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Is Malaysia ready for Industry 4.0? Issues and Challenges in Manufacturing Industry

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Abstract: Despite as a strong manufacturing economist in ASEAN, manufacturers in Malaysia are the beginners who are lack of proper understanding of the concepts and practices of Industry 4.0. The purpose of this paper is to identify the issues and challenges of Industry 4.0 from industry-based companies' aspect by conducting a literature review. This paper also highlighted the comparison between the potential challenges stated in the Malaysia National Policy on Industry 4.0 with the challenges proposed by previous studies of other countries. This paper is a literature review on previous studies regards to challenges or issues on implementation of Industry 4.0 from 2015 to 2019. Total 11 challenges in the processes of implementation Industry 4.0 into manufacturing companies are reviewed. Compared to previous studies, Malaysia National Policy on Industry 4.0 overlooked 3 challenges on Industry 4.0. This is the first review paper to compare the existing challenges in Industry 4.0 with the potential challenges stated in the Malaysia National Policy on Industry 4.0.

Keywords: Industry 4.0, Challenges, Manufacturing Industry

1. Introduction

The process to merge the application of Industry 4.0 concepts into practice in the entire manufacturing environment is complex. There are tremendous increments of the scientific papers being published in the area of Industry 4.0 from 2011 until 2019, indicating a significant interest in this issue, which results in numerous attempts to define it. Manufacturers had defined it in two main categories: (i) from technical point of views - this view can be described as the digitization and automation of manufacturing environment's in addition to an increased communication enabled by the creation of a digital value chain; and (ii) operational point of views, Industry 4.0 is considered as integrated, adapted, optimized, service-oriented, and interoperable manufacturing process with the implementation of a list of advanced technologies [1].

Leaders in global manufacturing industries such as the United States, German and Japan treat Industry 4.0 as an opportunity, not as a threat even though some manufacturers are slightly less confidence because of the complexity on reshaping the industries boundaries [2]. Nonetheless, [3] claimed that the level of preparation of manufacturers to individual dimensions of Industry 4.0 and the ability to take the advantages of Industry 4.0 is lower than expected. Japan, for example, shows a lower level of preparation for Industry 4.0 in comparison to US and German [4]. The development of Industry 4.0 also transforms the landscapes of Asian countries close to Malaysia such as Singapore and China. Singapore Economic Development Board launched the Smart Industry Readiness Index to assist manufacturers to start their first step towards implementation of Industry 4.0 by evaluating their current readiness [5]; China government introduced an initiative namely "Made in China 2025" to promote their industries into high-tech mode to secure in global market [6]. As manufacturing industries is one of the contributors to national income, Industry 4.0 start emerging relatively in manufacturing industries in Malaysia presently. As Industry 4.0 is relatively a new concept, manufacturers in Malaysia may a shortage of knowledge about the exact impacts and cost-effective of the Industry 4.0 related

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technologies to their business [7]. Moreover, lack of technology infrastructures and facilities, high-skilled workforce and resources become challenges or barriers to manufacturing industries of Malaysia to implement Industry 4.0. Though the government of Malaysia introduced Malaysia National Policy on Industry 4.0 (Industry4RWD) which purposed to push manufacturing industries towards Industry 4.0, at this juncture, the initiatives may not be very visible among the public in general as the touch base is rather confined to the technocrats. Where the Industry 4.0 is concerned, reaching the medium-sized enterprise or even small and micro-sized enterprise at the far end of the technological divides will prove to be a challenge if the infrastructure is insufficient. Coupled with Malaysia is not a technology-producing country, the evolution of production evolution from 2.0 to 3.0 takes place quite slowly [8]. [9] insist on Industry 4.0 is a fairy tale to the developing countries when the nation is ambiguous about an explicit definition for proper understanding and practice in business. Hence, this study attempts to provide an overview of Industry 4.0 and a literature review about the challenges during the implementation processes of Industry 4.0. In this paper, there is also a comparison between the potential challenges stated in the Industry4RWD with the challenges proposed by previous studies to determine whether Malaysia is ready for Industry 4.0.

1.1 Manufacturing Industry of Malaysia and the Current State of Industry 4.0

For now, the state of the industrial revolution of the manufacturing sectors of Malaysia is in between Industry 2.0 and 3.0 [10]. As shown in Table 1, 98.5% out of the total 49101 establishments in Malaysia manufacturing sector are small and medium enterprises (SMEs) whilst the rest of 1403 companies are large firms [11]. SMEs are is the majority of manufacturing industries in Malaysia. At present, SMEs contributed 59% to the total employment in the nation [12] and contributed 38.3% to the national gross domestic product in 2018 [13]. It is a crisis to the nation if SMEs remains unaware of the importance to embrace Industry 4.0 to improve their manufacturing competitiveness in the future [8].

In Malaysia, there is only 30% of manufacturers aware of the concept of Industry 4.0 [14]. Although the manufacturers are realized of the importance of Industry 4.0 for future improvement and opportunities in competitiveness, the state of preparations for its implementation varies widely depending on the country, sector, or even an individual company. However, significant numbers of Malaysian executives are keeping an optimistic attitude about entering the fourth industrial revolution [15]. In terms of global competitiveness, Malaysia is closing the gap from 25th (2016-2017) to 23rd (2017-2018) out of 137 global economies as reported in Global Competitiveness Index 2017-2018 [16]. Among 17 economies in East Asia and Pacific, Malaysia is ahead of countries such as Korea Republic (26), China (27), Thailand (32) and Indonesia (36). Manufacturing industries of Malaysia contributed 23% to national gross domestic profit (GDP) [17]. Despite the unawareness about Industry 4.0, Malaysia still locates at a strong and competitive position among global competitors.

