

**DRIVING FACTORS OF INDUSTRY 4.0
READINESS AMONG MANUFACTURING SMES
IN MALAYSIA**

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**DRIVING FACTORS OF INDUSTRY 4.0
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IN MALAYSIA**

by

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LIST OF ABBREVIATIONS

SME	Small and medium sized enterprise
SMEs	Small and medium sized enterprises
RBV	Resource Based View
PKS	Perniagaan Kecil dan Sederhana

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FAKTOR-FAKTOR PEMACU KESEDIAAN INDUSTRI 4.0 DALAM KALANGAN PKS PEMBUATAN DI MALAYSIA

ABSTRAK

Revolusi perindustrian keempat, juga dikenali sebagai Industri 4.0, meningkatkan kecekapan pengeluaran dan daya saing syarikat. Walau bagaimanapun, pelaksanaan Industri 4.0 agak rendah di negara membangun. Lebih-lebih lagi, PKS pembuatan Malaysia masih di peringkat permulaan penggunaan Industri 4.0. Oleh itu, situasi ini menandakan keperluan untuk meluaskan pengetahuan semasa bagi persediaan Industri 4.0 dalam kalangan PKS pembuatan Malaysia dan faktor pendorong yang memainkan peranan penting dalam meningkatkan kesediaan PKS untuk transformasi digital di Malaysia. Berdasarkan Teori Pandangan Berasaskan Sumber, kajian ini membina rangka kerja penyelidikan untuk mengawal penyiasatan keupayaan organisasi, sokongan institusi PKS, kelebihan yang terlihat dan faktor pasaran sebagai faktor pendorong kesediaan Industri 4.0 firma pembuatan PKS Malaysia, manakala saiz firma sebagai penyederhana. Soal selidik dalam talian telah dihantar kepada pemilik dan pengurus PKS pembuatan Malaysia yang terletak di seluruh Semenanjung Malaysia, yang mana firma tersebut telah menerima salah satu bentuk bantuan kerajaan. Seramai 110 pemilik dan pengurus daripada PKS pembuatan Malaysia mengambil bahagian dalam penyelidikan ini. Data yang dikumpul dianalisis menggunakan pemodelan persamaan struktur kuasa dua terkecil separa. Berdasarkan analisis, kajian menunjukkan bahawa keupayaan organisasi, sokongan institusi PKS, dan faktor pasaran mempunyai hubungan positif dengan kesediaan Industri 4.0, manakala kelebihan yang terlihat tidak mempunyai kesan ke atas kesediaan Industri 4.0. Sementara itu, saiz firma bukanlah penyederhana yang signifikan terhadap

hubungan antara keupayaan organisasi, kelebihan yang terlihat, faktor pasaran, dan kesediaan Industri 4.0. Walau bagaimanapun, saiz firma didapati boleh menyederhanakan hubungan antara sokongan institusi PKS dan kesediaan Industri 4.0. Dapatan kajian ini bermanfaat kepada pengamal industri dan penggubal dasar yang ingin memacu masa depan ekosistem perniagaan PKS Malaysia serta menyumbang kepada literasi Industri 4.0.

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ABSTRACT

The fourth industrial revolution, also known as Industry 4.0, increases production efficiency and competitiveness of companies. However, implementation of Industry 4.0 is comparatively low in developing countries. Moreover, Malaysian manufacturing SMEs are still at their infancy stage of Industry 4.0 adoption. Hence, it signals the need to broaden the current state of knowledge in Industry 4.0 readiness of Malaysian manufacturing SMEs and the driving factors that play significant roles in strengthening SMEs' readiness for digital revolution in Malaysia. Based on the Resource Based View Theory, the present study builds a research framework to govern the investigation of organizational capabilities, SME institutional support, perceived advantage and market factors as the driving factors of Industry 4.0 readiness of Malaysian SME manufacturing firms, firm size as the moderating variable. Online questionnaire was sent to the owners and managers of Malaysian-owned manufacturing SMEs located throughout Peninsular Malaysia, which the firms have received some form of government assistance. A total of 110 owners or managers from Malaysian manufacturing SMEs participated in the research. The data collected were analysed using partial least squares structural equation modeling. Based on the analysis, the study indicated that organizational capabilities, SME institutional support, and market factors have a positive relationship with Industry 4.0 readiness while perceived advantage has no impact on Industry 4.0 readiness. Meanwhile, it was determined that firm size is not a significant moderator on the relationship between organizational capabilities, perceived advantage, market factors, and Industry 4.0

readiness. However, it was found that firm size does moderates the relationship between SME institutional support and Industry 4.0 readiness. The findings of this study are beneficial to both industry practitioners and policymakers who wish to drive the future of Malaysia's SMEs business ecosystem and contribute to Industry 4.0 literature.

