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Industry 4.0 Adoption and Diffusion in Manufacturing SMEs in Malaysia

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Abstract. The world is at a moment of transformation that will change humans' well-being and workplaces in the near future. Companies in various sectors and countries should expect big changes as a result of this technological transformation. However, it is believed that this transition would be unique due to the scope and volumes of the transformation are based on digital technologies adoption. Thus, many industries around the world are considering how to embrace the increasing prevalence of technological optimization in conventional manufacturing systems, which has led to intelligent manufacturing. Therefore, the main objective of this paper is to explore the industry 4.0 technologies adoption employed by the manufacturing SMEs Malaysia and the issues and challenges considered to be the game changer and pave the way for increased efficiencies as well as transforming existing relationships in manufacturing SME Malaysia.

Keywords: industry 4.0, manufacturing, small medium enterprises, digital transformation

1. Introduction

Since the time of the Industrial Revolution, large-scale of operational activities in production process have made a significant contribution to better living conditions, offered many alternatives, and led to a lot of unwanted side effects, such as COVID-19 pandemic lockdown, emissions, pollution, waste disposal and carbon footprint. Small and medium-size enterprises (SME Malaysia) have been under huge pressure throughout the period of IR4.0 (Industry 4.0) and support their manufacturing activities. Figure 1 illustrates the segregation of Malaysian SME with a wide range of categories. The adoption of IR4.0 technologies has been observed and expected to further achieve the objective of ethical and sustainable operations [1]. While a significant amount of research has been conducted for big companies, there is less research available on the application for sustainable operations of IR4.0 developments in manufacturing SME Malaysia. In the light of the immediate effects of the declining market for many goods and services as well as the urgent need to ensure the well-being of employees, SME Malaysia struggle with technological changes and economies shift to the "new normal," businesses that will have some significant changes in their operations while help alleviate the disruption of climate changes and sustainability practices [2].

These developments range from the advent of hybrid digital technology devices and entirely electrifying activities to the enhancement of performance by digitization, advanced analytics and artificial intelligence in manufacturing SME Malaysia. In spite of this, [3] stated that business model innovation also aims to meet the need for low-carbon solutions and environmentally natural products, as well as to redirect production supply chains to more "circular" practices. These quick-hit overviews can serve as a helpful starting point for thinking and guidance for managers of every business looking manufacturing SMEs to map their own sustainability path [4]. Therefore, in order to support the prospect of long-term strategic advantage and profitability, manufacturing SMEs realize that their processes must be achieved more than ever before, by stronger resilience, quicker growth, and higher customer loyalty with more committed employees [5]. This includes making the most of digital transformation in all production activities, including support functions in

manufacturing activities. However, in order to better re-imagine the introduction of IR4.0 for a digitally-infused future, manufacturing SMEs must find avenues that expand value through new consumer engagement, through integrated digital technologies that facilitates the adoption of IR4.0 [6].

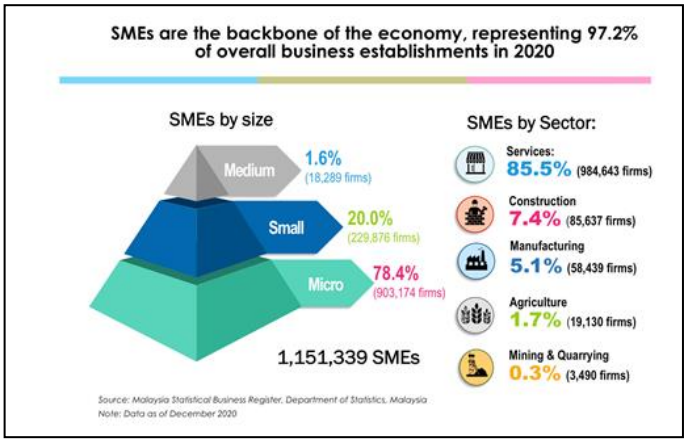

Fig. 1: Segregation of Malaysia SME with a wide range of categories.

