

SMEs Maturity Model Assessment of IR4.0 Digital Transformation

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Abstract. This paper reports on the revolution of industry that leads to the current industry 4.0 through digital transformation. Industry 4.0 promotes innovation in organising and controlling for the entire value chain life cycle. The advancement of technology become future insights of digital transformation is aimed to have a high-flexibility, high-productivity, and become resource friendly that may provide a new level of human-machine relationship. The research is aimed in understanding the readiness of the Small Medium Enterprise (SME) in Malaysia towards digital transformation of Industry 4.0. Hence, a comparative study of the maturity assessment model towards industry 4.0 had been conducted. The IMPULS maturity assessment model is applied and six dimensions were chosen as our research model. Each dimension is explained, calculated and discussed in this paper. Each dimension is then weighted to refer to the level of readiness. The research uses questionnaires in attaining the data pertaining to the readiness of Malaysian SMEs towards industry 4.0. Next, findings of this research will be able to explain and provide a better understanding of where Malaysian SMEs stand in comparison to the maturity level that is set to test out the readiness of SMEs towards industry 4.0. This is to create and increase SMEs' market sustainability hence creating or increasing profitability.

Keywords: Digital Transformation, Industry 4.0, Maturity Model, Readiness Model, Small Medium Enterprise (SME), Sustainability

1 Introduction

In terms of technological revolution, the first paragraph of Transformation and changes in the technology evolved since 1945 [1]. It starts from the large big machine, desktop, mainframe, microchips, smartphones and lately the aim for all the devices are revolutionising to be more personal and smaller as it evolves and transforms towards the future. Throughout the years, the development of the industry has been gradually changing. The first industrial revolution occurred with the automation of using steam power and water power. Meanwhile, mass manufacturing which is sup-

ported by electric energy and production lines occurred in the second industrial revolution. The application of electronics and digital revolution in order to further automate the production line have impacted positively towards the third industrial revolution previously and now it is revolving into the Industry 4.0.

The paper that was written by MIT Sloan and Cap Gemini [2] refers to a Digital Transformation as an environment where everything for an organisation is connected which creates digital imperatives for companies to create transformation through technology that impacts Customer Experience, Operational Improvement and Business Model Change thus covering the organisation's overall performance. The digital transformation is able to become a drive as well as an enabler for new forms of innovation through transformation, management of the knowledge environment, and enabling of demand driven supply chains [3].

As digital transformation is headed to Industry 4.0 where technologies are growing in an accelerated pace that is drastically changing and modernising. It has created an opportunity for the business to grow and envelope into a shorter process with better results. However, the readiness of SMEs needs to be recognised before applying digital transformation into the business processes as according to Bloomberg [4]. As Malaysian SMEs continues to grow by aiming to accelerate their contribution to the Gross Domestic Product (GDP) to a staggering 41 percent and the country's exports share from SMEs to a 23 per cent by 2020 [5], Malaysian SMEs need to be prepared to the advances and challenges of Industry 4.0 in order to be competing with the world.

2 Research Work

2.1 Industry Revolution

The revolution begins with the improvements and advances in agricultural techniques that have created an increased supply of food and raw materials. The changes in industrial organisations as well as technological advancement have caused an increase in production, profits, efficiency and the increase in commerce, where all conditions which created the beginning of the Industrial Revolution. Therefore, the movement in which machines changed or altered people's way of life as well as their methods of manufacture is called The Industrial Revolution [6].

The First Industrial Revolution was initiated in Britain and had spread through the whole world. It was a period in where fundamental changes have occurred and greatly impacted the sectors of agriculture, textile and metal manufacture, transportation, economic policies and the social structure in England. At this period, it is labelled as a revolution where it thoroughly destroyed the traditional or old manner of doing things [7]. Prior to the Industrial Revolution, the industrialisation marked a shift of power, mass production, factories and special-purpose machineries [8].

The Second Industrial Revolution occurred between 1870 and 1914 after the civil war. Production costs and prices fell dramatically and there was a rapid growth in

productivity. Prior to the development of elaborate transportation systems, economies were often localised and were based off the barter system [9].

The Third Industrial Revolution marks the forthcoming distribution of new productive systems, along with the advanced software development which paved the way to new potentials in connecting the design domains and construction. Besides, it helps to realise the components where a certain algorithmic description is given and to synthetically describe the physical environment and its behaviours within the digital environment [10].

