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Review Article



Malaysia's Sustainable Future: Navigating Industry 4.0 through a Low-Carbon Agenda

Muhammad Shabir Shaharudin ^{a,*}, Yudi Fernando ^a and Anisha Banu Dawood Gani ^a^a Faculty of Industrial Management, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Kuantan, Pahang Malaysia.* Correspondence: shabir.shaharudin@gmail.com (M.S.S.)

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Abstract

The evolving technological landscape has transformed the business realm, compelling companies to navigate a dynamic environment and embrace innovation to maintain competitiveness. One of the most recent trends in this pursuit is the Industrial Revolution or Industry 4.0 (IR 4.0). Industry 4.0 has been widely discussed as a means of providing greater advantages for countries and firms. However, the shift to automation and data-driven decisions of IR 4.0 is still slow, especially in developing countries like Malaysia. Throughout the world, IR 4.0 is still in policy development, and the literature shows that IR 4.0 is still in the conceptual stage. As IR 4.0 is inevitable, countries like Malaysia must start gearing toward readiness. This must be done without impacting the environment, such as by increasing carbon emissions. In order to do that, this paper has investigated the challenges, impact, issues, enforcement and risk minimization of IR 4.0 without sacrificing low carbon performance among Malaysian firms. The review of current literature and whitepapers found that Malaysia is still creating awareness for IR 4.0, and policymakers are still developing IR 4.0. This paper has proposed future research that will gear Malaysia to establish an IR 4.0 readiness framework and provide empirical evidence from the industry.



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1. Introduction

Recent advancements in technology have changed the landscape of doing business. Businesses face dynamic environments that force firms to innovate and adopt the latest business movements to stay competitive. One of the latest movements is the Industrial Revolution or Industry 4.0 (IR 4.0). The requirements of IR 4.0 are data and automation of processes (Ardito, Petruzzelli, Panniello, & Garavelli, 2018). Big data is becoming critical for firms to collect and manage to forecast industrial trends and consumer preferences better. Due to big data, firms have achieved benefits such as more market penetration, more market share, more responsiveness to consumer demand, and excel in operations (Schroeder, Ziaee Bigdeli, Galera Zarco, & Baines, 2019). As firms focus on identifying and analyzing consumers' data, firms' operations are moving toward inter-organizational, where integration with supply chain partners becomes more important. In addition, firms' increasing market share has led to firms

choosing an agile manufacturer that can produce at a faster rate. This has given rise to manufacturing automation to cope with consumers' demand and complex preferences. This trend has set the stage for IR 4.0 in the industry.

Even though IR 4.0 has swept the world since 2011, when it was first introduced in Germany, it has not yet been fully implemented worldwide, but the awareness has been increasing progressively. Nevertheless, recent environmental disasters worldwide, such as the California and Indonesia wildfires, air pollutions in Malaysia and Singapore and flash floods in UK and Japan have increased concerns from every stakeholder of the firms to mitigate the impact of climate change. Climate change experts have repeatedly warned governments, policymakers, firms, and society to reduce carbon emissions, one of the heaviest contributors to climate change (Shaharudin & Fernando, 2015). Thus, governments and consumers have demanded that firms take more proactive measures to reduce carbon emissions in their operations and supply chains

(Shaharudin & Fernando, 2019). Therefore, for IR 4.0 to expand, countries need to ensure that firms are ready to adopt IR 4.0. This requires firms to not forego low carbon management throughout their operations and supply chain.

However, adoption of IR 4.0 is progressing slowly due to limited awareness of the impact of IR 4.0. Even though IR 4.0 will impact every stakeholder, including government and society, there is not enough coverage of IR 4.0 in the media except from a business perspective (Hermann, Pentek, & Otto, 2016). That is why IR 4.0 is very popular in the manufacturing industry. For example, it is called Smart Manufacturing Industry 4.0 in the USA, Industry 4.0 in Germany, and Made in China 2025 in China. Other countries moving towards IR 4.0 include Japan, South Korea, Singapore and Malaysia. Iskandar Malaysia and the Malaysian government have partnered to identify the adoption of new technologies and enhance market position to stand out amongst other ASEAN countries (World Economic Forum, 2016).