No doubt, the government of Malaysia alerts about this revolution, hence, encourages manufacturers to embrace the fourth industrial revolution [18]. This is particularly challenging for manufacturers fully transformed into Industry 4.0 compliance. In national Budget 2019, the government allocated funding to support manufacturers especially SMEs to adopt advanced Industry 4.0 technologies, transformation on the traditional business processes and operating models to digital base. In 2019 budget, the government of Malaysia allocated RM210 million for Readiness Assessment Program and RM3 billion for the Industry Digitalization Transformation Fund to accelerate the adoption of Industry 4.0 related technologies by manufacturing companies at Malaysia [19]. In national Budget 2020, government Malaysia allocates funding to build 5G Ecosystem, kick start National Fiberisation and Connectivity Plan, and numbers of investment incentives to assist local companies to get in Industry 4.0 [20]. Government via several initiatives such as Digital Transformation Acceleration Program by Malaysian Digital Economy Corporation, Industry Digitalisation Transformation Fund by Malaysia Development Bank, Domestic Investment Strategic Fund and Automation Capital Allowance by Malaysian Investment Development Authority, and Soft Loan Scheme for Automation and Modernisation by Malaysian Industrial Development Finance Berhad as Industry 4.0 gateway for manufacturers especially from SMEs [21].

Latterly, the government of Malaysia launched Industry4RWD to assist local manufacturer especially the SMEs to keep in pace with the global trend, transforming into Industry 4.0. Ministry of International Trade and Industry (MITI) as the leader in this high-level task force and followed by Ministry of Communications and Multimedia Malaysia (MCMM) who in charge of digital infrastructure and eco-system, Ministry of Finance (MOF) preside over funding and incentives, Ministry of Human Resource (MOHR) and Ministry of High Education (MOHE) in charge of talent and human capital, and last but not the least, Ministry of Energy, Science, Technology, Environment and Climate Change(MESTECC) responsible in technology and standards [22]. Industry4WRD augur an increment in manufacturing productivity per person by 30%, enhance the contribution of manufacturing industries to the national economy from MYR254 billion to MYR392 billion [23]. Industry4WRD also aims to elevate the innovation capacity and capability, last but not the least, develop more high-skilled workforce in manufacturing industries from 18% to 35% [24].

Table 1 - Total establishments of Malaysia in 2016 by sector

Sector	Economic Census 2016 (Reference Year 2015)				
	Total	SMEs	% of SMEs to total	% of SMEs to total SMEs	% of SMEs to total by sector
Services	818311	809126	87.9	89.2	98.9
Manufacturing	49101	47698	5.2	5.3	98.5
Construction	40558	39158	4.3	4.3	96.5
Agriculture	11628	10218	1.1	1.1	87.9
Mining & Quarrying	1026	865	0.1	0.1	84.3
Total	920624	907065	98.5	100.0	-

Source: Department of Statistics Malaysia (2017) [25]

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1.2 National Policy on Industry 4.0 (Industry4WRD)

Industry4RWD has highlighted both potential internal and external either issues or challenges might face by local manufacturing industries to explain the low acceptance of Industry 4.0 among local manufacturing companies at the stage of beginning. There is a total of 6 internal potential issues. The first challenge is the lack of awareness among manufacturing companies on the impact and necessity of Industry 4.0 technologies either in terms of business opportunities or business model disruption. Since the concept of Industry 4.0 is still ambiguous and fresh among the local manufacturing sector, there are very few successful cases can be used as a reference on implementing Industry 4.0 technologies and processes in manufacturing plant. Meanwhile, deficiency centralized and easily accessible information platform for local manufacturers to understand the best practice of Industry 4.0. The high cost of Industry 4.0 related adoptions is also a stumbling block to manufacturing sectors to transform into Industry 4.0. The long payback period for Industry 4.0 development, coupled with short of understanding about cost and benefits in Industry 4.0 business case analysis, leads to a challenge for manufacturers to begin for adoption.

Another issue to be concerned is lack of skill enhancement among manufacturing companies due to low understanding of the required skills, talents and knowledge of Industry 4.0. Hire low skilled foreign labours still as a prevalent of local manufacturers due to the lower labour cost [26]. Besides, the connectivity and adoption of advanced technologies is the focal point of Industry 4.0. However, the draft highlighted the use of automation is less than 50% among most of the local manufacturing companies. The adoption of information and communication technology (ICT) by SMEs in developed countries is at least 50% but around 10% for SMEs in Malaysia [27]. A study by [28] shown SMEs in Malaysia are confine themselves with the use of ICT for social media and personal digital content though they have computing capabilities and Internet connectivity. The usages of ICT to improve their business processes are underdeveloped. The digitalisation survey 2018 shown SMEs in Malaysia are less exposed to digital tool usage, short of knowledge on advanced technologies [29]. The digital readiness and connectivity with ICT are low among manufacturing companies in Malaysia. It is a challenge for companies to innovate their current systems to fulfil future customers' demand for individualization of products within a short delivery time.

Six potential external challenges are being summarized in Industry4WRD. One of the challenges is short of the national platform and mechanisms governance on Industry 4.0 related programs, structure and approaches. Consequentially, the standards of Industry 4.0 related equipment, technologies and system is fuzzy. Initially, there are no specific financial incentives is specifically for Industry 4.0 development. There is no financial aid to manufacturing companies to develop technologies, conduct research and development, prototyping, testing and upgrading to forefront facilities. Step up the development of high-speed broadband infrastructure in key industrial and training locations and incapable to support the use of Industry 4.0 technologies are another gap in the implementation of Industry 4.0.