CHAPTER 1

INTRODUCTION

1.1 Introduction

The present chapter describes the background of the study, problem statement, research objectives, research questions, and the significance of the study. It is followed by the definition of key terms and the organization of the thesis.

1.2 Background of the Study

Global manufacturing industries have seen digital transformation compelled by Industry 4.0 as an important agenda due to its operational advantages and market opportunities (Nagy et al., 2018). Industry 4.0 revolutionize by what means products are designed, fabricated, delivered, produced, used, operated, serviced and maintained (Ministry of International Trade and Industry, 2018). It also changes the processes, operations, supply chain management, skill requirement and manufacturing power, and the energy footprint of the factories (Ministry of International Trade and Industry, 2018). Product lifecycles are becoming shorter, which drives the sector's constant and ongoing flow of product development projects (Santos et al., 2022). Furthermore, the current COVID-19 pandemic provides an opportunity for a new generation of entrepreneurs to lead the next industrial transformation and innovate new methods of doing business through the use of state-of-the-art technology (Akpan et al., 2022). According to Bawany (2018), Industry 4.0 is about the idea of smart factories where machines are augmented by using web connectivity and linked to a system that can envision the whole production chain and make decisions on its own. Smart factories exhibit a big step further from more traditional automation to a fully connected and flexible system, where computers and machines communicate to each other, collect

and exchange data, and based on the data, enhance production efficiency to better positioning in the competitive marketplace (Burke et al., 2017). From a macroeconomic approach, Industry 4.0 is regarded as the new competitive advantage of a nation (Erro-Garcés, 2019).

In the context of Small and Medium-sized Enterprises (SMEs), globalization and rapid technological advancements have paved the road for SMEs to become more competitive. SMEs are regarded as an economy's backbone, and they are the largest contributors to the gross domestic product in most countries (Robu, 2013). According to Organization for Economic Co-operation and Development report (OECD, 2019), SMEs represent 99 percent of all firms in the OECD area, and almost one out of three persons are employed in a micro firm with less than ten employees, and two out of three persons in an SME. While in the Malaysian context, SMEs are defined based on qualifying criteria such as sales turnover and employment. For the manufacturing sector, SMEs are defined as establishments with sales turnover not exceeding RM50 million or the number of full-time employees not exceeding 200 (SME Corporation Malaysia, 2020b). Based on the SME Insights of SME Corporation Malaysia (2020b), SMEs account for 98.5 percent of all businesses and contributed 38.9% of GDP in 2019, while there were 907,065 business establishments classified as SMEs, and they contributed to 48.4 percent of the country's workforce employment.

In terms of manufacturing firms, Industry 4.0 can change manufacturing SMEs in a variety of ways, including increasing productivity, efficiency, flexibility, and cost-effectiveness; increasing production capacity; allowing for improved quality control and monitoring, as well as a reduction in waste, delivery time, and system downtime (Kayikci, 2018; Koch et al., 2014; Waibel et al., 2017). Therefore, investing in

Industry 4.0 is crucial for manufacturing firms that desire to remain competitive in this global economy (Bosman et al., 2019). On top of that, the manufacturing sector has the greatest multiplier effect on the nation's operations and progress, and it remains the most important sector in the Malaysian economy (Singh, 2021). As of 2020, Malaysia recorded RM164 billion in approved investments, while the total investments approved were led by the manufacturing sector, which received RM91.3 billion (Singh, 2021).

Globally, the manufacturing industry is evolving from a labor-intensive to an automation and digitalization landscape conforming to Industry 4.0 (Geissbauer et al., 2016). The trend toward automation and data exchange in manufacturing technologies, such as cyber-physical systems, artificial intelligence, the internet of things (IoT), cloud computing, and robotics, enables companies to respond faster to market changes and more easily implement configurations or replan production (Kayikci, 2018). In Malaysia, the manufacturing sector is the second-biggest contributor to the overall SMEs, with 47,698 establishments constituting 5.3% of SMEs (SME Corporation Malaysia, 2021). On 21 February 2020, the Ministry of International Trade and Industry (MITI) initiated the National Automotive Policy 2020 (NAP 2020), which is an expansion and prolongation of NAP 2014 and aims to propel Malaysia into a regional leader in automotive manufacturing as the automotive industry plays a significant role in the country's transformation into an industrialized nation (Ministry of International Trade and Industry, 2020). Malaysia's manufacturing sector accounts for 80% of interregional merchandise trade, and only 20% of interregional trade is in services (Wu, 2019). This study focuses on manufacturing SMEs as it has a significant impact on the country's economy.

