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Navigating the future of industry 4.0 in Malaysia: A proposed conceptual framework on SMEs' readiness

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ABSTRACT

As technology keeps advancing at an accelerated rate, small and medium-sized enterprises (hereafter SMEs) must prepare to adapt to the emergence of technology under an uncertain economic realm. Growing evidence shows Industry 4.0 has brought massive opportunities in respective industries, manufacturing and information technology. Innovation capability has become a distinct possibility, set to serve better product and service reengineering and distinction. Although Industry 4.0 paradigm has emerged worldwide, it is, however, still a challenge for small firms to adopt particularly in developing countries. The adoption process of Industry 4.0 digitalization varies considerably. Coming to terms with the low involvement and unreadiness of SMEs in Malaysia towards Industry 4.0 has induced researchers to conduct this study so that by employing cloud computing, Big Data, Artificial Intelligent, and the Internet of Things (IoT) SMEs can secure a new competitive advantage thus evolve significantly over time. Therefore, this study served as a solid conceptual paper with a proposed framework that intends to highlight potential factors which are people, process, and technology (PPT) enhancing SMEs' readiness towards Industry 4.0 in a Malaysian context. At the end of the study, it is expected to conclusively contribute to a new horizon of knowledge supporting the significant development of SMEs.

1. Introduction

Small and medium-sized enterprises (SMEs) have set off as one of the country's substantial contributors, amounting to more than one-third of the Malaysian economy. SMEs being a prominent resource is noteworthy and profound considering the contribution to the country's GDP. In line with the presence of Industry 4.0, the government has intensely stepped up SMEs competitiveness with intensification efforts by introducing several mechanisms and incentives in the form of financial integrate with technological support to encourage SMEs to expand their market and economic growth.

SMEs are expected to grow their competitiveness degree and become resilient towards the unpredictable business environment. Since Malaysian SMEs represent 98.5% of the total establishments, it is crucial to adopt automation infusion and digital technologies embedded in Industry 4.0 in the pursuit to remain competitive and relevant. The performance of companies with manufacturing and technology-based is important to be analyzed and assessed (Xuan, 2020). According to a report by the Ministry of International Trade and Industry (MITI, 2017), the government has introduced a new plan and policy namely Third Industrial Master Plan 2010-2020 (IMP3) and Science, Technology, and Innovation (STI) policy (2013-2020).

These strategies are devised as preparatory steps for Malaysia to embrace the Industry 4.0 era. Additionally, in indicating encouragement and support towards SMEs' growth and progress as well as ascertaining the priorities in national Industry 4.0, the government supplied some financial and technological inducements as a form of targeted assistance. The initiative also emphasizes empowering SMEs in aligning with Industry 4.0 by offering support in automation, digitalization, and robotization. However, there are several obstacles impeding their way such as less developed

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infrastructure, the burden in regulatory and administrative, shortage of high skills workforce, and limited access to finance.

Despite an abundance of studies exploring Industry 4.0 application on SMEs was done previously, efforts to explore SMEs' readiness in the context of the Asian region are yet still insufficient. Chiarini et al. (2020) and Moeuf et al. (2018) agreed that the research on Industry 4.0 in small businesses is minimal. Therefore, this study is important as it focuses to fill the gap in understanding the factors that enhance SMEs' readiness towards Industry 4.0 in Malaysia.

1.1. Industry 4.0

It is evidently vivid how the current economy is rapidly progressing towards Industrial Revolution 4.0, characterized by the application of service innovations, cyber-physical systems as well as smart factories (Lee et al., 2014; Shamim et al., 2017). The phenomenon emerged widely around the world as one of the radical factors contributing to production efficiency and competitiveness predominantly in service, manufacturing, automotive, and aerospace industries. Entrepreneurs from various economic sectors fuelled their business models with innovation to muster an ounce of competitive advantage. The notion of the fourth industrial revolution comprises of design and implementation of competitive products and services, powerful administrative and flexible logistic and production systems is highlighted as one of the key strategies to remain competitive in the future.