Another potential issue to be concerned is lack of training providers who capable of provides training programs which sufficient to support Industry 4.0 talent development due to trainers at present unable to keep abreast of the advanced technologies. Manufacturing companies might face an issue where a lack of support from the ecosystem to provide Industry 4.0 solutions and lack of local capabilities to provide cybersecurity solutions to protect assets of Industry 4.0. The root of the above issue is only very few numbers of experts from the field of manufacturing industry, academia and research institutions across most Industry 4.0 technologies.

2. Literature Review

2.1 Ethos of Industry 4.0

Industry 4.0 was first introduced as "Industries 4.0" by the German Federal Government in 2011 while proposed government-sponsored industrial initiative towards digitalization and automation to foster the industrial sustainability in a competitive global market [30]. There is no universal meaning to describe the meaning of Industry 4.0, hence, Industry 4.0 can be addressed as a term which represents for collective advanced technologies and digitalization concepts of value chain organization [31]. The implementation of Industry 4.0 is a building block process. The required building blocks, namely big data and analytics, autonomous robots, simulation, horizontal and vertical system integration, internet of things (IoT), cybersecurity, cloud computing, additive manufacturing, and, the last but not the least augment reality, to make concept of Industry 4.0 can be realized [32]. Besides, cyber-physical systems (CPS), machine-to-machine components, autonomous vehicles, nanotechnologies, biotechnologies, energy storage, and quantum are also a key to ensure the degree of connectivity and communication during Industry 4.0 development [14, 33]. All efforts are provision for connectivity, communication, networked entities, real-time data and pervasive information throughout the entire value chains to achieve full automation, digitalization, and intelligent manufacturing environment. Manufacturing companies must construct a connection network fulfil with 3 features which are vertical integration (intra-organization systems integration), horizontal integration (inter-organization systems integration) and end-to-end digital integration of engineering to achieve the above results [20, 34, 35].

i. Vertical Integration

In brief, vertical integration in manufacturing context is the data from smart-sensor-attached items from physical production floor sent to network embedded systems and the physical processes can be monitored and controlled via the network [36]. According to [37], the integration of smart systems at different hierarchical levels such as human-machine interface, the actuators, sensors and controllers of different production objects, production management, manufacturing and execution and corporate planning levels are regarded as vertical integration in the field of production view. CPS is an ensemble of a networked embedded system to form a new system to combine the functionality of the systems [38]. CPS allows production being managed by automation administration system as the changes in orders can be trace, the materials and parts are self-control, as well as the machines breakdown can be diagnosed and auto-troubleshooting [39]. Vertical integration enables intra-organization integration through a network of both manufacturing and IT systems, processes and data flow through the entire company from start to the end of manufacturing processes [40].

ii. Horizontal Integration

The horizontal integration refers to an entire value network integrates multiples companies (from suppliers to end customers) involved in the value chains to enhance close inter-organization collaboration [41]. The network is real-time optimized which is supposes to intelligent and digitalize [33]. The requirements to integrate a network laterally are the full equipment of network, infrastructures and technologies involved in IoT among value chain partners [42]. IoT is a massive intelligent network combines the information sensing equipment and systems, all kind of access networks and the Internet. In the context of Industry 4.0, IoT is applicable to virtualize the manufacturing process and promote autonomous in the factory [43]. Smooth information, finance and materials flow in this efficient network that can be optimized in real-time [44].

iii. End-To-End Digital Integration of Engineering

The combination of both vertical integration and horizontal integration allows end-to-end integration across the entire value chain [45]. It is about an intelligent cross-linking and digitalization throughout all phases of a product life cycle [46]. End-to-end digital integration is essential to facilitate individualized products and consequently, internal operating costs are reduced [40]. End-to-end digital integration describes the integration throughout the engineering process to ensure the digital world is interconnected with real-world across company's entire supply value chain and different business partners, as well as including customer demand [47]. By using advanced methods of communication and virtualization to integrate engineering along the entire value chain allow significant optimization potential [48].

2.2 Benefits of Industry 4.0

Smart integrations enable the manufacturing environment turns into a smart and intelligence Industry 4.0 platform on behalf of the sustainability of the company. This section discussed the potential economic benefits brought to the company.

According to [44], Industry 4.0 applicants able to meet fluctuating demands by changes its organization and performances level dynamically. For the overall manufacturing performance, the company can cope with customer individualize and customize demand with short delivery time. Besides, the manufacturing companies can promote mass production where the production can be optimized and a high level of collaboration in both intra- and inter-organization are achieved. Business structure shift to decentralized management structure which allow day-to-day problem solving quick and efficient. Moreover, the company has the upper hand the market when able to make use of big data to create values.

In IoT ecosystem, sensors are functioning as to detect temperature, weight, motion, vibration, acceleration, humidity, and location [49]. Through the functions of a sensor, not only the parts and products are traceable but also allowing the real-time data collection [50]. Supply chain network becomes transparent when the entire systems revolutionized by IoT, smart sensors and communication technologies, support the reduction in inventories cost [51]. Moreover, smart sensors allow remote monitoring of energy consumption data across the factory. The collected data can be stored and analyzed in the cloud. The result of analysis will then show on the mobile devices to allow IoT connects suppliers, manufacturer and customers which allowed transparent supply chain information that can be delivered in real-time to let all parties in the value chain understand the flow of materials, and manufacturing cycle times [52]. The smart systems able to adapt flexibly with rapid changes and able to decide with the optimize use of energy and resource [30, 53]. The flexibility in resource and optimization on decision making are depended on the transparency throughout entire supply chains [2]. All these are carried out automatically and the role of man will change to focus on value-adding activities [35].The smart systems also proactive in maintenance where remote monitoring could be achieved.