1.3 Problem Statement

The Malaysian government has recognized the significance of integrating the Industry 4.0 initiative into the national agenda to accelerate the country's revolution into a smart and modern manufacturing system (Ministry of International Trade and Industry, 2018). Therefore, there is an imperative need to distinguish the current state of readiness in Malaysia's manufacturing industry to realize Industry 4.0. Although the readiness of SMEs for digital transformation is critical, largely unknown about to what extent Malaysian SMEs are ready for digital transformation to achieve sustainable competitiveness. The need to assess companies' readiness to embrace Industry 4.0 stems from the need for businesses to introduce ICT into manufacturing processes and understand what remains to be done to accomplish that task (Flamini & Naldi, 2022). Thus, there is a need to understand how ready or prepared SMEs are for Industry 4.0 and why they would get ready for it. This need has led the researcher to raise two key questions: *“Are SMEs in Malaysia ready for Industry 4.0? and “What factors would drive SMEs to get ready for Industry 4.0?”*

Lately, the manufacturing industry in Malaysia has been challenged by lower-cost competitors from emerging economies and swiftly transforming technologies (Ministry of International Trade and Industry, 2018). Therefore, Malaysia needs to improve the value chain toward a higher-end manufacturing base (Sima et al., 2020). Subsequently, it is crucial for Malaysian manufacturing firms, especially SMEs, to digitally transform their production processes and technologies at an accelerated pace and embrace Industry 4.0 to propel and sustain their future manufacturing competitiveness (Ministry of International Trade and Industry, 2018).

Although the Future of Production Report (WEF & A.T. Kearney, 2018) underlines that Malaysia is well-positioned to benefit from Industry 4.0, and large

firms and MNCs have successfully engaged in the process, but most SMEs do not seem ready yet. Many SMEs struggle to keep abreast with the staggering speed of technological evolution because they face many issues and challenges related to resources and operational costs (Mallinguh et al., 2020). Although the Malaysian government has established initiatives to support the technological development of manufacturing firms, however digital adoption, especially among SMEs, is still at about 20%, and most manufacturing firms implement less than 50% automation (Yatid, 2019). Moreover, despite the initiatives that the Malaysian government has launched to encourage SME digitalization, only 25% of Malaysian firms accelerated their digital transformation processes due to the COVID-19 pandemic, while 60% slowed down (Tong & Gong, 2020). In this respect, understanding why SMEs are slower on the uptake of Industry 4.0 is thus critical to assist policymakers. In addition, the large manufacturing firms are seen to be aware of the advantages and risks of adopting Industry 4.0 practices, while many SMEs still lack information and knowledge about it and remain relatively unaware of their role in driving economic growth amid the digital disruption (Ministry of International Trade and Industry, 2018; Sharon, 2019a). Under those circumstances, a limited understanding of Industry 4.0 and its benefits may restrain the broader adoption of digital technologies. Therefore, the perceived advantages of Industry 4.0 could be one potential driving factor to consider in getting ready for Industry 4.0.

On the contrary, Giotopoulos et al. (2017) found that SMEs encounter increased difficulty in adopting new technologies due to inadequate skills, resources, commitment, and proper understanding of digital opportunities. Furthermore, Horváth and Szabó (2019) also argued that financial resources pose a high barrier for SMEs. In this regard, SMEs with strong financial capabilities are more possibly to hire more

skilled employees, thus improving their technical capabilities to handle the Industry 4.0 operation. As a result, they will feel more confident and motivated to prepare for Industry 4.0 sooner.

On the other hand, government support for digital transformation is another significant driver for SMEs, such as financial support in the form of funding, incentives, and technological support in the form of training, consulting, and guidance (Chen et al., 2021; Doh & Kim, 2014; Lee, 2008). The availability of government initiatives and incentives must be communicated to SMEs, as many are unaware of government initiatives and incentives for digitalization (Tong & Gong, 2020). SMEs face significant obstacles in adopting new digital technologies due to the lack of necessary resources (Ongori & Migiro, 2010). Therefore, if they have any assistance in obtaining the resources they need, they would be more inclined to engage in this costly transition.

Besides, customers' needs for products made using the Industry 4.0 manufacturing process will drive the manufacturers to adopt Industry 4.0 because they risk losing the consumer if they do not (Deloitte, 2015). Many global manufacturers of finished goods have begun to place their requirements for the Industry 4.0 standard on their raw materials suppliers (Agrawal et al., 2020) and Malaysian SMEs. Meanwhile, as market competition in the Asia Pacific region heats up, SMEs in Malaysia risk losing local and foreign customers if their rivals implement the Industry 4.0 system (Jacobs, 2017). Therefore, consumer needs and competitors' rapid adoption of Industry 4.0 will push Malaysian SMEs to prepare for digital transformation.