Although Industry 4.0 is booming as a trend, it is, however, still a challenge for small companies to adopt specifically in developing countries. Industry 4.0 has become phenomenal by taking over global economies heroically, changing the degree of competitiveness in firms and regions ultimately. According to Drath and Horch (2014), the current industrial revolution was linked with the other three revolutions in the past. They asserted the first began with the introduction of mechanical production facilities, followed by the distribution of labor and discovery of electricity in Industrial Revolution 2.0 whereas the third was initiated as Information and Communication Technology (ICT) and modern electronics have catalyzed "the digital revolution", contributing massively to the progress and operations of automation of production.

Subsequently, it remains a fact how these modern innovations have dramatically and radically altered various aspects of the life cycle on a global scale, created an array of new concerns and constraints for manufacturing companies, prompted significant transformations and sophisticated inventions, as well as contributed to making great impacts in man's living standards (Huang, 2017; Mohamed, 2018). Substantially, it is clear that the current global business environment is increasingly demanding and drastically changing customer needs.

1.2. Importance of SMEs

SMEs have been one of the exceptional backbones supporting Malaysia's economies extensively considering its epic financial contribution. In 2019, SMEs' GDP contribution was over 38.9%, with an increased growth rate of 0.6% compared to 38.3% a year before. SME gross exports also escalated progressively from 17.3% in 2018 to 17.9% in 2019 and the employment rate is growing to 48.4% in 2019 from 48.0% in 2018. Fig. 1 summarizes the total contribution of SME GDP, gross exports, and employment rate.

Fig. 1: The total contribution of SME GDP, gross exports, and employment rate

On top of that, it should be noted that SMEs possess a great perspective and an incredible capability in upholding the country's economic progress as well as generating accumulation of wealth (Rahim, 2017). This particular notion is further accentuated by Musa and Chinniah (2016) as it is asserted that SMEs act as a prime cornerstone and have a key role in growing a dynamic economic climate, apart from being the central aspect of Malaysia's industrial development. Correspondingly, it is mentioned how the local SMEs are making good progress in their contribution to the nation's GDP as the figure rose from 32% in 2012 to 41% by 2020, considering the fact that SMEs in Malaysia have presently become suppliers for multi-national companies (MNCs) in the global chain supply.

Furthermore, the 2nd Industrial Master Plan (IMP2) that was finalized back in 2005, comprises schemes and strategies proposed by the Government as their role in taking part and committing to the growth and expansion of local SMEs. Accordingly, the 3rd IMP was initiated–incorporating the period from 2006 to 2020, in correspondence to Malaysia's Vision 2020 (Ahmad et al., 2013). This illustrates that the government is vigilantly concerned and proactively reacts to the development and progression of SMEs in Malaysia considering various plans have been enforced to tackle unwanted issues.

1.3. SMEs' readiness towards industry 4.0

In Malaysia, the rankings of the World Economic Forum Global Competitiveness Report are reviewed as the outline in benchmarking the readiness of the country to propel in the new era of Industry 4.0 (MITI, 2018). In 2016, Malaysia maintained steady with one spot rising to 31st position in the Network Readiness Index and this is due to complacency enforcement and support devoted by the

government is moving towards digital agenda and technology advancement (Baller et al., 2016).

Equally, the Readiness for the Future of Production Report 2018 declared that Malaysia is categorized as the "Leader" and this position is ranked according to observations made from nations with a "strong current production base" and "positioned well for the future" (MITI, 2018). According to the report, Malaysia and China are the only two non-high income countries listed in the position. Local SMEs need to seize this golden opportunity by utilizing modern technological facilities in the current Industry 4.0 for the purpose of expanding and revising existing commercial and operating procedures, establishing values, developing their market growth as well as creating worldwide presence and building an international reputation by employing incentives stipulated by the government.