3. Research Methodology

This paper applied systematic literature reviews and follow the guidelines by [54]. Table 2 summarizes the steps for executing the SLR for this study.

Table 2 - Step adopted in SLR

Steps	Criteria
Define research questions	RQ1 What Industry 4.0 challenges or issues assist during the implementation process?
Selecting data bases	ScienceDirect; IEEE Xplore Digital Library; ACM Digital Libraries;
Inclusion criteria	i. The full accessible English publication between 2014 to 2019 ii. The research focuses on challenges of Industry 4.0, but not specifically on the manufacturing industry. iii. The research focuses on challenges of Industry 4.0, but not specifically on the developing country. iv. The research paper explicitly discusses challenges and issues of Industry 4.0 in the manufacturing industry v. The research paper explicitly discusses challenges and issues of Industry 4.0 in developing country vi. The research paper focuses on challenges of Industry 4.0 in Malaysia.
Exclusion criteria	i. The full text of the paper is not in English, except for the title, abstract, and key words ii. The full text of the paper partial or cannot be accessed iii. The research paper is not related to Industry 4.0 and challenges iv. The research paper addresses Industry 4.0, but does not focus on challenges/ issues

The search string, comprising the keywords “Industry 4.0” AND “challenge” were deployed within the online databases to search for relevant publications for the period 2014 to 2019. The term “Industry 4.0” is substitute with aalternative terms such as “Fourth Industrial revolution”, “I4.0”, “Industrie 4.0”, and “IR4.0”; the term “Challenge” is substitute by the alternative terms which are “barriers”, “issues”.

i. ScienceDirect- 4285
ii. IEEE Xplore Digital Library - 468
iii. ACM Digital Libraries - 441

Although massive quantities of paper being identified (5194 including duplications), only 46 literatures met the criteria after reading the full texts.

4. Challenges of Industry 4.0

Though Industry 4.0 will spawn economic benefits, at the same time, there are challenges during the processes of implementation. The early development to put Industry 4.0 into practice is a controversial issue among researchers and practitioners. The issues and challenges of Industry 4.0 involved in many aspects and can be categorized into scientific, economic, social, political and technological [55].

In the preliminary stage of Industry 4.0 implementation, management will be the first to face a challenge in this new revolution acceptance to admit the implementation is essential and get ready with the company's transformation processes. Before starting a transformation, management has many considerations and concerns not only about the risks during the processes but also the marginal profits after implementation of Industry 4.0. These concerns are the challenges of Industry 4.0 acceptance.

The most probable cause of hesitation among company about to start Industry 4.0 initiative is the exorbitant investment cost might higher than the predicted company growth, lastly result in economic deficiency [56]. Industry 4.0 is complex and its development is a building block process. Different financial models and aspects in investment should be evaluated from beginning to the end of implementation to ensure return on investment. A survey by [57] shown one of the obstacles faced by companies who are implementing is funding for sustaining Industry 4.0 implementation. A survey by [58] shown challenge encountered by SMEs is high investments in machine parts, IT infrastructures, last but not the least, the costs for IT personnel and technical training. Financial challenge is faced by all types of companies, regardless of size when discussing the cost implications in either to upgrade existing IT infrastructures or to replace with a new system [34]. Development of industrial IoT needs enormous amounts of money to bring in Industry 4.0 related and advanced IT facilities [59]. A study by the [14] highlighted funding is also essential to support a company either to buy-in or sign up to Industry 4.0 roadmaps. Moreover, the cost implications of the preliminary state of Industry 4.0

implementation include consultation from professionals, high-performance information and communication technologies, infrastructures, and new advanced technologies throughout all levels of the organization, high skilled workers and the re-evaluation and re-engineering shall be established to build Industry 4.0 platform but are not limited to the following. The lack of clarity about economic benefits is another challenge for Industry 4.0 [60]. The uncertainty about the costs and benefits give rise to management hesitates to step towards Industry 4.0.

The time factor is another concern by management. Shifting to Industry 4.0 platform is a time-consuming project [61]. [32] expect the time requires for a complete transformation into Industry 4.0 is 20 years. Specifically, 10 years is a needed period for a company to build up a digital foundation [39]. A complete Industry 4.0 platform requires multiple smart device configurations, and these developments consume time and money before it to employ in manufacturing firms [35]. The management has two concerns on time factor. First, the time requires for Industry 4.0 related systems adoption, testing and run might affect the daily operation. Second, a long period for unfolding the benefits of implementing Industry 4.0, couple with the premise is the company has developed a mature Industry 4.0 environment.

Implementing a new Industry 4.0 related business systems it is worth assessing business needs and requirements for the new system. Manufacturing companies must change their current business model, processes, and capabilities to enjoy the full potential benefits under Industry 4.0 [62]. The decision of a business model is according to company-specific knowledge, ideas, data, and algorithms and defines utilization of these assets developed [63]. Business model innovation is an obstacle to the management in the age of Industry 4.0 as the key to company success is innovation capability [64]. Besides, currently is to be short of a clear Industry 4.0 related maps and guidance which support companies' implementation [65]. [66] emphasized company must have a detailed strategy with clear goals to have a smooth Industry 4.0 development. Though many key technologies being proposed and the significance being discussed, but the exact Industry 4.0 is undefined [67]. Therefore, [31] concluded that there is no universal meaning to describe the Industry 4.0 in concreted, hence, the actual concepts and standards are ambiguous. Without an unclear benchmark, it is difficult to ascertain the payback and determine a clear long term Industry 4.0 plan and strategies according to the limited knowledge. As a consequence, this situation turns to a risk, top management and stakeholders wavered over whether to support the high complex Industry 4.0 development. Thus, one the challenge is to define the exact concepts, standards and requirements of Industry 4.0.