Even though the readiness of SMEs for digital transformation is critical, manufacturing firms have a limited understanding of the needed future skills and

experience and their readiness to embark on the Industry 4.0 transformation. It is crucial to investigate manufacturing SMEs' readiness for Industry 4.0 because implementation efforts on new technology processes or organizational change frequently fail as leaders do not establish adequate organizational readiness for change (Leonard-Barton & Kraus, 1985). According to Weiner et al. (2008), organizational readiness for change refers to how organizational members are behaviourally and psychologically ready to execute organizational change. When organizational readiness is high, the organizational members are more likely to initiate change, unleash greater effort, show greater persistence, and exhibit more cooperative behaviour, which overall results in more effective execution of the initiated change (Weiner et al., 2008). The outcome is more effective execution. In that regard, organizational readiness for change is perceived as a pivotal herald to the successful adoption of Industry 4.0.

Nevertheless, researchers such as Maavak and Ariffin (2018) claimed that studies on the driving factors of readiness for Industry 4.0 in Malaysia are still in their early stages. Moreover, although there is few research studied on the impacts of capability and financial resources towards SMEs engagement in innovative activities, however there is currently a dearth of research connecting financial aptitude with digital technology adoption. In the current literature, the bulk of research analysed firm size solely from the perspective of firm performance; consequently, the moderating effect of firm size on the deployment of Industry 4.0 remains insufficient. This study extended the relationship between the driving factors, namely organisational capabilities, SME institutional support, perceived advantage, and market factors and readiness for Industry 4.0, and empirically demonstrated the moderating effect of firm size in order to address this research gap.

Based on the discussion above, this study intends to find out how prepared Malaysian manufacturing SMEs are for digital transformation. Importantly, there is a need to comprehend the driving factors that will empower Malaysian manufacturing SMEs to embrace digital transformation. Therefore, this study aims to broaden the current state of knowledge in Industry 4.0 readiness of Malaysian manufacturing SMEs and the driving factors that play significant roles in strengthening SMEs' readiness for digital revolution in Malaysia.

1.4 Research Objectives

The present study proposes that organizational capabilities, SME institutional support, perceived advantage, and market factors are the four key driving factors that may encourage manufacturing SMEs in Malaysia to get ready for Industry 4.0 by digital transformation.

The objectives of this research are:

- 1) To examine the relationship between organizational capabilities, institutional support, perceived advantage, market factors, and SMEs' readiness for Industry 4.0
- 2) To assess if firm size moderates the relationship between organizational capabilities, institutional support, perceived advantage, market factors, and SMEs' readiness for Industry 4.0

1.5 Research Questions

The research aims to answer the research questions as follows:

- 1) What are the relationships between organizational capabilities, institutional support, perceived advantage, market factors and SMEs' readiness for Industry 4.0?
- 2) Does firm size moderate the relationship between organizational capabilities, institutional support, perceived advantage, market factors, and SMEs' readiness for Industry 4.0?

1.6 The Significance of the Study

Since Malaysia places a high priority on the SMEs' adaptation of Industry 4.0 technology to help the country in its rapid economic growth, the present study is timely. This study focuses on the driving factors of readiness for Industry 4.0 among manufacturing SMEs in the Malaysian context.

1.6.1 Theoretical Significance

From the theoretical perspective, the present study amplifies the literature surrounding Malaysian manufacturing SMEs' readiness toward Industry 4.0 and the driving factors that will empower them to embrace digital transformation. More specifically, this study will provide valuable information to understand the relationships between independent variables, namely organizational capabilities, government support, perceived advantage, and market factors. Furthermore, this study also intends to contribute to the collection of research done in Industry 4.0, especially in a Malaysian context. Studies on the driving factors of readiness for Industry 4.0 in the Malaysian context are still in their infancy (Maavak & Ariffin, 2018). Therefore, it is anticipated that the findings of this study are expected to remedy the knowledge gap and allow a deeper understanding of the driving factors of readiness for Industry 4.0 within the context of Malaysian SME manufacturing firms.

In addition, this study will be able to validate the applicability of the resource-based view (Barney, 1991) in conceptualizing Industry 4.0 readiness on four driving factors, namely organizational capabilities, SME institutional support, perceived advantage, and market factors.

1.6.2 Practical Significance

By understanding the driving factors of readiness for Industry 4.0, this study hopes to provide insights to Malaysian SME manufacturing firms on how to develop and leverage their capabilities to embark on a digital transformation journey. Above all, the top management of SME manufacturing firms will understand how to motivate their managerial employees to get ready for digital transformation that will positively impact their business performance.

In addition, the findings of this study could provide some empirical points for Malaysian governmental institutions in formulating and implementing policy for intensifying Industry 4.0 transformation, allowing SMEs to benchmark themselves to improve their capability in embarking on the digital transformation journey. In light of increasing competition and liberalization, it is hoped that findings from this study will help the Malaysian SMEs manufacturing firms to develop effective strategies in stimulating the Industry 4.0 preparation among its managerial employees in order to help the country in achieving high-income nation status, as envisioned in Shared Prosperity Vision 2030 (Economic Planning Unit, 2019).

