. Firms with positive operating cash flows are more flexible and have more possibility of adopting IR4.0 technologies. Besides that, the findings on the effects of board characteristics shed some light on corporate governance policies regarding the quantity and quality aspects of the board. In summary, the positive moderating effects are explained by applying resource dependence theory, while the negative moderating effects are justified by agency theory. The positive findings highlight the importance of "quantity" within the board—having a larger board size and more independent directors establishes a stronger connection between the firm and additional resources, reinforcing the positive association between operating cash flows and firm innovation. Conversely, the "quality" of the board is equally vital. Chairman-CEO duality, multiple directorships and busy board are shown to reduce the monitoring quality, thereby exerting a negative influence on the relationship between operating cash flows and firm innovation.

Last but not least, this study is subject to some limitations, particularly those related to data constraints. The challenge of measuring firm innovation is evident. The proposed measurement for adopting IR4.0 technologies may also have shortcomings and potentially not capturing the full spectrum of firm activities related to innovation. Due to data unavailability, this research relies solely on cross-sectional data, with panel data being a more preferable option. In addition, Malaysia is a developing country, and the relationship between operating cash flows and adopting IR4.0 technologies may only partially reflect the situation in developed countries. Developed countries have robust corporate governance policies and hence may not have issues such as excessive multiple directorships or over-busy boards of directors. Despite these constraints, efforts were made to enhance the reliability of the findings.

Endnotes

[1] Discretionary accrual is also known as "abnormal accruals". According to Dechow (1994), discretionary accruals is flexible and hence often provide opportunities for managers to manipulate earnings.

[2] There are total eleven countries and one region in the list, namely Malaysia, Germany, China, Europe, the United States, the Netherlands, Spain, France, the United Kingdom, Sweden and Italy.

[3] Firm data is mainly downloaded from S&P Capital IQ. There are 954 publicly listed firms traded on Bursa Malaysia's main market in 2019. Using data from 954 firms, we identified the minimum, 0.25 percentile, median, 0.75 percentile and the maximum of each variable (as shown in Table 1). The percentiles of each variable from the population are essential for us to convert the continuous variable into a binary variable for the moderators. Of the 954 firms, 263 have zero or negative operating cash flow. As the natural logarithm of zero and the negative value of operating cash flows would result in undefined numbers, 263 firms are excluded from the analysis, leaving behind 691 firms with positive cash flow for logistic regression. However, 49 of them have missing data (e.g. TOBINQ), hence, resulting in 642 firms for the final sample size.

[4] DBSIZE takes the value of one if BOARDSIZE more than or equals to 7. As shown in Table 1, the median of board size (BOARDSIZE) in this study is 7; DINDEP takes the value of one if INDEPENDENT more than or equals to 0.667. The value 0.667 is selected as it is assumed that when majority (two-third) of the board are independent directors, they show high-level of board monitoring; DMULTI takes the value of one if MULTI more than or equals to 1.75. The value of 1.75 is selected as according to Table 1, the 0.75 percentile for MULTI is 1.75; DBUSY takes the value of one if BUSY more than or equals to 0.333. The value 0.333 is selected as it is assumed that when one-third of the board is busy (holding at least three directorships), majority of the directors (two-third) could still involve in board activity.

[5] DUALITY takes the value of one if the CEO also serves as a chairman of the board.

[6] To preserve space, variance inflation factor (VIF) result is not presented and available upon request. According to Hair et al. (2013), VIF value less than 5 shows there is no collinearity among the variables.

References

Abdul-Hamid, A. Q., Ali, M. H., Osman, L. H., & Tseng, M. L. (2021). The drivers of industry 4.0 in a circular economy: The palm oil industry in Malaysia. *Journal of Cleaner Production*, *324*, 129216. https://doi.org/10.1016/j.jclepro.2021.129216

Abidin, Z. Z., Kamal, N. M., & Jusoff, K. (2009). Board structure and corporate performance in Malaysia. *International Journal of Economics and Finance*, *1*(1), 150-164. https://doi.org/10.5539/ijef.v1n1p150

Adams, R. B., Almeida, H., & Ferreira, D. (2005). Powerful CEOs and their impact on corporate performance. *The Review of Financial Studies*, *18*(4), 1403–1432. https://doi.org/10.1093/rfs/hhi030

Al-Debi'e, M. M. (2011). Are operating cash flows a superior predictor of future operating cash flows than earnings? Evidence from Jordan. *European Journal of Economics, Finance and Administrative Sciences*, *40*, 36-46.