MITI has proactively introduced a thoughtful evaluation called Industry4WRD Readiness Assessment (Industry4WRD-RA) under The National Policy on Industry 4.0 (Industry4WRD) whereby firms will be able to evaluate their capabilities and readiness before implementing Industry 4.0 (MITI, 2018). This assessment is important because besides being able to assess their state of readiness, firms also will be able to initially recognize areas for improvement. Nevertheless, the only weakness is that the target audience preferred to comprise of manufacturing and manufacturing-related services sector only which means it does not cover all sectors of SMEs. Therefore, this study aims to cover all sectors of SMEs.

The assessment was introduced in an effort to support structures and envisioned the manufacturing industry and its related services are becoming more dynamic, competent, and adaptable. Not only that, according to SME Annual Report 2017/18, a survey by SME Corporation Malaysia has been carried out thoroughly during the third quartile of 2017 to discover the status of awareness and readiness of SMEs towards Industry 4.0. The results showed 31.8% which mainly consists of the manufacturing sector and small and medium-sized companies responded they are aware of the presence of Industry 4.0. 69.0% from the main results of 31.8% are particularly from microenterprises and SMEs manufacturing sector are ready to adopt Industry 4.0. Fig. 2 illustrates the percentage of awareness of Industry 4.0 in Malaysia.

SME Corporation Malaysia has carried out a survey called The Third Quarter 2017 (3Q 2017) SME Survey involving 1469 respondents, weighing on the awareness and readiness status of Industry 4.0. The main objective is to determine the mechanisms in coping recent business performance of SMEs plus to identify challenges experienced by SMEs. Based on the findings of this particular survey, 31.8% affirmed the acknowledgment and awareness of the existence of the Fourth Industrial Revolution, 69% responded they are prepared to adopt Industry 4.0, 66.4% stated their anticipation to see progress in the Industry application in terms of cost-effectiveness and productivity whereas another 62.1% concurred to the fact that employees' insufficient knowledge and inadequate expertise posed as a daunting challenge (SME, 2018).

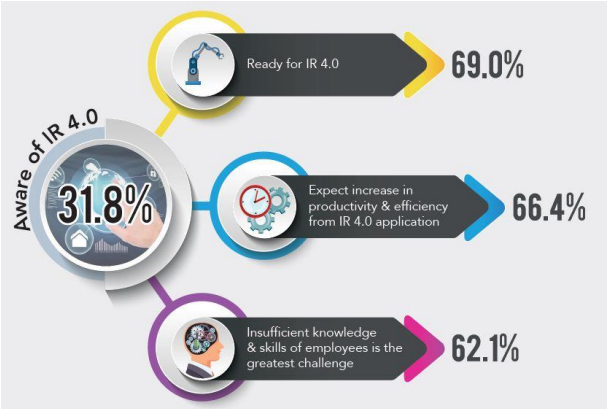

Fig. 2: Awareness percentage on industry 4.0 in Malaysia (SME, 2018)

1.4. Problems faced by SMEs

MITI (2017) disclosed that the percentage of digital adoption among SMEs in Malaysia is relatively small (~20 percent) together with the limited utilization of automation by industrial companies. This whole occasion has clearly manifested that most production enterprises adapt the operation of automation for only, at most, 50%. It also appears that the local SMEs are being highly attentive and wary, unwilling to go a step further in adjusting to Industry 4.0 while a huge proportion of these manufacturers are still oblivious and unmindful of the subject matter. This particular account is definitely of grave concern since the majority of the market-leading industrial companies have already jumped on the bandwagon, forecasting and making a prognosis of risk-benefit assessment upon embracing Industry 4.0.

Nevertheless, the vigilant approach conducted by some local SMEs is not entirely null and void as Dalenogare et al. (2018) contended that it is a relevant measure since the conception of Industry 4.0 is rather brand new, comprising a broad range of different elements and varying components which are yet to be comprehended and discovered. Hence, due to that, it would be sensible for any enterprise to be cautious of undertaking measures as the already existing expertise and experience would not suffice to face the uncertainties of the actual implications and contributions of Industry 4.0, which generally pertains to technologies in the context of evolving nations.