The Fourth Industrial Revolution depicts that Industry 4.0 focuses on the end-to-end digitisation towards all of the processes and integration into a digital ecosystem within the value chain. Currently, technological advances in Industry 4.0 with the internet and supporting technologies serves as a pillar to integrate human actors, physical objects, intelligent machines, production lines, and processes across and beyond organisational boundaries that produced networked, intelligent and agile value chains [11].

2.2 Industry 4.0

The main focus of Industry 4.0 is towards the factories of the future, the vertical networking of smart production system using cyber-physical production system to enable each production plant to rapidly change in stock level or demand and to minimise mistakes [12]. Smart factories organise and empower production to custom made for customers. Next character of Industry 4.0 is the horizontal integration via a new generation of global value chain networks which offers a higher level of flexibility in the response time towards problems while facilitating better global optimisation [13]. The third character of industry 4.0 is through the development of a new product that integrates and coordinates with the product's life cycle, enabling new synergies to be created between product development and the production system. The fourth character of Industry 4.0 allows individual solutions, flexibility and cost saving in industrial processes. Industry 4.0 requires automation solutions to be highly cognitive and highly autonomous. In relation the that, the emergence of Artificial Intelligence (AI), advance robotics and sensor technology have the potential to increase the autonomy in order to accelerate individualisation and flexibility

2.3 Digital Transformation

The Information and Communication Technology that is also referred as ICT, has been evolving since 1945 [1]. The adaption of ICT provided a platform for change in global logistics and communications to work with massive amounts of data moving at top speed, enabling large organisations to be agile. Digital transformation is described as the most profound and accelerating transformation for business activities, processes, competencies and models to leverage the changes of digital technology and their impact in a strategic and prioritised way [14].

Several technologies that make this possible are:

- Cloud Computing - Cloud computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the data centres that provide those services [15].
- Mobile Computing - Mobile computing has proved to be an extremely disruptive technology innovation and has significant sustainability impacts [16].
- Big Data - The emerging of big data and business models to analyse and aggregate industry data for new business growth opportunities [17]. The exponential growth of data is being driven by the proliferation of devices that can communicate with other devices, also referred as the Internet of Things (IoT) through various channels such as mobile, web, stores or any electronic devices. The IoT assist the creation of smart factory which govern smart mobility, smart logistic, smart product, smart grid and smart buildings [18].
- Data Science and Business Analytics - The data driven decision making is now being recognised as the Big Data is introduced to the industry [19]. As a data-centric approach, business intelligence and analytics has its roots in the longstanding database management field. It relies heavily on various data collection, extraction, and analysis technologies [20].
- Social Computing - Through the design of web 2.0, numerous amounts of new application and services that that facilitates collective action and social interaction online with multimedia information exchange and comprehensive knowledge evolution came to dominate the Web which also known as online communities and social computing [21].

2.4 Small Medium Enterprise (SME) Malaysia and Its Sustainability

SMEs have been at the core of Malaysia's economic transformation since the 1990s to become an upper-middle income nation as well as being a significant driver of employment and growth. These businesses are responsible for nearly 36 percent of the country's GDP, 65 percent of the country's employment, and nearly 18 percent of Malaysia's exports [5]. These numbers show that SMEs plays a vital part in Malaysia's economic growth as well as the development of the country.

There are approximately 645,136 SME businesses operating in Malaysia according to the Census Report on SMEs 2011 with a 97.3 percent out of the total number of business institutions. Malaysian SMEs are described as a vital economic wheel for Malaysia. SMEs have the capability to not only contribute significantly to Malaysia's economy, but also to provide a strong foundation for the growth of new industries, as well as strengthening current industries, which soon supports the development of Malaysia's future [5].

In order to persevere with developing, SMEs are dealing with more global challenges with new emerging technologies in ICT and production processes by taking into consideration of the increasing of costs and export competitiveness [22]. Hence, among the benefits that will be missed if Malaysian SMEs refuse to engage in the Industry 4.0 are:-

- *Increase competitiveness*

The Industry 4.0 is able to resolve constraints by having innovative technologies that opens new opportunities. There are nine technological advances that powers the Industry 4.0 approach which are autonomous robots, augmented reality, big data and analytics, additive manufacturing, the Industrial Internet of Things, horizontal and vertical system integration, the Cloud, simulation, and cyber security [23]. Through this, Malaysian SMEs are able to compete in both global and local markets.