The literature on IR 4.0 adoption is still in the conceptual stage, and many scholars have provided a framework for adopting IR 4.0 (Gunasekaran, Subramanian, & Ngai, 2019). This is done by creating awareness and discussing policies and processes for firms to be ready for IR 4.0 and the advantages of early adopters of IR 4.0. However, most of the investigations are done in developed countries, and limited studies on the methodology for firms to achieve IR 4.0 are currently being conducted by Klingenberg, Borges, & Antunes (2019). This paper argues that most developing countries or ASEAN countries, especially Malaysia, will not be able to be ready soon enough at current state. This is because developing countries are still focusing on improving sustainability to ensure that IR 4.0 can be adopted sooner. Due to that, Malaysian firms are improving its economic performance (Fernando, Jasmi, & Shaharudin, 2019), operational performance (Shanmugan, Shaharudin, Ganesan, & Fernando, 2019), social performance and environmental performance (Shaharudin & Fernando, 2015). This allows firms to appease stakeholders and work alongside government agencies and policymakers to focus on technological advancement. Moreover, as consumers' trust increases, data sharing will become more reliable, enabling firms to make decisions through data-driven practice. Only after achieving or investing in technology (Fernando, Wah, & Shaharudin, 2016) and focusing on data-driven practices can developing countries, especially Malaysia, be ready for IR 4.0.

Therefore, this paper's objective is to provide a review of IR 4.0 from the perspective of Malaysia and to provide recommendations on how Malaysian firms can minimize the risk and be ready for IR 4.0 without sacrificing low carbon performance. In order to answer the research objective, a literature review on IR 4.0, especially for Malaysia, was analyzed and synthesized to

extract information on the challenges, impact, issues, enforcement and risk minimization for firms in Malaysia.

This paper contributes to the literature by providing useful insights for Malaysia to be ready for IR 4.0 without sacrificing environmental performance critical to sustainable development. Moreover, this paper also provides rich information on the challenges, issues, impact and enforcement of IR 4.0 in Malaysia based on the review. On the other hand, this paper shows Malaysian firms how to adopt IR 4.0 while still pursuing low carbon performance. Thus, the next section of the literature review will discuss the challenges, impact, issues, enforcement and Malaysian IR 4.0, as well as how Malaysian firms can minimize the risk of IR 4.0. After the literature review, the next section discusses future research and the conclusion of the investigation.

2. Literature Review

2.1. Industry 4.0

In general, IR 4.0 termed has been used interchangeably with Industry 4.0. However, scholars have concluded that the impact of IR 4.0 includes civil society, governance structures, human identity, economics and manufacturing, while Industry 4.0 is widely used in the manufacturing context. Unclear definitions of IR 4.0 and Industry 4.0 show that this topic will receive more consideration from academia, policymakers and industry. Whether IR 4.0 or Industry 4.0, the concept is similar in moving the industry towards automation and data exchange through technology adoption (Kagermann, Helbig, Hellinger, & Wahlster, 2013). It includes cyber-physical systems, the Internet of Things (IoT) and cloud computing that have changed manufacturing and society's way of life. The reason that IR 4.0 is changing the way of life is because four disruptions drive it: i) the reliance on data, computational power and connectivity; ii) the emergence of data analytics and business intelligence for decision-making; iii) human-machine interaction such as touch interfaces and augmented-reality system; and iv) improvement in transferring digital instructions to the physical world such as 3D printing and robotics (Lee, Lapira, Bagheri, & Kao, 2013). These disruptions have challenged firms and consumers to adopt changes for the best.