2. Industry Revolution 4.0

In the 18th century, the first industrial revolution was a significant time for human progress, since it changed the society in which we all exist. For industrialization, the invention of the steam engine had been important, paving the way for the construction of more advanced heat engines for power production. In times of prevalent agricultural and rural societies, it was transformed into kick-started manual labor substitution with machines to transform the workforce into urban and industrializing. This is called industrialization of the world, starting in Great Britain and gradually expanding to Europe and the Americas and rest of the world [7].

The second wave of industrialization started more than one century later following the 1st Industrial Revolution. The 2nd Industrial Revolution, popularly known as the Technological Revolution, has been inspired by technological progress, and new forms of electricity, gas and oil have emerged. Transportation has also made a significant breakthrough with the railways between towns and communities. In the early 20th century, the 3rd Industrial Revolution began, which saw an increase in electronics and the use of IT to automate manufacturing. The development of miniaturized devices has resulted in new digital technology transformation such as microprocessors, telecommunications systems and computers.

This transition for manufacturing has led to the age of high- level process automation by two big innovations–automation and robots [8]. If steam engine and machine transition characterize the 1st Industrial Revolution, the 2nd is the use of power for mass manufacturing. In order to carry out the development of IR 4.0, the 3rd Industrial Revolution is divided by the use of computers and electronics. This transition is embedded in the volatile spread of new technology-cyber physical systems (CPS) and in complex data treatments to fully transform digital economies worldwide, intermittent the gap between physical, automated and biological scopes [9]. As manufacturing SME Malaysia recognize the value of automation and emerging technologies, rigorous studies efforts are being made to increase reliability and mass customization of these systems. Furthermore, current digitalization in manufacturing SME Malaysia changes have modified the way personalized goods are produced [10]. Thus, the IR4.0 technologies have given rise to a cloud production model where products are produced according to consumer requirements.

3. Problem Statement

[11] Stated that the global business conditions manufacturing SMEs are highly ambitious. In an environment of manufacturing activities, SMEs can make use of innovations and technology in order to increase manufacturing sustainability. [12] Found that sustainability impacts the success of a manufacturing SME Malaysia. Furthermore, [13] also found that IR4.0 technologies could provide manufacturing SME Malaysia a competitive advantage. Focusing on operational activities and technological advancement, manufacturing SME Malaysia are able to increase efficiency and task fulfilment [14]. While technology

adoption can increase the productivity of production processes [15], the efficient and sustainable use of process digitization and quality management will make production processes efficient and sustainable. [16] Pointed out that manufacturing quality, process improvements and resilience can be increased by the implementation of IR4.0 technologies. Comparatively, SME Malaysia have to adopt new technologies to support their success in order to succeed and excel in the domestic and international business scenario [17].

In like manner, adopting IR4.0 technological processes incompletely will affect the efficiency of SMEs [18]. Thus, SME Malaysia can improve efficiency, versatility, responsiveness and environmental performance by using emerging technologies [19]. However, very few studies have explored holistically the problems faced by other manufacturing SMEs in developed countries in the adoption of IR4.0 [20]. Therefore, research issues concerning manufacturing SMEs in developing countries would consequently need to be analysed accordingly with regards to the adoption and diffusion of IR4.0 in manufacturing SMEs.

4. Technologies Employed in the Manufacturing SMEs

In view of the digitalization changes and mass customization of IR4.0 technologies, Figure 2 highlighted the main IR 4.0 technologies used by manufacturing SMEs nowadays.

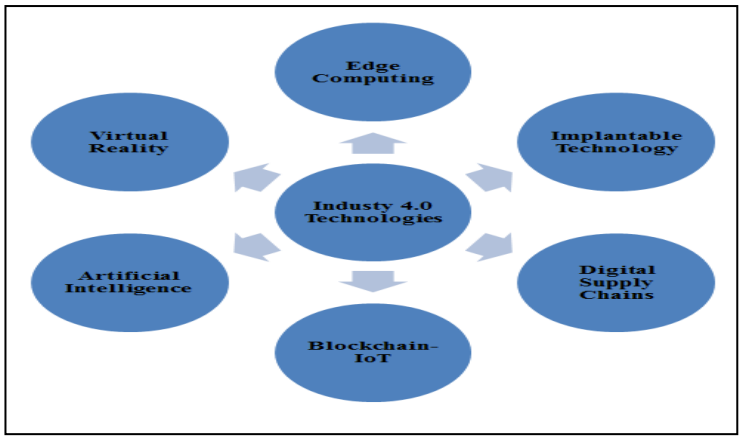

Fig. 2: Industry 4.0 technologies employed in the manufacturing SMEs.