- *Utilising opportunities*

The technologies that are used in Industry 4.0 will be able to satisfy customer's needs. The integration into digitisation of every component in an organisation's value chain is embedded through digital technologies. The Cloud Computing business model provides a significant impact towards organisational sustainability [24]. In the future, manufacturing companies need to attain capabilities to manage value-chain ecosystem responsively in order to overcome these challenges. Physical and virtual structures are required for companies that shall allow rapid adaption and close cooperation along the whole life cycle of the value chain from innovation to production and distribution [25].

- *Adjust talent and IT resource*

Due to the increasing complexity and dynamics of products as well as processes, SMEs have to be qualified for more than just operations. Among the skills required to autonomously deal with ails or new tasks is crucial. Within the same time, SMEs will have to focus on the individuation of production that poses new and major challenges of the qualified production work [26].

3 Industry 4.0 Maturity Assessment Models

The term maturity refers to a state of being perfect, ready or completes [27]. It denotes the development and progresses of a system. Through the creation of the maturity model it to propose an approach to improve an organisation's processes including its business process management [28]. Maturity models are used in a wide range of applications and is expected to increase in terms of its adoption in the industry [29], as well as the growing academic interest in such models [30].

Maturity models includes a sequence of levels or stages that forms an anticipated, desired, or logical path from an initial state to maturity [31]. An organisation's current maturity level represents its capabilities as regards a specific class of objects and application domain [32]. Maturity models are used to assess as-is situations in order to guide improvement initiatives, as well as to control progress.

4 Research Model

The research model is adopted from the Industry 4.0-readiness maturity model [33] - IMPULS have been chosen to assess organisations' readiness. The model consists of six dimensions. The survey questionnaires are designed from quantitative data collection and were adopted from previous research based on the IMPULS maturity model. Each of the questions has their own unique answers to fit into the dimension of Industry 4.0.

The targeted respondents are the Malaysian SMEs. The questionnaires are tabled in Google documents and are distributed to SMEs using emails. Other than that, face to face approach by going to SME's offices and their premises in distributing questionnaires with a total of 250 invitations from various industries are held to participate in the survey. The IMPULS model [33] has six dimensions that consists of:

1. Employees: Through successful development of Industry 4.0 it requires qualified staff
2. Strategy and organisation: This is crucial in implementation of Industry 4.0
3. Smart factory: It is for enable distributed, highly automation process
4. Smart operations: To create a smart workspaces guide the production process
5. Smart product: All physical product need to be equipped with ICT components
6. Data-driven services: It is built into business model

Each dimension contains a six level model for measuring Industry 4.0 readiness. The formula for weighting the dimension scores was determined in the survey by asking the companies to assess the relative importance of each dimension in the implementation of Industry 4.0. From a total of 100 possible points, the dimensions are weighted as follows:

- Strategy and organisation – 25
- Smart factory – 14
- Smart products – 19
- Data-driven services – 14
- Smart operations – 10
- Employees – 18

Through this calculation, the score and average of each dimension is gathered into a statistical comparison to check the average of each dimension for SMEs. Through this, the dimensions involved in SMEs' readiness as well as weaknesses that needed to be improved are able to be detected.

5 Readiness of Malaysia SMEs'

Fig. 1 below shows the readiness of Malaysian SMEs towards Industry 4.0 according to the dimensions as discussed previously.