2.2. Challenges

In order to change for the better, firms need to maximize their potential by shifting from the traditional business model to IR 4.0. Similarly, society needs to consider IR 4.0 because of its advantages in the future, even though, in the short run, IR 4.0 will face many problematic challenges. Challenges that may occur for firms and society as well as government are:

- IT security issues when upgrading and adopting new technology
- Reliability of new technology

- Maintaining the integrity of production processes
- Unethical approach of business through advance technology adoption
- Governance of industrial knowhow and control industrial files
- Lack of skills to expedite IR 4.0
- Threat of redundancy of the corporate IT department
- Lack of top management support for change
- Jobs are lost due to automation, especially in a lower-educated society.

As such, every stakeholder, especially firms, must be agile to react to these new competitive challenges. For example, 84 percent of manufacturing suppliers expect new competitors to enter the market soon after IR 4.0 (Baur & Wee, 2015). However, the most difficult challenge for firms is determining where and how to begin when IR 4.0 transpires. In order to be ready for IR 4.0, firms need to ponder which data would benefit them. Which technologies would deliver the highest return on investment and which technologies should firms avoid? (Sung, 2018). This is critical because IR 4.0 success relies on data availability and good data. For example, an oil exploration firm collected over 30,000 pieces of data from each of its drilling rigs, but all data was lost due to data transmission error and data storage problem (Sung, 2018).

On the other hand, in regard to data, consumers' personal data will become a huge concern and difficult to manage. Due to the interconnected IR 4.0 with consumers, the gap between firms and consumers has become narrow, challenging both parties (Sung, 2018) to find synergy. Firms' integrity will be questioned when a new product or service using new technologies adapts to consumers' personal requirements. In addition to the integrity challenge, firms will also face the decision to train workers with IR 4.0 related skills or hire new workers to adopt IR 4.0 quickly. Furthermore, firms could see employment rates rise and face societal repercussions when replacing old or uneducated workers (Sung, 2018). This means that the education system must support and help society be ready for IR 4.0.

In Malaysia, readiness to embrace IR 4.0 is rather slow compared with Vietnam and Thailand, which already have IR 4.0 policy frameworks (Pandiyan, 2017). According to Ministry of Investment, Trade and Industry (2018), Malaysia is developing policies and frameworks for IR 4.0. The slow process of designing IR 4.0 frameworks has caused firms to be hesitant to adopt IR 4.0 practices such as advanced technology, automation systems and skilled workers. Thus, many firms prefer foreign workers and wait for the Malaysian government to introduce incentives to adopt IR 4.0 (Pandiyan, 2017). The cost of IR 4.0 adoption also is a major challenge for local firms, especially Small and Medium Enterprises (SMEs). The majority of SMEs also argued that they do not need an internet-based business model because the

current issue facing SMEs is still a financial challenge (Ministry of Investment Trade and Industry, 2018). As a result, Malaysia is trying hard to increase the speed of IR 4.0 adoption in all its industries. Only the Electric and Electronic (E&E), automotive and aerospace industries are currently viewed as "IR 4.0 ready".

As for other industries in Malaysia, gearing towards IR 4.0 will need intervention from the Malaysian government in terms of incentives and policies and collaboration from firms to face challenges in the Malaysian environment (Ministry of Investment Trade and Industry, 2018) such as:

- Lack of awareness of IR 4.0 in Malaysia in regard to its benefits
- Vague comprehensive policy and coordination on IR 4.0
- Lack of infrastructure to support IR 4.0 particularly in digital infrastructure
- Lack of incentives to help firms move to IR 4.0
- Mismatch skillsets and lack of right talent
- Lack of standards resulting in difficulty of integrating different systems and reliability issue.

Whitepapers by government agencies show that even though IR 4.0 has been discussed among government and firms, the awareness is still subject to policy of government. Firms are not playing active role in promoting IR 4.0 as it is costly research and there are no incentives to undertaken or practicing IR 4.0 in Malaysia at this moment

2.3. Impact

Challenges of IR 4.0 if left unchecked will impact on economy and social of a country. Economy will improve in the long run after firms and industry reach IR 4.0. However, in the short run, support from top management, government incentives and industry policy are important to reduce the negative impact of IR 4.0 and taking advantage of IR 4.0 benefits. On the other hand, IR 4.0 also will impact on society in terms of communication, government policy and education system. For society to be ready for IR 4.0, consumers need to improve skills especially related to technology, government need to advance infrastructure and policies in all department and education system need to be revamped with technology as its medium. In regard to education system, academicians need to help government, industry and society ready for IR 4.0 in terms of refining research on IR 4.0.