Human resource development is another concern to the management to put Industry 4.0 into practice. Challenges are by no means peculiar to the financial capital required to deploy advanced technologies, as yet about the obtainable of qualified staff to fix to different organizational levels that can cope with the increasing complexity of future manufacturing processes [68]. Low-skilled jobs will be a takeover by autonomous machines in the future, the worker must top up with new skills related to smart machines operation [69]. Industry 4.0 risk management done by [70] revealed human resource department will undergo a phenomenon where a lack of qualified workers to be placed in the digital working environment. The shortage of expertise and workers on learning curves will intensify the production issue [71].

Most of the labour workforce will be replaced by autonomous in soon, thus, the future workforce should higher be educated with the Industry 4.0 needed competencies [72]. The survey done by [66] revealed the acceptance of employees on Industry 4.0 is a major challenge for an organization to overcome. The cause of low acceptance on Industry 4.0 among both veteran and new employee is lack of Industry 4.0 skills and competencies, especially in the aspect of IT, they will end with job loss. However, instead of replacing by robots, [73] considered human and robots are in a mutualistic relationship. In the era of Industry 4.0, workers have a major part to handle complex and indirect tasks such as monitoring daily work with smart devices rather than transfer objects. The role of worker will transform, hence, management should emphasize interdisciplinary education in the areas of economics, engineering, informatics, and mathematics [59]. [74] explained workers will have to face the following conditions: unstructured problem solving, dealing with continuous and massive information data from machines, and last but not the least, carry out many non-routine manual tasks. High skilled workforces are needed by companies to operate advanced manufacturing tools and systems, the ability to analyze data received from machines, consumers, and global resources [75]. The trend of growing use of software, connectivity, and analytics will lead to a higher prerequisite for workers competencies in software development and IT technologies, such as mechatronics experts with software skills [32]. In the era of Industry 4.0, the demand for the digital workforce as a function to operate smart drones, robots and intelligent assistance will much greater than expected [14].

The complexity of Industry 4.0 requires to redesign the current organization and operational structures to ensure the implementation of new ICT and advanced technologies are well integrated with the business and operation processes [76]. Several psychosocial risks might arise and becomes a major challenge in the field of occupational, health and safety [71]. For example, existing workers might feel unsafe when physical works are replaced by robots or ageing [73]. The close collaboration between human and machines is associated with an increase in relative risks. [77] stated the possible hazards from human and machines collaboration in the context of Industry 4.0 namely hazards from robot during collaboration, hazards from the industrial process during collaboration, and hazards from robot control system malfunction during collaboration.

Computational intelligence is decisional for the success in cyber intelligence in tracking, analyzing, identifying digital security threats to combat viruses, hackers and terrorists that exist on the Internet for cyberstalking and harassment, extortion, blackmail, stock market manipulation, complex corporate espionage, and planning or carrying out terrorist activities. At present, the existing information-based network architecture is unable to possess the function of self-

sensing, self-computing, a self-organizing, and self-maintaining method for the decision-making optimization of production and management. These technologies consider as a premature idea to fulfil the expectations such as robustness, autonomy, smart maintenance, predictability, and interoperability present challenges to the fields of computer sciences, information and communication technologies as also to manufacturing science and technology [74]. Without a doubt, the initial stage of Industry 4.0, immature or incomplete technologies, is a management concern. The concerns are about the effectiveness and the cost-benefit of the technologies. For instance, on current CPS development, the issues are four: cooperation between different systems, CPS modelling and model integration, the integration of CPS as well as verification and testing of CPS [54]. CPS is a significance technology used to overcome the issues such as timeliness, distribution, reliability, fault tolerance, security, scalability and autonomous operation which impulse the transformation from Industry 3.0 to Industry 4.0 [49]. [78] indicated the complexity of CPS is a problem in developing and designing trustworthy, secure, and guaranteed systems and control methodologies. Industry 4.0 reveals the vision of transform manufacturing into an intelligent environment, in which people, systems, products and even customers are interconnected. [43] described there is still a range of technical challenges exist in the initial phase of Industry 4.0, particularly development of IoT, including the lack of standardization, the fact that security and privacy solutions, and the faultiness in data analytics technologies.

Since the platform of Industry 4.0 is either in web or cloud base, data security and privacy are the two major concerns among most manufacturers [79]. The issue lies in cybersecurity as data become a fatal asset [80]. Massive amount of data that collects from different systems, for instance, system by analyzing production data and coordinating the findings with customer information systems [34]. Furthermore, an ideal Industry 4.0 scenario is the organizations within the corporate value chains able to share data and receive information via either CPS or IoT. The issue concerns are different cooperate organizations might have difference hierarchy of cybersecurity and lastly leads to the confidential data and information disclosed. The small organizations within a value chain which under resources restriction might have poor cyber-security arrangements [81]. The use of IoT, data and people will create chances and avenue for data theft, industrial espionage and attacks by hackers [34]. The cybersecurity issues not only limited to data disclose but also about to betray the proprietary information, last but not the least the production system controlled by illegal third parties [2]. The protection of data will be Industry 4.0 raised demands for security architecture and security by design [82]. The smart manufacturing system should have these features: automatic detection of malware, threats and attacks with zero-installation.