Backhaus, S. K. H. & Nadarajah, D. (2019). Investigating the relationship between Industry 4.0 and productivity: a conceptual framework for Malaysian manufacturing firms. *Procedia Computer Science*, *161*, 696–706. https://doi.org/10.1016/j.procs.2019.11.173

Bathala, C. T., & Rao, R. P. (1995). The determinants of board composition: An agency theory perspective. *Managerial and Decision Economics*, *16*(1), 59-69. https://doi.org/10.1002/mde.4090160108

Bhagat, S., & Welch, I. (1995). Corporate research and development investments international comparisons. *Journal of Accounting and Economics*, *19*(2-3), 443-470. https://doi.org/10.1016/0165-4101(94)00391-H

Bekhet, H. A., & Latif, N. W. A. (2018). The impact of technological innovation and governance institution quality on Malaysia's sustainable growth: Evidence from a dynamic relationship. *Technology in Society*, *54*, 27–40. https://doi.org/10.1016/j.techsoc.2018.01.014

Beladi, H., Deng, J., & Hu, M. (2021). Cash flow uncertainty, financial constraints and R&D investment. *International Review of Financial Analysis*, *76*, 101785. https://doi.org/10.1016/j.irfa.2021.101785

Black, E. L. (1998). *Which is more value-relevant: earnings or cash flows?*. retrieved on 19 June 2023, from https://ssrn.com/abstract=118089

Bordeleau, F.-E., Mosconi, E., & de Santa-Eulalia, L. A. (2020). Business intelligence and analytics value creation in Industry 4.0: A multiple case study in manufacturing medium enterprises. *Production Planning & Control*, *31*(2–3), 173–185. https://doi.org/10.1080/09537287.2019.1631458

Boyd, B. K. (1990). Corporate linkages and organizational environment: A test of the resource dependence model. *Strategic Management Journal*, *11*(6), 419-430. https://doi.org/10.1002/smj.4250110602

Boyd, B. K. (1995). CEO duality and firm performance: A contingency model. *Strategic Management Journal*, *16*(4), 301-312. https://doi.org/10.1002/smj.4250160404

Brown, J. R., Fazzari, S. M., & Petersen, B. C. (2009). Financing innovation and growth: Cash flow, external equity, and the 1990s R&D boom. The Journal of Finance, *64*(1), 151-185. https://doi.org/10.1111/j.1540-6261.2008.01431.x

Chen, H. L., Hsu, W. T., & Chang, C. Y. (2016). Independent directors' human and social capital, firm and performance implications: An integrated agency-resource dependence view. *International Business Review*, *25*(4), 859-871. https://doi.org/10.1016/j.ibusrev.2015.10.010

Cheng, C. A., Li, S., & Zhang, E. X. (2020). Operating cash flow opacity and stock price crash risk. *Journal of Accounting and Public Policy*, *39*(3), 106717. https://doi.org/10.1016/j.jaccpubpol.2020.106717

Clifford, P., & Evans, R. (1997). Non-executive directors: A question of independence. *Corporate Governance: An International Review*, *5*(4), 224-231. https://doi.org/10.1111/1467-8683.00064

Dalton, C. M., & Dalton, D. R. (2005). Boards of directors: Utilizing empirical evidence in developing practical prescriptions. *British Journal of Management*, *16*(S1), S91-S97. https://doi.org/10.1111/j.1467-8551.2005.00450.x