Based on the key aspect discussed, the adoption of IR4.0 technologies will be able to eliminate the limitations of traditional manufacturing processes by encouraging manufacturing SME Malaysia to build dynamic structures with greater productivity and produce highly customized products [21]. Therefore, manufacturing SME Malaysia should adopt IR4.0 technologies and focus on new manufacturing processes to improve their manufacturing capacity and capability. This suggests that the adoption of IR4.0 technologies will increase rapidly and greatly revolutionize the manufacturing industry generally and SME Malaysia particularly [22]. In addition, the research and development for the advancement of IR4.0 technologies adoption should be undertaken seriously in order to close the technological gaps currently faced by manufacturing SMEs globally. Indeed, the introduction of IR4.0 technologies adoption is gathering momentum as the manufacturing sector progresses along with the on-going wave of automation and digitalization due to increased demand and mass customization [23].

Even though evidence shows that the adoption of IR4.0 technologies in manufacturing SME Malaysia can help increase efficiency, improve productivity and enhance the robustness of manufacturing processes, the main objective of this paper is to explore the IR4.0 technologies adoption employed by the manufacturing SMEs [24]. Subsequently, this paper will also identify the issues and challenges considered to be the game changer and pave the way for increased efficiencies as well as transforming existing relationships in manufacturing between suppliers, manufacturers, consumers and human-machine interaction.

5. Materials and Methods

Important keywords, such as “Industry 4.0”, “Artificial Intelligence”, “Cyber Physical System”, Autonomous Robots”, “Smart Factory”, Internet of Things”, “Simulation”, “Additive Manufacturing”, Augmented Reality” and “The Cloud” were used for literature-based research in this paper. These technical

key words were mixed in a variety of ways to access the relevant research materials to narrow down the objective of the literature review. Most of the journal articles was collected from "Google Scholar" academic research engine, and numerous research papers were also obtained from peer- reviewed journals such as IEEE Xplore, ScienceDirect, Emerald, ResearchGate, Routledge, Sage and Taylor & Francis for unified search options.

6. Issues and Challenges of IR4.0 Adoption

As industrial demand increases, technological innovations are rapidly emerging to fill the difference between market needs and the product offered. By integrating the IR4.0 technologies, manufacturing companies able to address the new technologies considered to be the game changer and pave the way for increased efficiencies as well as transforming existing relationships in manufacturing companies towards the adoption of IR4.0. While manufacturing SME Malaysia are still mindful of the value and usefulness of technology, they have far lower levels of technology adoption than multinational enterprises (MNE) and multinational companies (MNC). The main motivation for the adoption of IR4.0 technology is to reduce costs [25, 26], improve time-to-market [27], legal requirements/changed legislation and lack of qualified labor force [28], lack of knowledge [29], further focus on operation at the expense of company growth, lack of understanding of strategic importance, very few human resources and the need for continued education [30]. These findings suggest that more tools are required to prepare manufacturing SMEs to be ready for digital change and, surprisingly, they also imply that obstacles that reduce preparation have a low impact on the adoption of IR4.0 technologies [31]. Table 1 addresses some of the issues & challenges of IR4.0 adoption in manufacturing SMEs among scholars.