Meanwhile, [14] discussed the issue on scalability where several companies face problem to scale up the technologies across the entire company and multiple factories at the initial stages of Industry 4.0 design and implementation. At present, many companies still using separate application network. Scalability turns to a challenge when a large number of physical objects are connected to a network. Multiple level data transferring and networking, data processing and management, and service provisioning aggravate the challenge in scalability [83] The scalable solution is essential to fulfilling the demand of entire and cross companies cooperation, and to suppliers and customers [84]. About the technological issues on scalability, [85] suggested the implication of a group-based industrial wireless sensor network (GIWSNs). Based on [86], it is a system management challenge to stakeholders to align the architectures, design principles, and system models with the complexity.

Heterogeneous machine data will obtain during manufacturing processes through CPS. The challenges here are obtaining the right data from sensors networks for tracking fault in machine and troubleshooting automatically [87]. Though a company has fully adopted and connects all the Industry 4.0 related technologies, IoT hardware and communication protocol, [63] stated there is still a gap for this complete connected platform to obtain meaningful data and data analyzing for implications. Besides, handling a massive amount of data with additional function to retrieve, represent and interpret the information under secure situation is also an obstacle for IT team [88]. [34] highlighted one of the challenges possess in Industry 4.0 is the management of a massive quantity of generated data and transform the data into useful information. A survey by [84] shown data integration is one of the top three challenges during Industry 4.0 implementation. Another sticking point was being brought out were transforming the data collected from different smart devices into a universal format is an issue awaiting for solution during Industry 4.0 [87]. Data turns to an asset for a company in Industry 4.0, hence, the immature development on technologies would cause the risks of wrong data collection, wrong data interpretation to not useful information as well as data disclose. The information risks such as data losses, loss of integrity and available information might happen in the process management [89].

A company undergoing technology challenges can lead to trouble in introducing new products or services, innovation, and business models. Companies are imposed by the different degree of autonomous and varying lifecycle level of the machinery, as parts of machines have to be replaced whilst the rests might require varying degrees of retrofitting [2]. The size of the company affects the degree adoption of Industry 4.0 applications [89]. In opinion [34], SMEs can be more quickly to implement the digital transformation since they are more easily development and implementation of new IT structures from scratch. In contrast, large companies and multinational companies need to concern more complexity to deal with in terms of their existing, organically grown structures Large companies will find out the efficiency gains from the implementation of Industry 4.0 compared to SMEs as large companies have constant process management whilst SMEs lay emphasis on manual activities [90]. The reason is these two kinds companies have to ensure entirely new systems are compatible with existing IT infrastructure systems; unless new exponential technologies substitute the existing systems completely with manageable effort and justifiable risk [34]. However, SMEs

are less capable of coping with the financial, technological and staffing challenges than large enterprises [91]. Major challenges faced by SMEs while embracing Industry 4.0 are lack of financial resources, capability to develop workable Industry 4.0 strategy, low degree of standardization, unknowledgeable regarding the concept of integration, cost and benefit analysis about the Industry 4.0 technologies, data security and shortage of talent in information technology [89,92].

5. Discussion

Table 3 summarized the challenges discussed in both Industry4WRD and previous studies. Most of the potential challenges listed in Industry4RWD are coherence with the challenges studied by previous researches. The time factor is one of the similar potential challenges. Before looking for payback, there is time taken for developing, testing and monitoring the new systems and infrastructures. The payback period on investment in Industry 4.0 is long and the realization might take 10 to 20 years [51].

The next challenge is financial as the upfront investment on Industry 4.0 is huge and it is a long-term development. Industry4WRD would list financial as a barrier is due to manufacturing companies in Malaysia dominant are SMEs which low fund tolerance to support the high adoption cost. Huge upfront capital for investment in both technologies and talent is affordable for industries in Malaysia [93]. Supported by [94], local industries are hard to have continuous capital to afford advanced technologies, upgrading their current infrastructures, continuous adopt more advance technologies in future, technical equipment, training and consultant fees to form Industry 4.0 ecosystems.

The level of understanding about Industry 4.0 will determine the enthusiasm of manufacturers to start Industry 4.0 adoption. A survey by [95] shown SMEs in Malaysia is an outsider in the trend of building smart factory as they short of understanding on the impact of infusing advanced technologies into their business model. Besides, only 300 local SMEs are joined the readiness assessment prepared by Ministry of International Trade and Industry even if government provide fund and sent assessors to evaluate their current Industry 4.0 indicators due to most of SMEs are low awareness on Industry 4.0 [96]. The data reflect their insensibility to this revolution owing to short of an information platform on Industry 4.0 practices and lastly reflects the low acceptance to develop in Industry 4.0. Local manufacturers, especially from SMEs would remain hesitant or even lack the initiative to start as they are unable to have a clear understanding about Industry 4.0 and could not identify the most suitable technologies to fit in their current business [97].

The broad define on Industry 4.0 would confuse the manufacturers. Though Industry 4.0 contains plenty of elements, choices on the right elements and time to implements are based on various specific industry, market, business, organization and manufacturing environment features [98]. Presently, SMEs in Malaysia is positioned as a beginner in the aspect of Industry 4.0 strategic and organization, the overall Industry 4.0 maturity is low [95]. Less Industry 4.0 related knowledge, as well as guidance exposure and strategy and guidance deficiency, lead to top management no idea where to begin. Steps of Industry 4.0 transforming processes must have a roadmap with clarity of processes at every stage right after both management and IT define their opportunities and threats in this era [38]. However, Industry 4.0 is actualized in recent years which is hard to have a mature set of benchmarking on its indicators which can be the reference during planning the Industry 4.0 related roadmap or strategies.