1.7 Definition of Key Terms

Definitions of the key terms in this study are presented below:

1.7.1 Industry 4.0

Industry 4.0 is regarded as the production or manufacturing-based industries' digital transformation, impelled by connected technologies. Industry 4.0 introduces the ideas of “smart factory”, whereupon cyber-physical systems keep track of the real-time physical development of the factory and can make decentralized decisions (Ministry of International Trade and Industry, 2018).

1.7.2 Industry 4.0 Readiness

Industry 4.0 readiness is interpreted as firms' readiness for digital revolution towards Industry 4.0. Industry 4.0 Readiness has three dimensions: managerial readiness, operational readiness, and technological Readiness (Rajnai & Kocsis, 2018). In this study, **Managerial readiness** refers to awareness of the management toward digital transformation in terms of commitment, ready to establish a strategic plan to start the digital transformation process of the firm. **Operational readiness** refers to SMEs' readiness in human and financial resources, processes, and infrastructure. **Technological readiness** is defined as the firms' readiness in the dimensions of skill and technology knowledge of the staff and technical preparedness of systems and machinery (Khin & Kee, 2020).

1.7.3 Organizational Capabilities

Organizational capabilities are the unique combination of skills, processes, technologies, and human abilities that differentiate a firm. In this study, organizational capabilities are conceptualized into two main dimensions: financial capability and technological capability (Khin & Kee, 2020). **Financial capability** refers to the financial ability of a company to fund operational resources, including funding, human resources, and infrastructure, that are essential for digital transformation. **Technological capability** in this study refers to the firm's ability to respond to, learn,

and adopt the skills, experience, and knowledge required to initiate and manage technology changes.

1.7.4 Institutional Support

Support from the government or related agencies aims to support SMEs growth (SME Corporation Malaysia, 2021). This study focuses on two forms of institutional support: financial and technological support. In this study, financial support is defined as the support for business organizations from governmental or non-governmental institutions in funding, grants, and financial incentives to encourage and assist them in their technological transformation (Khin & Kee, 2020). In the context of this study, technological support is defined as the support for business organizations from governmental or non-governmental institutions in the form of technical advice, guidance, training, program, and services in order to improve the technological capability required for technological transformation (Khin & Kee, 2020).

1.7.5 Perceived Advantage

This study focuses on two main dimensions of perceived advantages: perceived benefits and opportunities. Perceived advantage is how the organization leader perceives the adoption of modern technology as advantageous to their business. Khin and Kee (2020) defined perceived benefits as potential benefits of adopting new technology such as Industry 4.0, considered by organizations as beneficial to their operation or business development". In this study, perceived opportunities are pertained as potential market opportunities for implementing new technology such as Industry 4.0, considered by organizations as beneficial to their operation or business development (Khin & Kee, 2020).

1.7.6 Market Factors

Industry 4.0 will transform the manufacturing industry, boosting consumer reach and establishing new competitors (Leong & Kasmuri, 2017). Therefore, market factors are important drivers of Industry 4.0 adoption among SMEs. The market factor is defined as any external factor that impacts a company's sales. According to Day and Nedungadi (1994), customers and competitors are the two most important aspects of a competitive market, and each becomes a dimension along which a competitive advantage can be determined. The researcher focuses on two main market factors in this study: customer needs and competitive pressure. In this study, customers' needs refer to customers' preferences or requirements for features, functions, attributes, and standards of the products they buy from their suppliers (Khin & Kee, 2020). Competitive pressure in this study context is referred to as the pressure an organization feels because of a threat of its competitors' possible shift towards new technology, which is a competitive advantage to attract new customers (Khin & Kee, 2020).

1.7.7 Small Medium Enterprises (SMEs)

This study focuses on SMEs in the manufacturing sector in Malaysia. For the manufacturing sector, SMEs are defined as firms with sales turnover not exceeding RM50 million **OR** the number of full-time employees not exceeding 200 (SME Corporation Malaysia, 2021).

1.7.8 Firm Size

Based on the definition by SME Corporation Malaysia (2021), SMEs in the manufacturing sector is divided into micro, small and medium. **Micro enterprises operate with less than five full-time employees and a sales turnover of less than RM300,000 per annum. Small enterprises operate with 5-74 full-time employees**

and an annual sales turnover of between RM300,000 and RM15 million. **Medium enterprises operate** with 75-200 full-time employees and annual sales turnover of between RM15 million and RM50 million. Hence, the study will look at Micro, Small, and Medium SMEs.

1.8 Scope of Study

The scope of this study is to investigate the influence of organizational capabilities, SME institutional support, perceived advantage, and market factors on manufacturing SMEs in Malaysia to prepare for Industry 4.0 by digital transformation. This study also aims to investigate if firm size moderates the above relationship. The unit of analysis is at the organizational level. The main target respondents of this research are SMEs owners or managers of Malaysian-owned manufacturing SME firms from various sectors, including automation, pharmaceutical, electronic and electrical, which have been operated for at least one year and are located throughout Peninsular Malaysia.