Davis, G. F., & Cobb, J. A. (2010). Resource dependence theory: Past and future. *Research in the Sociology of Organizations*, *28*, 21-42. https://doi.org/10.1108/S0733-558X(2010)0000028006

de Villiers, C., Naiker, V., & Van Staden, C. J. (2011). The effect of board characteristics on firm environmental performance. *Journal of Management*, *37*(6), 1636–1663. https://doi.org/10.1177/0149206311411506

Dechow, P. M. (1994). Accounting earnings and cash flows as measures of firm performance: The role of accounting accruals. *Journal of Accounting and Economics*, *18*(1), 3-42. https://doi.org/10.1016/0165-4101(94)90016-7

Dehaene, A., De Vuyst, V., & Ooghe, H. (2001). Corporate performance and board structure in Belgian companies. *Long Range Planning*, *34*(3), 383-398. https://doi.org/10.1016/S0024-6301(01)00045-0

Delbecq, A. L., & Mills, P. K. (1985). Managerial practices that enhance innovation. *Organizational Dynamics*, *14*(1), 24-34. https://doi.org/10.1016/0090-2616(85)90041-5

Ding, N., Gu, L., & Peng, Y. (2022). Fintech, financial constraints and innovation: Evidence from China. *Journal of Corporate Finance*, *73*, 102194. https://doi.org/10.1016/j.jcorpfin.2022.102194

Dionne, G., & Ouederni, K. (2011). Corporate risk management and dividend signaling theory. *Finance Research Letters*, *8*(4), 188–195. https://doi.org/10.1016/j.frl.2011.05.002

Eisenberg, T., Sundgren, S., & Wells, M. T. (1998). Larger board size and decreasing firm value in small firms. *Journal of Financial Economics*, *48*(1), 35-54. https://doi.org/10.1016/S0304-405X(98)00003-8

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, *14*(4), 532-550. https://doi.org/10.5465/amr.1989.4308385

Fama, E. F., & Jensen, M. C. (1983). Separation of ownership and control. *The Journal of Law and Economics*, *26*(2), 301-325. https://doi.org/10.1086/467037

Gandía, J. L. (2008). Determinants of internet-based corporate governance disclosure by Spanish listed companies. *Online Information Review*, *32*(6), 791–817. https://doi.org/10.1108/14684520810923944

García-Sánchez, I. M., Domínguez, L. R., & Alvarez, I. G. (2011). Corporate governance and strategic information on the internet: A study of Spanish listed companies. *Accounting, Auditing and Accountability Journal*, *24*(4), 471–501. https://doi.org/10.1108/09513571111133063

Ghobakhloo, M., Fathi, M., Iranmanesh, M., Maroufkhani, P., & Morales, M. E. (2021). Industry 4.0 ten years on: A bibliometric

and systematic review of concepts, sustainability value drivers, and success determinants. *Journal of Cleaner Production*, *302*, 127052. https://doi.org/10.1016/j.jclepro.2021.127052

Goodstein, J., Gautam, K., & Boeker, W. (1994). The effect of board size and diversity on strategic change. *Strategic Management Journal*, *15*, 241-250. https://doi.org/10.1002/smj.4250150305

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2013). Partial least squares structural equation modeling: Rigorous applications, better results and higher acceptance. *Long Range Planning*, *46*(1-2), 1-12. https://doi.org/10.1016/j.lrp.2013.01.001

Haniffa, R. M., & Cooke, T. E. (2002). Culture, corporate governance and disclosure in Malaysian corporations. *Abacus*, *38*(3), 317-349. https://doi.org/10.1111/1467-6281.00112

Haniffa, R., & Hudaib, M. (2006). Corporate governance structure and performance of Malaysian listed companies. *Journal of Business Finance & Accounting*, *33*(7-8), 1034-1062. https://doi.org/10.1111/j.1468-5957.2006.00594.x

Harris, C., & Roark, S. (2019). Cash flow risk and capital structure decisions. *Finance Research Letters*, *29*, 393-397. https://doi.org/10.1016/j.frl.2018.09.005

Hastuti, C. S. F., Arfan, M., & Diantimala, Y. (2018). The influence of free cash flow and operating cash flow on earnings management at manufacturing firms listed in the Indonesian Stock Exchange. *International Journal of Academic Research in Business and Social Sciences*, *8*(9), 1133-1146. http://doi.org/10.6007/IJARBSS/v8-i9/4686