What worse is, reports have suggested that Malaysian SMEs apparently refuse to be risk-takers, insufficient innovativeness, and are not ready for vigorous competition (Ismail and Zakaria, 2018). Radzi et al. (2017) concluded in their study that due to technology incompetence among Malaysian SMEs, caused them to produce low performance in business. It is revealed that the overall survival rate

of an enterprise in the presently fierce competitive market, particularly SMEs, extremely low (Marimuthu et al., 2011; Yusof, 2003). For example, as mentioned by Arasti et al. (2014), SMEs have high failure rates due to one particular reason–the unsuccessful attempts in simultaneously expanding their products as well as retaining their quality. However, this case could be avoided if owners are willing to invest in new technology so that product quality can be maintained through research and development (R&D).

2. Factors enhancing SMEs' readiness towards industry 4.0

The focus of this paper is subjected to identify whether there is a relationship between people, process, and technology with SMEs' readiness towards Industry 4.0 in the Malaysian context.

2.1. People factor

As mentioned before, Industry 4.0 comes with higher value-added components and advanced technologies. This indirectly affects and changes the way people are performing their everyday tasks. As a matter of fact, small companies have the tendency to encounter challenges in going into digital, due to a lack of resources and high-skilled employees. This technological evolution has become one of the biggest hurdles for many organizations worldwide to ensure the skills contained therein align with Industry 4.0 automated technologies as Bonekamp and Sure (2015) pointed out the most obvious implication of Industry 4.0, which is to cause standardized, low-skill activities to deteriorate, resulting in an upsurge in high-skill operations, implementation planning and control as well as computer-related activities. Likewise, by implementing Industry 4.0, it is highlighted how employees would be accustomed to the practice of multi-tasking and such acquisition of competencies should remain ongoing and persistent (Bonekamp and Sure, 2015; Hecklau et al., 2016).

In addition, this notion was further elaborated by Bowles (2014), Brynjolfsson and McAfee (2014), and Bonekamp and Sure (2015) as it is foregrounded how the innovation of technology would not only propel to eradicate customary, conventional jobs as high-skilled career specified by cognitive non-routine tasks, as well as pattern recognition, would be in jeopardy too. Results from the Third Quarter 2017 (3Q 2017) SME Survey in Malaysia indicated that SMEs had retrenched their incompetent local workers, which comprise of low-skilled and semi-skilled employees as a consequence of their unsatisfactory job performances, and insufficient productivity. Also, firms decided to opt for downsizing as means of their cost-reducing strategy.

In essence, one of the important aspects to excel in socio-cyber physical systems and Industry 4.0 is the people according to Fleischmann et al. (2016) which is more reasons for SMEs hiring a suitable set of ingenuity workforces. A research study done by Manufacturing Leadership exhibits that future-focused leadership behaviors and mindsets were the basis in measuring the readiness of manufacturing organizations for Manufacturing 4.0 (Brousell, 2015) while Tate (2015) has stressed that manufacturing 4.0 requires a workforce skilled in digital technology such as programming and robotics.

As technology progresses, thus the consolidation of qualifications and skills requirements for employees will be higher than before considering the integration of technologies has taken over traditional job tasks. Darus et al. (2017) on the other hand argued that intellectual capital refers to an experience dynamic person and thus more than just certificates and high education. However, demand for highly skilled labor has been one of the biggest challenges in applying Industry 4.0 technologies within emerging-market economies (Tortorella and Fettermann, 2018).

Hypothesis 1: There is a relationship between the people factor and SMEs' readiness towards Industry 4.0.

2.2. Process factor

Fundamentally, the significance of processes and procedures as a core element of organizational performance has elevated because of rising competition on quality, time and costs, customer needs, and increased product complexity, as well as the growing networks in the inter-organizational chain (Margherita, 2014). The implication of Industry 4.0 is broader and does not cling to the use of technologies only but also the process within the management of the organization. The more well-designed the process is, the more efficient the management. The process includes internal management of the supply chain, operations of products and services, and product lifecycle activities.