1.9 Summary and Organization of the Thesis

This chapter, Chapter 1, discusses the study's overall view and highlights the study's background, problem statement, research objectives, research questions that stimulate this study, the significance of the study, and definitions of key terms. While Chapter 2 underlines the relevant literature review of the chosen variables comprising of readiness for Industry 4.0 in the Malaysian manufacturing SMEs as a dependent variable, with the four categories of independent variables (organizational capabilities, SME institutional support, perceived advantage, market factors), and firm size being treated as a moderating variable. Chapter 3 outlines the study's methodology, including research design, population, data source, unit of analysis, minimum sample

size, sampling technique, data collection procedure, research instrument, and common method variance. The third chapter also illustrates the statistical techniques and analysis to sort out the answers to the study's research questions. Chapter 4 introduces the statistical results of this research. Lastly, Chapter 5 discusses the study's findings, implications, limitations, and future research recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This study aims to broaden the current state of knowledge on the Industry 4.0 readiness of Malaysian manufacturing SMEs and the driving factors that significantly strengthen SMEs' readiness for digital revolution in Malaysia. This chapter reviewed the relevant literature leading to the research framework's development. Particularly, literature on managerial readiness, operational readiness, technological readiness, organizational capabilities, government support, perceived advantage, and market factors is discussed. Previous empirical results of each variable are disclosed as well. Besides, the theories that support the research framework are introduced and discussed. Prior to having the research framework and the hypotheses formed at the end of the chapter, the firm size as the moderator is also discussed.

2.2 Readiness for Industry 4.0

Industry 4.0 is defined as the recent technological advancements in which the internet and facilitating technologies such as embedded systems are used as a backbone to link physical objects, intelligent machines, production lines, human actors, and processes beyond organizational boundaries to establish a new type of agile, intelligent, and networked value chain (Schumacher et al., 2016). The manufacturing industry is the second biggest contributor to Malaysia's gross domestic product (GDP) at 22.1% in 2019 (Mahidin, 2020), and SMEs are attributed to 98.5% of total companies in Malaysia (World Bank Group, 2020). Although Malaysia's GDP shrank 5.6% in 2020 due to the coronavirus pandemic, the manufacturing industry recorded growth of 3% year on year, apart from all other economic sectors that

continued to record negative growth rates (Anand, 2021; Bank Negara Malaysia, 2021; Bernama, 2021). Moreover, Hirschmann (2021) stated that the employment rate in Malaysia's manufacturing industry had been steadily rising, and around 2.55 million people were employed in Malaysia's manufacturing industry in 2020.

Amid this dynamic environment, the Malaysian government is well-situated with fundamental strategies to establish more international SMEs through digitalization, automation, and robotization. National Policy for Industry 4.0, known as "Industry4WRD," was initiated in 2018 with particular attention to four overarching goals, which are (i) drive continual growth in manufacturing GDP; (ii) uplift national productivity; (iii) establish higher skill employment opportunities; and (iv) enhance innovation capabilities and competitiveness (Ministry of International Trade and Industry, 2018). Moreover, the Malaysia Ministry of Entrepreneur Development (MED) and the Malaysian Technology Development Corporation have collaborated to launch a program named "MED-MTDC Industry 4.0 SME Accelerator Programme", to prepare entrepreneurs to be Industry 4.0 ready and prepare some to develop Industry 4.0 solutions (Yee, 2019).

Industry 4.0 provides new technological capabilities by communicating and integrating information technologies to maximize production performance (Amjad et al., 2021; Xu et al., 2018). Adopting Industry 4.0 is a crucial strategic decision. The inadequacy of a shared understanding of the factors that influence the implementation of Industry 4.0 technologies may reasonably explain SMEs' hesitation to embrace digital revolution under Industry 4.0 (Ghobakhloo & Iranmanesh, 2021). Hence it is critical to analyze the organization's readiness for Industry 4.0 implementation before making such a significant decision (Lucato et al., 2019). Readiness for new technology has been defined differently. According to Holt et al. (2007), a readiness assessment

offers an opportunity for the leaders to identify any gaps in the current organization ahead or throughout the change implementation process. In a more practical sense, the systemic analysis of an organization's ability to deal with and implement a revolutionary process or change is defined as assessing or measuring readiness (Pirola et al., 2019).

Furthermore, a readiness assessment also intends to address potential barriers to success, empowering the companies to overcome the barriers before starting the transformation project (Pirola et al., 2019). In this study, Industry 4.0 readiness is defined as the preparedness level of organizations to benefit from Industry 4.0 technology (Stentoft et al., 2020), which includes management commitment, operational resources, technological skills, and technical requirements (Rajnai & Kocsis, 2018). Several studies have evaluated the maturity or readiness of manufacturing companies for Industry 4.0.