Healy, P. M., Palepu, K. G., & Ruback, R. S. (1992). Does corporate performance improve after mergers? *Journal of Financial Economics*, *31*(2), 135–175. https://doi.org/10.1016/0304-405X(92)90002-F

Hellström, K. (2006). The value relevance of financial accounting information in a transition economy: The case of the Czech Republic. *European Accounting Review*, *15*(3), 325-349. https://doi.org/10.1080/09638180600916242

Hidalgo, R. L., García-Meca, E., & Martínez, I. (2011). Corporate governance and intellectual capital disclosure. *Journal of Business Ethics*, *100*(3), 483–495. https://doi.org/10.1007/s10551-010-0692-x

Hillman, A. J., Withers, M. C., & Collins, B. J. (2009). Resource dependence theory: A review. *Journal of Management*, *35*(6), 1404-1427. https://doi.org/10.1177/0149206309343469

Jang, G. B., & Kim, W. J. (2017). Effects of key financial indicators on earnings management in Korea's ready mixed concrete industry. *Journal of Applied Business Research*, *33*(2), 329-342. https://doi.org/10.19030/jabr.v33i2.9905

Jensen, M. C. (1986). Agency costs of free cash flow, corporate finance, and takeovers. *American Economic Review*, *76*, 323- 329. http://doi.org/10.2139/ssrn.99580

Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*, *3*(4), 305-360. https://doi.org/10.1016/0304-405X(76)90026-X

Jin, L., & Myers, S. C. (2006). R2 around the world: New theory and new tests. *Journal of Financial Economics*, *79*(2), 257-292. https://doi.org/10.1016/j.jfineco.2004.11.003

Latif, R. A., Kamardin, H., Mohd, K. N. T., & Adam, N. C. (2013). Multiple directorships, board characteristics and firm performance in Malaysia. *Management*, *3*(2), 105-111. https://doi.org/10.5923/j.mm.20130302.07

Li, M., & Yang, J. (2019). Effects of CEO duality and tenure on innovation. *Journal of Strategy and Management*, *2*(4), 536-552. https://doi.org/10.1108/JSMA-04-2019-0049

Liu, D., Jiang, Y., Zhou, Q., & Yao, S. (2023). R&D investment management and ambidextrous technological innovation: Evidence from Chinese listed firms. *International Review of Economics & Finance*, *88*, 843-860.

Liao, L., Luo, L., & Tang, Q. (2015). Gender diversity, board independence, environmental committee and greenhouse gas disclosure. *The British Accounting Review*, *47*(4), 409–424. https://doi.org/10.1016/j.bar.2014.01.002

Liao, Y., Loures, E. R., Deschamps, F., Brezinski, G., & Venâncio, A. (2018). The impact of the fourth industrial revolution: a cross-country/region comparison. *Production*, *28*, e20180061. https://doi.org/10.1590/0103-6513.20180061

Liman, M., & Mohammed, A. (2018). Operating cash flow and corporate financial performance of listed conglomerate companies in Nigeria. *Journal of Humanities and Social Science*, *23*(2), 1-11. https://doi.org/10.9790/0837-2302110111

Lewellen, J., & Lewellen, K. (2016). Investment and cash flow: New evidence. *Journal of Financial and Quantitative Analysis*, *51*(4), 1135–1164. https://doi.org/10.1017/S002210901600065X

Martani, D., & Dini, N. (2010). The influence of operating cash flow and investment cash flow to the accounting conservatism measurement. *Chinese Business Review*, *9*(6), 1-6, retrieved on 19 June 2023 from https://pdfs.semanticscholar.org/4e1b/220b8d01883aa69e97afe4c521efc54e18ab.pdf

Ministry of Finance Malaysia. (2021). *Budget Speech 2022*. Retrieved from https://budget.mof.gov.my/manfaat/en/budgetspeech.html