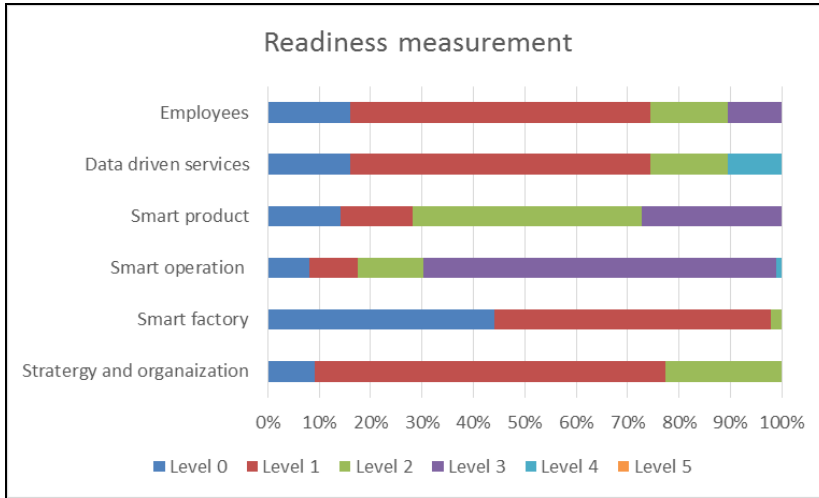


Fig. 1. Readiness Measurement for Malaysian SMEs

In the assessment, it revealed that the employees' dimension in Malaysian SMEs are in level 1 (beginner) for employee skills and skill acquisition for Industry 4.0. Based on the data, employees have skills but lack knowledge. It is found that employees may have different abilities as well as skill sets, but often not to the extent of that is essential for the implementation of Industry 4.0. As they need more knowledge and understanding of what is Industry 4.0. Employee's understanding and knowledge is crucial in adapting to the concept and strategy of Industry 4.0. Malaysian SMEs and the Malaysian government need to offer exclusive training seminars, knowledge transfer systems, and coaching to prepare their employees for Industry 4.0, teaching them the skills they'll need to keep up with the evolution towards a digitised production. In addition to basic knowledge of IT and control processes, employees will be able to learn how to exchange information with machineries and integrated systems.

In the assessment, Malaysian SMEs' data driven services are rated level 1 (beginner) which covers data-driven services, shared revenues, and shared data usage. This is due to the reason that most of the SMEs in Malaysia have their own database records that is used for accounts tracking as well as stocks and accounts. However, as the hallmark of Industry 4.0 is grounded on ICT as a fundamental in rethinking of existing business models with a focus on enhancing the benefit to the customer. SMEs will need to both digitise conventional business models and develop entirely new business models whose added value are derived from data collection and analysis. Hence, innovative business models under Industry 4.0 will be extended even fur-

ther, with the express aim of forcing open existing value chains and tapping into new potentials.

In addition to that, smart products which covered ICT add-on functionalities and data analytics are rated at level 2 (intermediate), which can translate that SMEs have the equipment and products that are able to assist them in getting a head start into Industry 4.0. Meanwhile the second highest percentage is at level 3 (experience). Getting the correct guidance and knowledge will lead SMEs into a better understanding as both equipment and product will catapult them into Industry 4.0. Therefore, all smart products need to be aligned with the strategy for Industry 4.0 as Malaysian SMEs acquire more knowledge and information.

The assessment also entails a high ranking of level 3 (experienced) with regards to smart operation that covers information sharing, autonomous processes, IT security and Cloud usage as the highest percentage achieved by Malaysian SMEs. Therefore, there may be reasons that reflect the interest of SMEs in driving the business into a business that involves intellect and technological advancements. The tendency for SMEs to use the cloud as well as having high security to secure their data explains that these companies are willing to spend their money into technological advancements. This clearly entails that Malaysian SME is willing to use IT and ICT in order to assist them in the business as well as data protection. This shows that if given the appropriate amount of pressure, Malaysian SMEs will be able to spearhead Industry 4.0 with an elevated use of high end products with advanced technological criteria. Through smart operation it will create a better factor of understanding and simplifying product development.

Smart factory consists of IT systems, data usage, equipment infrastructure and digital modelling. Malaysian SMEs are more in level 0 (outsider) and is split in half which is level 1 (beginner). This may be due to the lack of understanding of which part of IT is important in the business selection in order to assist the SME's Smart factory that requires the real-time, information systems, people and cross-enterprise collaboration between production systems. Large amounts of data are processed, analysed and integrated into decision-making models. Through the successful development the SME are able to successfully implement Industry 4.0 enables a distributed and highly automated production.

Finally, the strategy and organisation which consist of innovation management, investments and strategy. This is where SMEs state the strategy and organisation of their business in order to move forward. Most of Malaysian SMEs are in level 1 (beginner). SMEs need more understanding to move forward and plan accordingly. This is essential as the SMEs will need to understand the importance of Industry 4.0 and how it can benefit the business in order to move forward.