Other than economy, academic and society, industry also will be impacted especially industry that relies heavily in technology and industry that do not require technology. This is because IR 4.0 will bring about changes in technologies. Thus, industry will benefit from the investment. Nevertheless, investment of new technology is expensive and depending on availability of

skilled workers in the country. For example, manufacturing automation will provide fault diagnosis, self-awareness, and self-predictiveness for management in making decisions. This information is critical for decision-making, but if firms are unable to take advantage of this benefit, automation and technology investments will not be profitable.

On top of that, the industry that lacks in technology adoption will be further left behind or unproductive due to IR 4.0 in other industries or competitors already in IR 4.0. For example, firms with automation will outperform firms without technology for IR 4.0 due to automation and data being able to predict the components and alert manufacturing workers to trigger required maintenance (Javaid et al., 2022). As a result, quality, zero-defects and just-in-time concepts improved. Therefore, the impact of IR 4.0 on the economy, society, academia, and industry will be an issue for every stakeholder if it is not managed properly.

2.4. Issues

Schwab (2017) stressed that firms and society are not ready to embrace IR 4.0 even though knowing that IR 4.0 is inevitable. For example, Malaysian Employer 2015 found that more than 18,000 employees were retrenched in the banking industry when banks decided to replace certain jobs with technologies (World Economic Forum, 2016). Therefore, society must start accepting that automation and data will be part of everyday life. Thus, improving skills and education are critical for the readiness of IR 4.0.

The readiness of IR 4.0 means that there will be a rise in smart production, cyber-physical systems, decentralized decisions in organizations and the ability to create a virtual copy of the physical world (Hermann et al., 2016). Due to these benefits, firms and the government need to ensure that it will not be the trust and privacy of consumers. Furthermore, adhering to ethics and integrity in IR 4.0 will be difficult. IoT of IR 4.0, which comes with benefits, can also threaten consumers when firms mismanage data.

Mismanagement of data is an issue that escalates due to complexity of managing IR 4.0 development, especially in governance and integrity. Due to growing operations and networks of firms and interconnected consumers, ethical issues will become a grey area for firms. The grey area is because the boundaries between individual firms and consumers will likely be non-existent (Sung, 2018). A borderless business model due to IR 4.0 also will give rise to security issues. IR 4.0 require online integration among firms and consumers in a larger

demographic coverage. Since the coverage is enormous, data leaks and breaches will become a critical issue that firms and governments must pay attention to to reduce the threat of cyber theft. This is because cyber theft will lead to the risk of increasing costs for firms and a bad brand image (Sung, 2018).

Technologies also enable the government to increase surveillance and the ability to control digital infrastructure (Hermann et al., 2016) – [21]. If left unchecked, these surveillance and control will lead to societal disagreement but if the government able to use new technological power for betterment of society and industry, this will enable society to engage better with governments (World Economic Forum, 2016).

In Malaysia, the government is formulating an IR 4.0 policy to move from low-skilled workers' dependency to be ready for mass production of IR 3.0 to technologies and data-driven concept of IR 4.0. However, Malaysian firms still depend on cheap labour and are prone to errors. Adopting IR 4.0 will increase efficiency and zero defects (Ministry of Investment, Trade and Industry, 2018). For example, the Human Resources Development Fund (HRDF) found that 15 million Malaysian sector workers must improve their skills to be ready for IR 4.0 or face the reduction consequences. However, only two million Malaysian workers registered for skilled improvement programs in Malaysia. Furthermore, it was found that only half of graduates are employed after leaving university, while others remain jobless (Human Resources Development Fund, 2018). Therefore, Malaysia IR 4.0 must look into education system and policy development to progress in digitization.