Nguyen, D. D., & Nguyen, C. V. (2020). The impact of operating cash flow in decision-making of individual investors in Vietnam's stock market. *The Journal of Asian Finance, Economics and Business*, *7*(5), 19-29. https://doi.org/10.13106/jafeb.2020.vol7.no5.019

Peng, M. W., Zhang, S., & Li, X. (2007). CEO duality and firm performance during China's institutional transitions. *Management and Organization Review*, *3*(2), 205-225. https://doi.org/10.1111/j.1740-8784.2007.00069.x

Pfeffer, J. (1972). Size and composition of corporate boards of directors. *Administrative Science Quarterly*, *17*, 218-229. http://dx.doi.org/10.2307/2393956

Pfeffer, J., & Salancik, G. R. (1978). A resource dependence perspective. In R.J. Richardson, M.S. Mizruchi, & M. Schwartz (Eds.), *Intercorporate relations: The structural analysis of business* (pp. 258-261). Cambridge: Cambridge University Press.

Pfeffer, J., & Salancik, G. R. (2003). *The external control of organizations: A resource dependence perspective*. Stanford, CA: Stanford University Press.

Pham, L. T. M., Vo, L. Van, Le, H. T. T., & Le, D. V. (2018). Asset liquidity and firm innovation. *International Review of Financial Analysis*, *58*, 225–234. https://doi.org/10.1016/j.irfa.2017.11.005

Putri, P. A. D. W. (2021). The effect of operating cash flows, sales growth, and operating capacity in predicting financial distress. *International Journal of Innovative Science and Research Technology*, *6*(1), 638-646, retrieved on 19 June 2023, from https://ijisrt.com/assets/upload/files/IJISRT21JAN378.pdf

Malaysian Code on Corporate Governance (2017). Retrieved from https://www.sc.com.my/api/documentms/download.

ashx?id=4d1f5610-cf41-455c-9c20-21fa4c310f46#:~:text=2.3%20The%20MCCG%20permits%20a,market%20regulation%20is%20more%20appropriate.

Ryan Jr, H. E., & Wiggins III, R. A. (2002). The interactions between R&D investment decisions and compensation policy. *Financial Management*, *31*(1), 5-29. https://doi.org/10.2307/3666319

Sarkar, J., & Sarkar, S. (2009). Multiple board appointments and firm performance in emerging economies: Evidence from India. *Pacific-Basin Finance Journal*, *17*(2), 271-293. https://doi.org/10.1016/j.pacfin.2008.02.002

Sharma, V. (2011). Independent directors and the propensity to pay dividends. *Journal of Corporate Finance*, *17*(4), 1001–1015. https://doi.org/10.1016/j.jcorpfin.2011.05.003

Soet, M. A., Muturi, W., & Oluoch, O. (2018). Effect of operating cash flow management on financial performance of Mutual Funds in Kenya. *European Journal of Business, Economics and Accountancy*, *6*(5), 37-46, retrieved on 19 June 2023, from http://www.idpublications.org/wp-content/uploads/2018/10/Full-Paper-EFFECT-OF-OPERATING-CASH-FLOW-MANAGEMENT-ON-FINANCIAL-PERFORMANCE-OF-MUTUAL-FUNDS.pdf

Suki, N. M., Suki, N. M., Sharif, A., Afshan, S., & Jermsittiparsert, K. (2022). The role of technology innovation and renewable energy in reducing environmental degradation in Malaysia: A step towards sustainable environment. *Renewable Energy*, *182*, 245–253. https://doi.org/10.1016/j.renene.2021.10.007

Tay, S. I., Alipal, J., & Lee, T. C. (2021). Industry 4.0: Current practice and challenges in Malaysian manufacturing firms. *Technology in Society*, *67*, 101749. https://doi.org/10.1016/j.techsoc.2021.101749

Valencia, V. S. (2018). Corporate governance and CEO innovation. *Atlantic Economic Journal*, *46*(1), 43-58. https://doi.org/10.1007/s11293-017-9563-5

Van de Ven, A. H., Angle, H. L., & Poole, M. S. (2000). *Research on the management of innovation: The Minnesota studies*. New York: Oxford University Press.