According to Schumacher et al. (2016), the discrepancy between readiness and maturity is that readiness assessment occurs prior to captivating the maturing process, while maturity assessment intends to capture the as-it-is situation during the maturing process. Industry 4.0 in Malaysia was designed under Industry 4WRD policy, and SMEs were targeted because they contribute significantly to the country's income (Fernando et al., 2022). In the Third Quarter 2017 (3Q 2017), SME Survey conducted by the SME Corporation Malaysia which has involved 1469 respondents focusing on the awareness and readiness status of Industry 4.0, findings revealed that only 31.8% of the respondents are aware of Industry 4.0, 69% are ready for Industry 4.0, 66.4% of them are expecting an increase in efficiency and productivity from adopting Industry 4.0, while 62.1% agreed that inadequate skills and knowledge of employees are the biggest challenges for Industry 4.0 adoption (SME Corporation Malaysia,

2018). Since most Malaysian SMEs are in the preparation stage rather than the adoption or implementation stage for Industry 4.0, the researcher employs readiness for SMEs.

Since 2019, the Malaysian government has implemented the Industry4wrD Readiness Assessment Program to provide financial support and learn about manufacturing firms' status in Malaysia (Ministry of International Trade and Industry, 2019). According to their survey, 47% of SMEs are still unaware of the initiative, and only 3.6 percent are in the process of applying for the program. In addition, a survey conducted by the SME Association of Malaysia revealed that only 43% of respondents had begun a digitalization process, with almost a third stating their efforts had failed. In comparison, only half of the remaining 57% had plans to initiate digital revolution in the future, with less than half planning to do so within the upcoming six months (Lim, 2021). As shown in Table 0.1, based on the SME Industry 4.0 Quick Survey conducted by the SME Association of Malaysia, there are three main reasons for SMEs not embarking or delaying their efforts on Industry 4.0 implementation (BusinessToday, 2019).

Table 2.1 Three main reasons for SMEs not embarking or delaying their efforts on Industry 4.0 implementation.

54%	Industry 4.0 needs massive investment, which SMEs cannot afford
32%	Not sure of where to begin and whom to look for to help
29%	Unsure if they are ready for Industry 4.0

Moreover, a marketing research firm, Solidiance, has conducted an Industry 4.0 Readiness survey in three sectors of Malaysia, and the findings revealed that the manufacturing industry has the highest average scores for perceived current readiness and likelihood (Boegershausen et al., 2017). According to Boegershausen et al. (2017), the companies surveyed assess their current readiness rather low to moderate and expect this to change only moderately in the next five years because most companies

do not yet have concrete transformation and investment strategies in place. Correspondingly, the survey findings by Knowledgecom Sdn Bhd showed that the primary challenges SMEs face in adopting Industry 4.0 are a lack of financing, skills, and implementation knowledge (Ganapathy, 2018).

These findings demonstrated that Malaysian SMEs require extensive preparations to address the challenges of getting them ready for Industry 4.0, which is not easy. The Industry 4.0 level process cannot be implemented without adequate planning and support from authorities. Therefore, understanding the current level of readiness for Industry 4.0 among SMEs and the areas in which SMEs should be ready may assist the government in creating a conducive ecosystem and generating important Industry 4.0 initiatives to increase SMEs' readiness. This study evaluates SMEs' current readiness level and examines whether manufacturing SMEs in Malaysia are ready to transform and achieve Industry 4.0 status digitally.

The organization's readiness for Industry 4.0 is assessed based on a self-assessment instrument. Several readiness assessments have been developed in the literature, and the assessment dimensions range conceptually from model to model. For instance, Lichtblau et al. (2015) developed a maturity model with six dimensions in their earliest studies: strategy and organization, smart operations, smart factory, data-driven services, smart products, and employees. Schumacher et al. (2016) developed nine dimensions to measure the readiness of Industry 4.0, which are leadership, strategy, product, customer, people, operation, governance, culture, and technology. Most of those studies are geared toward MNCs manufacturing rather than SMEs. Furthermore, Arnold et al. (2018) argued that top management support has a significant positive influence on Industry 4.0 implementation, and thus firms that plan to adopt Industry 4.0 in their industrial value creation should include the executive

board and get the necessary support. Also, the findings of Krishnan et al. (2021) indicate that top management is a key enabler of Industry 4.0 implementation. Therefore, there is a need to establish an appropriate assessment model for Malaysian manufacturing SMEs.