Technology is another barrier as the actualization of Industry 4.0 is fully depends on advanced technologies. Malaysia is positioned at the infant stage of automating, no doubt, manufacturing industries more prefer to use foreign workers for tasking if compare to investment on Industry 4.0 related technologies [99]. Cost and benefit of the Industry 4.0 technologies are the concern for both Industry4WRD and previous studies but the difference is Malaysia short of analysing on this whilst the other county had misgiving about the uncertainty. Both the cost and benefit of Industry 4.0 technologies are hard to evaluate because all these are completely new without previous references [98]. Another divergence on this barrier is previous studies are pay attention to the result of the implemented advanced technologies but Malaysia has a gab on infrastructures and facilities to kick start Industry 4.0. According to the report by [100], Malaysia performed an average speed of the 4G line is 14.83 megabits per second (Mbps) which lagged behind the countries such as Singapore (44.31 Mbps), Japan (25.39 Mbps) and Vietnam (21.49 Mbps). Besides the report also stated the 4G availability in Malaysia is 74.88% which reflects the weak Internet connections and services within Malaysia is unable to provide stable, high-speed Industry 4.0 network connection. The Industry 4.0 company possesses high support for adaptable and consistence connectivity and fast communication between machine-to-machine or devices to human [101].

Another issue related to technology is the lack of technology standardization, for both newbie and developer. The standardization in communication, machines and system are required to interpret the interoperability communication processes [102]. For instance, a survey by [103] shown without standardization, unstructured and unorganized big data gather from Industry 4.0 ecosystems might not provide precise data analysis for right decision making. The interconnection which supporting fully automation and digitalization cannot realize as there is a standard throw among the players in a network of Industry 4.0. Without standardization, the company faces difficulties to govern and monitor the Industry 4.0 ecosystem. The standardization process between the technology providers, integrators and end-users should carry out by a few key stages [104].

The concern on cybersecurity is derived from the immature Industry 4.0 technologies development and technical support and the leaking of private data online. Every party in entire value chain use to protect their data, systems and

networks from the start of implementing IoT to prevent cyber-attack on data-stealing from the IoT data network [105]. The company itself need to bear a significant loss of operational time and significant impact on revenues and profits.A survey done by [106] reveals 55% out of 400 university students at Malaysia are consider transformation into Industry 4.0 would increase the rate of unemployment to the country. Students in Malaysia are unprepared and lack of technology skills to adapt themselves in Industry 4.0 workplace [107]. SMEs in Malaysia fearing automation would substitute their task lead to unemployed- an Industry 4.0 development repellent [108]. If Malaysian did not break this instinct, changing their mindset to accept this revolution will drag country behinds, other competitors. Routine works will be eliminated in Industry 4.0 era together with the change of working environment into more interesting, the employees' job scope enriched with various competencies and value creation [109]. Employment market should transform into skill-intensive based.

The essential Industry 4.0 related skills and competencies are hard to define, it is a challenge for Malaysia's institutions to cultivate future workforces [93]. A survey by [95] revealed the skill required for Industry 4.0 within SMEs in Malaysia is at the stage as a beginner. The lack of understanding of the required talent, skill, and knowledge, insufficient qualified trainers and trainees with advanced technology competences turn to obstacles to reach the ideal Industry 4.0 working environment. Malaysia plays the role of the follower in Industry 4.0 and not a domain to produce Industry 4.0 related technologies and systems. A study by [110] showed SMEs in Malaysia are preferred to be a technology follower as SMEs in Malaysia only able to learn more about IoT related services and product with the assistance of the third party. Hence, the challenge of technical aspect is not dominant in Industry4RWD. However, building a new and excellent Industry 4.0 platform pose a challenge to the technology, system, software developers. The immature technologies might cause the wrong data extraction or a wrong interpretation of data.

This study discovered Industry4RWD was overlooked a few challenges in scalability and OSH. Different company has its own decision on strategies and planning to realize Industry 4.0. Moreover, some Industry 4.0 technologies are top-up "computing incentive" to the existing technologies in the manufacturing company [98]. The discrepancies in system, technology, software, devices and machine are lead to scale up the technologies to the entire value chain.

The introduction of new advanced technologies into the manufacturing system deploys new level interactions between humans, machines, materials, and objects, consequently changing the role of employees. It is vital to discover and identify the new challenge in human work and ergonomics in Industry 4.0 [111]. European Framework Directive on Safety and Health at Work (Directive 89/391 EEC) emphasize the necessity of including safety and health as a part in the management process by enforcing employers consider works are safer and healthier [97]. All parties must embrace technology and discard traditional ways of doing things, such as the paper-based process of recording OSH data. The health and safety condition of worker can be recorded and monitored through mobile applications [112]. Malaysia overlooks these kinds of issues because the advanced technologies always are the focus in Industry 4.0. Infusion OSH into Industry 4.0, for instance, personal protective equipment with smart technologies could protect workers away from chemical, toxic, extreme noise or heat, to name a few. Moreover, [113] stated the worker real-time well-being data such as pulse, emotions and temperature are traceable by technologies which helpful to warn them when they are exposed to hazardous behaviours and facilitate worker to search for help. All possible challenges in Industry 4.0 are shown in Fig 1.