According to Harmon (2003), business process management is perceived as administering, coordinating, supervising, prioritizing as well as optimizing a company's process change resources and activities while other researchers referred to process management as recognizing potentials and opportunities for outsourcing as well as the application of technology to uplift one's business (Lindsay et al., 2003; Palmberg, 2009). Previous literature agreed that there is a positive relationship occurred between process change and business outcomes on which eventually process implementation resultant enhancement in organizations' performances and higher-level organization (Skerlavaj et al., 2007; Trkman, 2010; Battistelli et al., 2014; Langley et al., 2013; Akbaba and Altındağ, 2016).

Nevertheless, additional research argued by having innovation and process change only are deemed as not sufficient to build successful business practices and effective organization performance

despite both are important components (Costello, 2018). The advantage of utilizing and seizing the presence of Industry 4.0 has been broadened to various aspects and one of them is taking over the organization process with the introduction of cloud computing, Internet of Things (IoT), Artificial Intelligent and Big Data analysis which result in SMEs offering a high quality of products and services with lesser human intervention and more machinery involved. The development brought by Industry 4.0 aims to obtain a significant degree of operational efficiency, productivity, as well as automation of production systems (Thames and Schaefer, 2016). Automated processes carried out in a company are able to improve all activities and thus enhancing all areas of operations management (Fettermann et al., 2018). Besides, quality is increased by a higher degree of customization offered by a more sophisticated and more stable manufacturing process (Molino et al., 2020).

Based on the findings of the American Society of Quality (ASQ) survey in 2014, it is observed that 82% of companies with smart manufacturing claimed there has been an increase in efficiency as 49% went through fewer product defects while 45% experienced an increase in customer satisfaction (Shrouf et al., 2014). Therefore, it is proved that Industry 4.0 technologies benefits the process in organization operations management include minimizing human interaction, higher operational efficiency, productivity and automation, improve all activities, fewer product defects and increase in customer satisfaction.

It is unquestionably exhausting for small companies like SMEs competing with large manufacturers in the supply chain management process due to the disability of SMEs in adopting advanced machinery to process materials, optimize space utilization, and consume less energy (Thomas and Trentesaux, 2014). This disability has been one of SMEs' greatest hindrances in enforcing Industry 4.0 technology since it involves highly automated production. The high demand for automation in the supply chain has become a key component of the evolution process (MacCarthy et al., 2016).

Hypothesis 2: There is a relationship between process factors and SMEs' readiness towards Industry 4.0.

2.3. Technology factor

The most substantial factor behind the uprising of Industry 4.0 is technology. It offers a platform for physical assets and equipment to integrate with systems in order to allow data analysis with less human interaction. Industry 4.0 encompasses pervasive and high-scale systems with a high degree of automation. Upgrading the technology is relatively expensive, extensive, and complex which is exhausting for small companies. Even so, the innovations and technological advancement promising by this digital revolution will provide a feasible range of solutions to SMEs' rising needs and demands of informatization.

Even at an organizational level, the technology readiness concept can be evaluated as it is described as a company's eagerness to adapt and conform to the new epoch of technology, including the adeptness as well as capability to utilize the most recent technological assets (Vize et al., 2013). Equally, technology readiness has been acknowledged and deemed as essentially practical in adapting to technology-intensive services and Liljander et al. (2006) suggested that the concept can also be relevant to services.

Even so, as small companies, SMEs are deterred from making any decision under unforeseeable conditions and advised to weigh the risk first before owning high-scale technology. If it brings more advantages over time, SMEs should consider adoption despite higher costs and possibly require a longer adoption period and slow return on investment. The uncertainty, however, may subside over time, but the risks to bear over time are draining.

Hypothesis 3: There is a relationship between technology factors and SMEs' readiness towards Industry 4.0.