Aside from those critical dimensions or aspects to consider when assessing readiness, Gilchrist (2016) claims that the transition towards Industry 4.0 needs appropriate strategies and organizational models, which could result in radical changes affecting the entire organization in the aspects of human resources, physical manufacturing operations and technologies, infrastructure, and process management. Furthermore, Jung et al. (2016) proposed that readiness assessment models are intended to highlight that organizations must manage to enable technologies and new operational and organizational factors to create smart manufacturing systems. Given these literature reviews, this study will employ the three-dimensional readiness assessment tool (managerial readiness, operational readiness, and technological readiness) to examine the readiness of Malaysian SMEs manufacturing firms for Industry 4.0.

2.3 Organizational Capabilities

Organizational capability is defined as the ability of an organization to complete a coordinated set of tasks while leveraging organizational resources to achieve a specific result (Helfat & Peteraf, 2003). The transition to Industry 4.0 needs both tangible and intangible resources (Bharadwaj, 2000). Tangible resources of a firm are its physical assets, whereby examples of intangible resources of a firm include the quality of its product and personnel-based resources such as training and technical expertise (Shet & Pereira, 2021). In this sense, resources are the capabilities, assets,

firm attributes, organizational processes, information, expertise, and others manipulated by a firm that allows it to develop and execute strategies to enhance its efficiency and effectiveness (Barney, 1991). According to Porter (1981), firm resources are the strengths firms can employ to develop and carry out their strategy. Moreover, resources are the inventories of available factors that the firm owns or controls and converts into final products or services (Zott & Amit, 2007). Sirilli and Evangelista (1998) argue that manufacturing and service firms rely on diverse innovation sources.

One of the most vital resources required for the successful implementation and operation of innovation is the fund to improve existing or acquire new equipment, machinery, and skilled human resources and capital goods (Hall & Khan, 2003; Oum et al., 2014). Harvie et al. (2010) suggested that SMEs are more likely to participate in production networks if they have better access to financial institutions. A firm's innovation costs are mostly being spent on intramural research and development (R&D), acquired R&D services, acquired innovation-related machinery and equipment; other external technologies such as software and licenses; expenditure on innovation-related design; expenditure on innovation-related training related; and expenditure on the market introduction of inventions (Tether & Tajar, 2008). Khin and Kee (2020) proposed that firms have to invest in acquiring new machinery or equipment as the digital transformation process needs new digital technologies, and thus most firms engage with technology and service suppliers, which makes the entire process more expensive the short run. However, some firms can use their retained profits to fund the transformation project as they are foresighted enough to perceive the long-term potential for profit and growth (Khin & Kee, 2020). Kumar et al. (2021) also discovered that the ineffective integration strategy of Industry 4.0 with

sustainability and a lack of funds were the two main barriers to Industry 4.0 adoption. In this scenario, financial resources as part of the organizational capabilities are critical in enabling manufacturing firms to embark on their Industry 4.0 journey.

Even though many firms have the sufficient cash flow to invest in a costly project due to their stable business performance, they may lack human resources with digital skills or technological capabilities. Bell and Pavitt (1995) classified technological capability as the resources required to develop and manage technological change. Voudouris et al. (2012) described technological capabilities as the experience, knowledge, and skills required to execute and administer technological innovations. Technological capabilities comprise skills in engineering, IT, and other product and technologies relevant to production. Many government policies and programs have been implemented to assist companies in technological advancement. Martin and Scott (2000) have outlined the mechanisms for public support of innovation that targeted certain sources of innovation market failure in various industrial sectors. For instance, in sectors like equipment, instrument, and software, where innovation market failure is a pitfall due to new technology standards and limited validity of generic technologies, government policy instruments should include supporting venture capital markets and bridging institutions to motivate regular implementation. According to the literature, a better understanding of the organizational capabilities in terms of financial and technical ability likely to facilitate the readiness of Industry 4.0 implementation by Malaysian manufacturing SMEs is worth exploring. Next, the review continues with another important driving factor of Industry 4.0 implementation: SME institutional support.

2.4 SME Institutional Support

SMEs require government and other supportive entities' assistance and guidance to speed up their transition to Industry 4.0 (Jayashree et al., 2022). Abonyi (2005) argues that, in general, national governments tend to provide support in counseling and advice, information, training, technology development and transfer, financing, and business connections. In 2014, a German business leaders survey has identified the areas of support needed from policymakers for Industry 4.0 revolution, and the result of the survey is shown in Figure 2.1 (Davies, 2015). Over the past decades, many developed and developing countries have executed various incentives and support to promote technological advancement in the private sector. These supports and incentives are anticipated to stimulate and strengthen industrial technology advancement in the private sector (Intarakumnerd & Virasa, 2004). Nonetheless, several studies have found that the efficiency of existing systems and measures, particularly in developing countries, is not readily apparent as the policymakers in those nations do not fully recognize the central role of industrial enterprises, the relevance of non-R&D activities, the importance of technology flows between firms, and the value of people flows (Arnold et al., 2000; Lall & Teubal, 1998).