2.5. Malaysia IR 4.0

As shown in Table 1, Malaysia is ranked 23rd in global competitiveness behind South Korea, Belgium and France (Régner & Wild, 2016). Nevertheless, Singapore has outperformed Malaysia, and Thailand has already developed its IR 4.0 policy and framework. On the other hand, European countries are also planning on a long-term strategy for IR 4.0, which involves institutes, universities, local governments, and central government (Kwak & Kim, 2018). On the other hand, Japan has proposed seven strategic responses to foster IR 4.0. The Japanese government has identified reorganization of data utilization, improving human resources systems, accelerating innovation and technology development, strengthening financial function, facilitating employment structures, distributing benefits of IR 4.0 to SMEs and enhancing economic and social systems.

Table 1. Countries ranking based on IR 4.0 readiness

No	Country	WEF Rank	UBS Rank	IMD Rank	Average
1	Singapore	1	2	1	1.3
2	Finland	2	4	4	3.3
3	USA	5	5	3	4.3

No	Country	WEF Rank	UBS Rank	IMD Rank	Average
4	Netherlands	6	3	6	5.0
5	Switzerland	7	1	8	5.3
6	Sweden	3	11	2	5.3
7	Norway	4	8	10	7.3
8	UK	8	7	11	8.3
9	Denmark	11	9	5	8.3
10	Hong Kong	12	7	7	8.7
11	Canada	14	15	9	12.7
12	New Zealand	17	10	14	13.7
13	Germany	15	13	17	15.0
14	Taiwan	19	16	12	15.7
15	Japan	10	12	27	16.3
16	Australia	18	17	15	16.7
17	Austria	20	18	16	18.0
18	Israel	21	21	13	18.3
19	Korea	13	25	19	19.0
20	Ireland	25	14	21	20.0
21	Belgium	23	19	22	21.3
22	France	24	20	25	23.0
23	Malaysia	31	22	24	25.7
24	Portugal	30	23	33	28.7

Source: Kwak & Kim (2018)

On the other hand, Malaysia depends heavily on foreign labour for its production (Awad, Yussof, & Khalid, 2018). Therefore, Malaysia should embrace new technology for IR 4.0 to increase productivity and efficiency. Through improvements in operations, Malaysia can expand its market through digital platforms that benefit from IR 4.0 (World Economic Forum, 2016). Malaysia has a head start regarding automation and digital platforms, especially in the Electric & Electronics, automotive, aerospace and construction industries (World Economic Forum, 2016). It was reported that in the first half of 2017, Malaysia approved 16 manufacturing projects with Japanese counterparts to foster new technologies. In addition, these investments are worth RM559 million, with 75 percent of these projects are reinvest by Japanese firms already operating in Malaysia (Bernama, 2017).

Malaysia has also launched a task force to formulate IR 4.0 framework. In May 2017, several Malaysian ministry departments, such as MITI, the Ministry of Science, Technology and Innovation (MOSTI), and the Ministry of Higher Education (MOHE), were invited to develop this initiative. These technical groups of Malaysian ministries are involved in formulating a digital structure and eco-system, funding and incentives for IR 4.0, developing talent and human capital, technology and standards, and improving SMEs (Ministry of Investment Trade and Industry, 2018). However, at this moment, Malaysia is still in the early stages of identifying challenges, impacts, and issues that the government needs to act on to make recommendations for IR 4.0. This is done through outreach programs to increase collaboration with central and local governments and society, such as the public, industry and academia (Ministry of Investment Trade and Industry, 2018).

2.6. Enforcement

Malaysia was once part of the Asian Tigers with Singapore, Korea and Taiwan previously in the 80s. Nowadays, Malaysia is only ahead of ASEAN countries such as Indonesia and Thailand but still behind Singapore, South Korea and Taiwan. Even Vietnam and Cambodia are catching up with Malaysia regarding industrial growth. Thus, Malaysia needs to start acting to develop its industries. Malaysia has started progressing in manufacturing by capitalizing on technology adoption and free trade agreements with ASEAN countries and other Asian and European countries. Furthermore, in the last 2017 budget, the Malaysian government announced incentives for firms to invest in new technologies, especially green technology. This will help Malaysian firms to move towards IR 4.0 (World Economic Forum, 2016).