3. Conceptual framework

Factors that influence innovation adoption must be investigated in order to understand the factors that are responsible for technological acceptance. Past researchers adopted The Technology-Organization-Environment (TOE) framework in investigating a wide range of innovations and technology readiness concepts at an organization level. Also, it has been broadly utilized to support empirical work. TOE framework by Tornatzky and Fleischer (1990) emphasized three contexts which are technology, organization, and environment which according to previous studies, these contexts affect the process of organizations in adopting and accepting new technology. The theory of TOE is specifically targeted technology acceptance and most popularly underpin by many information systems studies that explain end-user adoption at the organizational level (Awa et al., 2016). Therefore, this theory is used as an underpinning theory to support the conceptual research of this study as it is able to serve as a strong theory to examine the degree of technology readiness. Existing frameworks and ongoing empirical studies are important to validate the continued technology innovation. So, as long as new technologies are developed and new concepts for adoption are found, the TOE framework is significant in offering a comprehensive understanding and perspectives of technology adoption to researchers. Fig. 3 shows the TOE framework developed by Tornatzky and Fleischer (1990).

The focus of this paper is subjected to identify the factors enhancing readiness among SMEs towards

Industry 4.0 with people, process, and technology as for independent variables. The independent variables are adopted from shift factors in National Policy on Industry 4.0 (Industry4WRD) announced by MITI in 2018 on which this policy emphasized bringing more stakeholders for Industry 4.0, develop an Industry 4.0 ecosystem, and revamping industry capabilities for a better result.

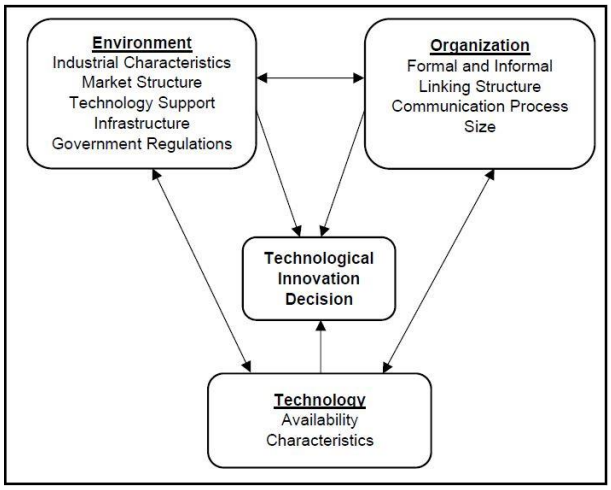

Fig. 3: The technology-organization-environment (TOE) framework by Tornatzky and Fleischer (1990)

In 2017, the factors are applied in Industry4WRD Readiness Assessment by MITI upon examining the level of preparedness among manufacturing SMEs in embracing Industry 4.0. This study is done as an additional effort to support the government specifically MITI in collecting data from SMEs in the Klang Valley area during this pandemic time.

Fig. 4 shows the conceptual framework developed for this study.

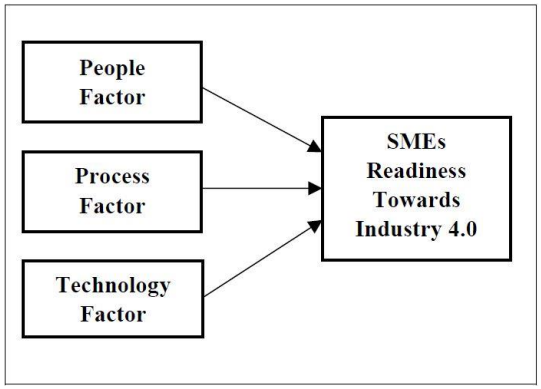

Fig. 4: A conceptual framework on factors enhancing readiness towards industry 4.0 among SMEs in Malaysia

4. Methodology

The common IBM Statistical Package for the Social Sciences (SPSS) version 22 will be used in generating the quantitative data gathered. This study intends to employ a cross-sectional study in which questionnaires are involved to test the aforementioned conceptual framework. The target population for this study consists of various sectors of SMEs in Klang Valley registered under SME Corporation Malaysia. Klang Valley is chosen due to the number of SMEs located here are the highest in Malaysia which according to SME Annual Report 2017/18, the amount recorded are 179,271 (19.8%) in Selangor and 133,703 (14.7%) in Wilayah Persekutuan Kuala Lumpur. So, the amount of total population is 312,974. In order to determine the sample size for this study, a formula created by Krejcie and Morgan (1970) is referred. According to the formula, the appropriate sample size for a population of 75,000 is 382 while the population of 100,000 and greater is 384 (Sekaran and Bougie, 2013). Thus, since the amount of total population for this study is 312,974 according to SME (2018), the appropriate sample size is 384. In order to easier administration in achieving the target sample size, 400 questionnaires will be distributed to 400 potential SMEs with each receiving one.