Vitolla, F., Raimo, N., & Rubino, M. (2020). Board characteristics and integrated reporting quality: An agency theory perspective. *Corporate Social Responsibility and Environmental Management*, *27*(2), 1152-1163. https://doi.org/10.1002/csr.1879

Wan, D., Ong, C. H., & Lee, F. (2005). Determinants of firm innovation in Singapore. *Technovation*, *25*(3), 261-268. https://doi.org/10.1016/S0166-4972(03)00096-8

Wang, J., Chen, M. H., Fang, C. Y., & Tian, L. (2018). Does board size matter for Taiwanese hotel performance? Agency theory or resource dependence theory. *Cornell Hospitality Quarterly*, *59*(4), 317-324. https://doi.org/10.1177/1938965517735906

Wijethilake, C., & Ekanayake, A. (2019). CEO duality and firm performance: The moderating roles of CEO informal power and board involvements. *Social Responsibility Journal*, *16*(8), 1453–1474. https://doi.org/10.1108/SRJ-12-2018-0321

Yermack, D. (1996). Higher market valuation of companies with a small board of directors. *Journal of Financial Economics*, *40*, 185-211. https://doi.org/10.1016/0304-405X(95)00844-5

Appendix I: Definitions of variables

Variable	Definitions
Dependent Variables	
DProfile	Dummy variable equals one if at least one of the key personnel profiles shows relevant experience with blockchain, machine learning (ML), robotic, industry 4.0, Internet of things (IoT), artificial intelligence (AI), business intelligence (BI), big data and analytics, zero otherwise.
DCIO	Dummy variable equals one if the firm has appointed Chief Information Officer (CIO), zero otherwise.
DComm	Dummy variable equals one if the firm has established a technology-related committee, zero otherwise.
DCustomer	Dummy variable equals one if the firm is a customer of IR4.0 technology, zero otherwise.
IR4.0	Dummy variable equals one if DProfile, DCIO, DComm or DCustomer equals one, zero otherwise.
Independent Variable	
CASH	Natural logarithm of cash from operations.
Control Variables	
TOBINQ	Natural logarithm of the sum of market capitalisation and the book value of total liabilities, divided by book value of total assets, winsorised at 0.5% to 99.5% level.
ROA	Earnings before interest and taxes divided by the average of the total assets in 2019 plus total assets in 2018, winsorised at 0.5% to 99.5% level.

Variable	Definitions
SIZE	Natural logarithm of the market capitalisation.
FIRMAGE	The difference between the year of study and the year founded of the firm.
PAYOUT	The percentage of the common and preferred stock dividends paid divided by the net income.
REVENUE	Natural logarithm of the absolute value of total revenues.
Moderating Variables	
BOARDSIZE	The total number of the directors sitting in the board, winsorised at 2% to 98% level.
INDEPENDENT	The number of independent directors divided by board size, winsorised at 2% to 98% level.
MULTI	The total board appointments of all individual directors, divided by the total number of board members.
BUSY	The total number of board members who hold at least three directorships, divided by the total number of board members.
DUALITY	Dummy variable equals one if the CEO also serves as a chairman of the board.
DBSIZE	Dummy variable equals one if BOARDSIZE more than or equals to 7, zero otherwise.
DINDEP	Dummy variable equals one if INDEPENDENT more than or equals to 0.667 (two-third), zero otherwise.
DMULTI	Dummy variable equals one if MULTI more than or equals to 1.75, zero otherwise.
DBUSY	Dummy variable equals one if BUSY more than or equals to 0.333, zero otherwise.

Appendix II: Descriptive statistics of the continuous variable of adoption of IR 4.0 technologies

Score	Frequency	Percentage (%)
0	815	85.97
1	100	10.55
2	25	2.64
3	8	0.84
Total	948	100

Notes: A score of 0 indicates that the firm has not hired key personnel with IR4.0 experience, appointed a CIO, established a technology committee, or acquired IR4.0 technology. In contrast, a score of 4 indicates that the firms have completed all four proxies in adopting IR4.0 technologies.