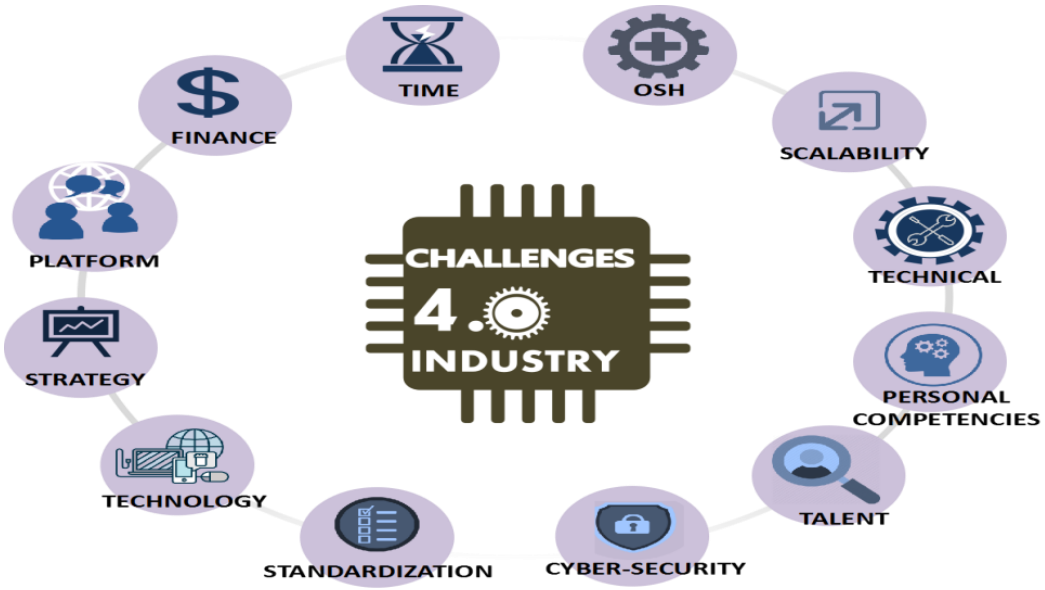

Fig. 1 - Summary on challenges of Industry 4.0

Table 3 - A comparison on challenges of Industry 4.0 between Industry4WRD and previous studies

Challenge	Industry4RWD	Previous Studies
Time factor	• Long payback period	• Requires 20 years for a mature Industry 4.0 ecosystems • Requires 10 years for a complete digital foundation • Time is required for Industry 4.0 systems adoption, testing and running which might affect daily production.
Financial	• High cost of adoption • Lack of funding and incentives	• Investment cost higher than company's economic growth • Funding for sustaining Industry 4.0 development(roadmap, consultation, systems, machines, advanced technologies, IT infrastructures, IT personnel, high skilled workers, training, re-engineering and re-evaluation Industry 4.0 platform)
Ambiguous concept of Industry 4.0	• Lack of understanding on Industry 4.0 practice as short of information platform • Low acceptance among manufacturers	• No clear definition of Industry 4.0 • Many concepts being used to address Industry 4.0 e.g Smart Manufacturing, IoT, Factory 4.0.
Strategy	• Short of Industry 4.0 initiative	• Short of strategic guidance and roadmaps
Technology	• Lack of cost and benefit analysis about the Industry 4.0 technologies • Low digital readiness and connectivity, especially SMEs • Lack of Industry 4.0 infrastructures	• Immature technologies at early stage of development • Uncertainty cost and benefit from Industry 4.0 technologies • Immature development on technologies would cause the risks of wrong data collection, wrong data interpretation to not useful information as well as data disclose

Table 3 - (continued)

Technical	None	• Technical challenge in develop an excellent Industry 4.0 system and technologies (e.g data analytic technologies and secure CPS)
Talent	• Lack of understanding about the Industry 4.0 required talents, skills and knowledge • Lack of capable training provider	• Lack of qualified workers to be replaced in digital working environment • Workforce with technology competences to handle advanced technology and system. • Company should emphasize on the interdisciplinary education in the areas of economics, engineering, informatics, and mathematics • Industry 4.0 era need digital workforce
Standardization	• Standards of Industry 4.0 related equipment, technologies and system are fuzzy	• Lack of standard of Industry 4.0 technologies at early stage of development • Standardized communication protocol
Cyber-security	• Company expose to cyber threats after implement IoT	• Develop computational intelligence to identify digital security threats
Scalability	None	• Varies on architectures, design principles, and system models with the complexity become obstacle on multiple level data transferring and networking, data processing and management, and service provisioning
Occupational, Safety and Health (OSH)	None	• The transformation might cause psychosocial risks to the existing workers • Hazards from robot during collaboration • Hazards from the industrial process during collaboration • Hazards from robot control system malfunction during collaboration

6. Conclusion

The government are aware of the global manufacturing industries transforming into Industry 4.0 is a good begin. However, Malaysia not ready to get into the Industry 4.0 in the aspect of people and facilities. There was still plenty of room for both government and manufacturing industries to improve. Malaysia willing to embrace Industry 4.0 at an average level, the effort to assist SMEs to understand and start investing in Industry 4.0 is significance. The government should enforce entire manufacturing industries to embrace Industry 4.0 to let them alert on this revolution since the transformation is inevitable. Manufacturing industries should aware of the global trend to avoid lost competitive opportunity because of the narrow view. Despite the stage of implementation, the company should consider the possible challenges from all aspects during strategies planning to fully realize the potential of Industry 4.0 and reduce the risk of investment losses.

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