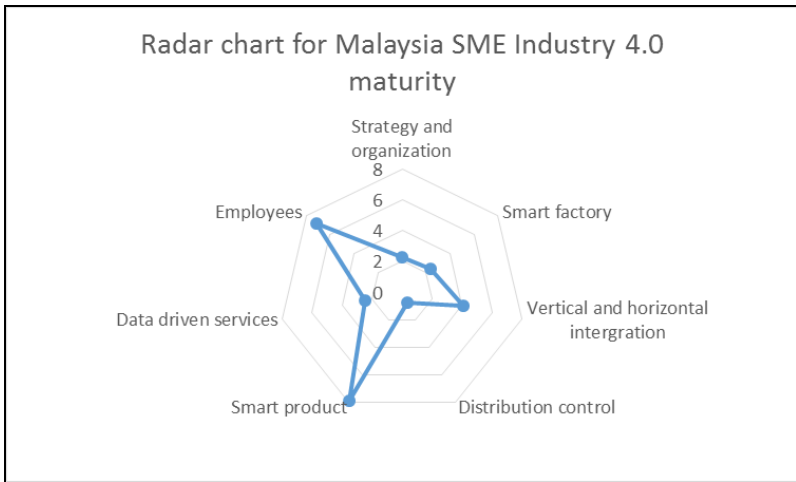


Fig. 2. Dimension for Average Readiness in Malaysian SMEs

In Fig. 12 above, the maturity level in seven dimensions is visualised. A radar chart is used to depict the overall result at-a-glance. The level of 0.79 is the lowest of the entire dimension which is for distribution control. It is caused mainly by the absence of the utilisation of the roadmap to Industry 4.0 as well as the absence and miscommunication and documentation of Industry 4.0 activities. The strategy and organisation is at the second lowest with 2.25. This reveals that Malaysian SMEs are aware although needs to cope towards Industry 4.0. Malaysian SMEs needs more education and exposure on Industry 4.0 which includes the knowledge on the benefits as well as strategies and organisation in Industry 4.0 in order to excel and compete globally.

This is followed by smart factory with 2.38, which relies on cyber-physical systems (CPS), which links the physical and virtual worlds by communicating through an IT infrastructure, the Internet of Things. This explains that Malaysian SMEs need to learn and familiarise in facing unexpected situations as well as coping with those situations as it occurs. The ability to recognise stakeholders and procedures that need to be undertaken if this occurs. Next is vertical and horizontal integration dimension by having a thorough integration with suppliers and customers in the value chain. For Malaysian SMEs, there is a need to be ready in facing unexpected situations in all phases of the process. They need to understand the stakeholder and prepare the business in all conditions.

Surprisingly, the second highest dimension among Malaysian SMEs are the employees dimension with 7.1, the employees are highly skilled but they need more training in understanding about Industry 4.0 which include IT infrastructure and automation technology. Most companies have already addressed the lack of Industry 4.0 skills and launched professional development programmes. More exposure and programmes are needed to train them.

Finally, the highest score for Malaysian SMEs is smart products dimension with an average of 7.8. Smart product is a vital component of a unified smart factory concept

facilitating automated, flexible, efficient production. Physical products are equipped with ICT components sensors, RFID, communications interface and all. Through smart products the SMEs can collect data on their environment and their own status. Using smart products during the usage phase makes news services possible in the first place, through communications between customers and manufacturers.

6 Conclusion

Industry 4.0 is a vision that describes the industry of the future. The specific potential lies above all in high-flexibility, high-productivity, and resource friendly production that makes it possible to manufacture highly individualised products under the economic conditions of mass production. Engineering, production, logistics, service, and marketing are ultimately interconnected in dynamic, real-time-optimised, value-adding cross-enterprise networks. Through implementation of Industry 4.0 the benefits are ability to control and monitor all its processes, personalisation, open communication and all this are achieved through the dimension of Industry 4.0. Furthermore, it will bring forward towards more sustainable industrial value creation. As per current research, this is predominantly categorized as contribution to the environmental dimension of sustainability. Apart from this characterisation, Industry 4.0 also embraces an impressive opportunity for pursuing sustainable industrial value creation on all three sustainability dimensions which are economic, social, and environmental.

Based on the findings above, Malaysian SMEs are lacking of knowledge pertaining to Industry 4.0 especially in terms of dimension of distribution control, data driven services, smart factory and strategy and organisation. It is hoped that by understanding the level of maturity among SMEs towards Industry 4.0 may assist them in using the technology to its fullest. However, there is a need to educate people for accepting machines as part of business advantage that respond to various requirements of customer and workers, rather than focusing on replacing operations and workers with machine. Lastly, embedding with knowledge about Industry 4.0 is a must in shaping it to achieve the strategy and goal set for their business with high value added operations and services that encourage in bringing human and machine interaction to the next level.

7 Acknowledgements

The authors gratefully acknowledge the financial grant 600-IRMI/Dana KCM 5/3/Lestari (156/2017) given by IRMI, Universiti Teknologi MARA, Malaysia and Faculty of Computer and Mathematical Sciences for all supports and resources.

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