To represent all the SMEs, the owner, director, or manager at each of the SMEs will be appointed as the sampling frame of the study. There are two types of sampling methods that will be used by researchers. First, researchers will use stratified sampling techniques based on geographical location to avoid cases in which some members of the population are significantly under or over-presented by the sample. Then, researchers will use a systematic sampling technique to select and contact every 26th consecutive SME on the list of enterprises registered under SME Corporation to yield a total of 400 enterprises. The list will be derived from the SME Corporation Malaysia website that has been updated until 2017. This is because it is an agency responsible for overall SME policy drafting and assessment of development programs.

The analysis process will be categorized into several stages. Frequencies, mean and standard deviation analyses will be performed to evaluate demographic profile. In order to avoid key-in errors in data and to look out for missing values in responses, data cleaning will take place through frequency analysis. Inferential statistics such as Pearson's coefficient and multiple linear regression analysis will explain the relationship between the independent dependent variables. Descriptive analysis will be used in identifying respondents' profiles. After that, data will be monitored for reliability tests in weighing the correlation of every item. According to George and Mallery (2003), only the score 0.7 and above will be selected for the purpose of this research. The inspection of factor loadings will be administered to ensure whether it is greater or equal to 0.30.

5. Discussion and conclusion

This paper carefully elaborated the conceptual framework on the factors enhancing readiness towards Industry 4.0 among SMEs in Malaysia by examining the relationship between people, process, technology factors, and SMEs' readiness towards Industry 4.0 that require scholarly attention. Incorporating digital technology into one's business can be extremely daunting yet the return is

fascinating. With the rising of technology advancement, SMEs have encountered demand to bring a new set of skills and knowledge embedded with digital and technical skills derived from education and training systems, re-shaping production processes that accelerate agilely supported by well-coordinated systems and a high degree of technology integrated with software and databases to achieve higher productivity and competitive advantage to compete in the market.

Competitive productivity conveyed by Industry 4.0 is competence in steering businesses into the form of dynamic progress. According to MITI (2017), the Industry 4.0 wave possesses the capability to change SMEs in multiple facets, including the upgrade and expansion of cost, efficiency, and productivity; enhancement of organizational, management, and production capacities; producing a better quality and ingenuity innovators and entrepreneurs. Industry 4.0 concept however is still in the initial phase in Malaysia as started in 2016 according to few studies while the origin country German introduced it in 2011.

Therefore, this study is important and will not be obsolete in the next five to ten years since various measures and processes need to be taken into account before Malaysia can fully implement the technology. Since this study served as a solid conceptual paper, researchers recommend future research to conduct an empirical study using this conceptual framework for further validation of the variables, improving its rigor and usefulness. Besides, future studies can also apply qualitative study since it offers thorough analysis and detailed explanations focusing on relationships that exist in the framework or they can identify other potential factors enriching SMEs' readiness towards Industry 4.0 by adopting methodology from this study.

6. Study limitation

The main limitation of this paper is that it is developed based on a proposed conceptual framework without collecting primary research data. The results and findings from data collection are essential in verifying the proposed framework. Secondly, the paper has only examined three internal independent variables, which are people, process, and technology (PPT), future research might add other significant factors that could also include external factors. Thirdly, the future study also may consider include a moderator or mediator variable to see whether they could strengthen or weaken the relationships. Lastly, the research is focusing on the manufacturing sector only, so other sectors may be examined because they have other contributions too, for example, service sector SMEs have been one of the biggest contributors to Malaysia's GDP.

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Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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