In moving towards IR 4.0, Malaysia has already developed a policy for smart manufacturing, increased capital venture, and increased education opportunities for future generations (Bhunia, 2017). As much as RM1 billion is provided for investments in main industries. At this moment, other than providing investments, Malaysia is also the only country other than China that has established a Digital Free Trade Zone (DFTZ). Accordingly, DFTZ has enabled technologies such as e-Fulfilment Hub (to help SMEs and firms exporting products and services), Satellite Service Hub (for local and global internet-based firms to provide end-to-end support) and e-Services Hub (for managing cargo clearance and other logistics processes for cross-border trade) (Bhunia, 2017). In addition to incentives for firms, Malaysia also has eUsahawan for digital entrepreneurship to enhance public income through online sales and eRezeki to help low-income households access digital income opportunities (Bhunia, 2017).

2.7. Risk Minimization for Firms

Hermann et al. (2016) have suggested more studies on IR 4.0 to follow a research process as follows:

1. Identify relevant literature review
2. Conduct quantitative analysis
3. Publish empirical studies
4. Organize workshop for discussion

In Malaysia, Non-Governmental Organization (NGO) have collaborated with governmental departments to recommend areas that need to be strengthened to reach IR 4.0. The recommendations are to develop talent in Malaysia, set governmental policy for IR 4.0, increase the awareness of IR 4.0 benefits, focus on firms that have already reached IR 4.0, learn from large firms, especially Multi-National Companies (MNCs), create a conducive business environment, improving internet infrastructure and focus on service industry (Sim, Ong, Agarwal, Parsa, & Keivani, 2003). Regarding infrastructure investment for IR 4.0, the Malaysian government has also improved cyber security so that firms' and society's data will not be at risk (Ministry of Investment Trade and Industry, 2018). Currently, the enforcement of IR 4.0 is not evident as Malaysia is in a stage of discussion among policymakers and industry to foster IR 4.0. Nevertheless, the Malaysian government has asked firms to strengthen the organizations' technological advancement and provide a better environment for IR 4.0.

On the other hand, manufacturing firms that are the heaviest contributors to carbon emissions can take pre-emptive actions and prepare for IR 4.0 by practicing reverse logistics. This practice allows firms to add value to the supply chain and gain more profits. Furthermore, as firms recollect materials or products and then reuse or remanufacture the product, this allows firms to automate the supply chain process (Fernando, Shaharudin, Ismail, Yew, & Ganesan, 2018). As a result, when firms enter the IR 4.0 era, automation will include the forward supply chain process (from supplier to customer) and the backward supply chain process (reverse logistics).

3. Conclusions

This study is one of the earliest studies of IR 4.0 that provides issues, challenges, impact, Malaysia IR 4.0, and enforcement of IR 4.0 so that scholars can undertake the next agenda of identifying relevant literature reviews and providing empirical evidence. Furthermore, an investigation of the framework for adopting IR 4.0, which consists of IR 4.0 enablers of technology, organization, and environment, should be undertaken to help firms' readiness for IR 4.0. The importance of IR 4.0 cannot be denied as the advantages of IR 4.0 have been generally accepted by all. Moreover, every country is now racing to be ready for IR 4.0 and to capitalize on its benefits. Yet, firms mostly affected by IR 4.0 must not neglect carbon emissions reduction to curb climate change.

This paper's findings show that it will be some time before countries are ready for IR 4.0. It must be done by improving firms' environmental, social, and operational performances, as firms have yet to promote IR 4.0 actively. Malaysia, on the other hand, is still in discussion of policies and NGOs have to play a role as in Malaysia NGOs are the intermediaries between government and firms. In order to further develop IR 4.0, Malaysia needs to focus on identifying relevant IR 4.0 enablers in terms of the technology organization and preparing the right environment for firms to be ready for IR 4.0.

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