Table 1: Issues & challenges of IR4.0 adoption in manufacturing SMEs

Issues	**Challenges**
Awareness	Lack of awareness of the effects and need of IR4.0 technologies, both in terms of opportunities and business model disruption, especially among manufacturing SMEs.
Innovation	Change in consumer preferences and customization and fast fulfillment demand.
Digital Readiness & Connectivity	Digital adoption among manufacturing SMEs is particularly low and the automation of production is restricted (majority of firms use less than 50 percent of automation).
Skill Enhancement	A significant shortage for IR4.0, particularly IoT, robotics and artificial intelligence, of necessary talents, skills and knowledge.
High Cost of Investment	Higher adoption costs and slower industry payback time IR4.0 processes and innovations.
Ecosystem Support	Few numbers of local players that provide solutions to IR 4.0 through key technology rather than costing foreign player competitiveness.
Funding & Incentive	No clear financial funding and incentives for the advancement of technologies in IR 4.0 from research and development to prototyping, training and upgrades.
Governance	There are, however, under-used training and growth funds and higher STEM training allocation needs (e.g. scholarships).
Infrastructure	Gaps in the introduction in main manufacturing and training sites of high speed width networks that can't always meet Industry 4.0 technology needs.
Training Providers	Existing training programs are insufficiently adapted to Industry 4.0, and the existing pool of practitioners is unable to keep up with technological advancements.

7. Major Contributions of the Study

In view of contribution of the study, IR4.0 connected technology is being increasingly integrated into businesses and people's everyday lives. This transition is new and physical technology offers enormous opportunities but they will also increase the current hierarchy and create almost full uneasiness, because they will be prosperous. In this way, IR4.0 encourages organizations, instead of just mistreating technology, to follow constantly recent approaches, to take advantage of the network-based, data-driven, autonomous and psychological technical and physical systems to form genuinely creative market solutions. It is also important to understand the vital links between market and social needs; monetary result and creative strategies; employees morale and a sense of well-being and stability; convergence of existing technology, and complete development of new ideas [32]. Overall, manufacturing SMEs managers should assess the full potential of IR4.0 in the early stages of their activities.

In spite of this, the most common enablers for automation in the operations of manufacturing SMEs Malaysia are decreasing labor costs, reducing manufacturing defects and rising product efficiency. However, extended literature shows that IR4.0 adoption enhances the industry's incorporation. For a small-batch output, configurable lines in the manufacturing process, machine-machine coordination allow reconfiguration and flexibility of product design [33]. Additionally, there is more assistance for decision-making with the CPS information technology businesses, and this leads to quicker adaptation with several events, including disruptions in production lines, and to manufacturing. Using this method, SME Malaysia are expected to effectively exploit resource management, for example, IR4.0 adoption help businesses achieve a greater competitiveness by incorporating renewable energy sources like solar and wind with a smart grid for instance. This will provide new advantages and new horizons for businesses of all kinds. Horizontal integration unites businesses by pooling capital, diversifying risks, and responding rapidly to emerging business conditions. In addition, ease of use and customer engagement is provided by digital solutions and goods, which allows the latter to contribute further to the overall success of the manufacturing SMEs through vertical integration [34].

8. Limitations and Future Scope of the Study

The IR4.0 adoption in manufacturing SMEs Malaysia has several goals but is basically a facet of industrial technologies that looks for ways to help businesses become more efficient, save time, and increase profits by enabling machines to do a variety of jobs instead of having employees do them one by one at a time. Furthermore, this paper has been designed to meet a wide range of applications of IR4.0 adoption issues and challenges. Though this is a conceptual study, nothing is performed to verify it with hypothetical testing. Future study’s scope will extend the CPS architectures allowing for mass customization in fast iterative processes. Furthermore, an adaptive closed-loop feedback system shall be implemented in the production of additive manufacturing processes to increase production performance. Thus, the incorporation of human-machine interfaces into industry could transform into a widespread practice signalling the arrival of IR 5.0 to support the integration of people, process and technology use to reduce the overall time required to satisfy consumer demand.

9. Conclusion

The literature review-based analysis has helped in identifying manufacturing technologies and IR4.0 adoption among manufacturing SMEs. It has been shown that the manufacturing SME Malaysia goals will focus on mass customization and personalization, while reducing material waste with fewer harmful emissions if manufacturing technologies embedded with sensor technologies. In conclusion, an indefinitely large number of industries can also explore this IR4.0 technology due to its application in diverse fields. Making use of IR4.0 adoption as input for this paper will help in the mass manufacturing of smart and resilient products, leading to massive industrial reforms.

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