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# Industry 4.0 Readiness for Manufacturing SMEs in Malaysia: A Case Study on the Industry4WRD Readiness Assessment (RA)

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## Abstract

The Industry4WRD readiness assessment (RA) model is a valuable tool for manufacturing companies to identify gaps and develop improvement plans for implementing Industry 4.0 concepts. It aligns with global implementation initiatives and has the potential to become a practical guideline and standard for Industry 4.0 implementation worldwide. With the competitiveness of manufacturing SMEs playing a crucial role in Malaysia's economy, it is imperative for these SMEs to embrace Industry 4.0 and enhance their global competitiveness. The Industry4WRD RA program, organized by the Ministry of International Trade and Industry (MITI), offers SMEs the opportunity to participate and align with Industry 4.0 through a structured assessment process. This paper presents the methodology and processes of applying the Industry4WRD RA model, including the results from a case study conducted on two manufacturing SMEs. The quantitative and qualitative findings explore the relationship between various shift factors, thrusts, and dimensions, defining the SMEs' Industry 4.0 readiness profiles. These results help SMEs identify their current baseline, pinpoint gaps, and develop improvement plans for full-scale implementation of Industry 4.0. The research serves as a reference for future work and enhancements in this field.

***Keywords:*** Industry 4.0; Industry4WRD; SMEs; SIRI; Readiness Assessment

## Introduction

### *Industry 4.0 technology enablers*

The significance of the Industry 4.0 transformation and the imperative to position countries within the global market has garnered increasing attention on a global scale. This has prompted various governments worldwide to announce initiatives aimed at facilitating its implementation. Originating as an initiative from Germany, Industry 4.0 has served as a catalyst, inspiring other nations to embark on comparable conceptualizations and approaches in alignment with this prevailing global mega-trend [1, 2]. The inception of Industry 4.0 concepts and terminology took place in Germany in 2011. This development was rooted in the evolutionary trajectory of technology, with a primary focus on envisioning the future of Industry 4.0. At its core, Industry 4.0 entails the seamless integration of Cyber-Physical Systems (CPS) into production and logistics systems. It also encompasses the introduction of a network of instruments and services into production processes, which, in turn, engenders novel avenues for value creation, business models, organizational structures, as well as decision and communication mechanisms [3]. A core focus of the Industry 4.0 transformation agenda is the extensive and pervasive implementation of a digital transformation framework within the manufacturing industry, encompassing Small and Medium Enterprises (SMEs) as well. This digital transformation has exerted substantial influence on various aspects such as business models, production processes, and corporate governance. Over the past decade, advancements in information and communication technologies (ICT) infrastructure and analytical capabilities have fueled a continuous stream of innovation across all levels of business models and corporate organization. The capacity of companies to effectively navigate and leverage these transformations has emerged as a critical element for achieving competitive advantage across nearly all economic sectors [4]. Industry 4.0 denotes an emerging paradigm in the manufacturing sector that embodies advanced principles of smart manufacturing and production. It is distinguished by the pervasive digitalization of processes and the establishment of real-time connectivity throughout the industrial value chain. This transformative approach leverages cutting-edge technologies, such as the Internet of Things (IoT), artificial intelligence (AI), robotics, and cloud computing, to optimize operational efficiency, enhance productivity, and enable dynamic decision-making within the manufacturing ecosystem. By seamlessly integrating digital technologies with physical assets and systems, Industry 4.0 aims to create a highly interconnected and intelligent manufacturing environment capable of driving substantial advancements in productivity, flexibility, and overall competitiveness [5]. Furthermore, the principles inherent in Industry 4.0 will facilitate the transition towards smart factories, incorporating additional design principles such as product individualization or mass customization, modularization, horizontal and end-to-end integration, autonomous operation, and service-oriented approaches [6]. The implementation of Industry 4.0 technologies, such as CPS, in the manufacturing sector offers the potential to enhance automation levels, thereby improving operational performance and efficiency for adopting manufacturers. This adoption of new concepts brings additional value, including increased revenue, improved efficiency, cost-saving, reduced debt, and increased investment [7, 8]. The CPS in Industry 4.0 facilitates improved logistic lead times through enhanced connectivity and traceability. This enables real-time monitoring of the supply chain, establishing seamless end-to-end connections with manufacturers [9]. The future of manufacturing, as envisioned by Industry 4.0 concepts, entails the decentralization and digitalization of manufacturing supply networks. These networks possess the ability to operate autonomously, effectively managing manufacturing operations by responding to real-time environmental changes and strategic business objectives [8]. The ultimate result of the transformation driven by smart factory concepts will be the integration of a broader value network that is capable of meeting specific customization requirements based on demand patterns [10, 11]. The integration and real-time connectivity of assets, including machines, equipment, and materials, contribute to the optimization and significant reduction of costs associated with mass production. These new value-added concepts enhance the efficiency and effectiveness of manufacturing processes, leading to cost savings [12]. The extent of a company's adoption of Industry 4.0 concepts is influenced by its readiness to embrace digitalization in all aspects of its activities, as mentioned earlier. One crucial factor that determines early implementation is the size of the company. Larger companies, which produce in large volumes and focus on continuous optimization through automated production, may have different approaches compared to small and medium-sized enterprises (SMEs). SMEs, in contrast, may rely on fewer or non-automated steps in their production processes [2]. German entrepreneurs predominantly view Industry 4.0 as an opportunity; however, they also anticipate that failing to overcome key challenges may lead to a decline in competitiveness. From a global perspective, the most significant challenges associated with implementing Industry 4.0 include the lack of a digital culture and adequate training, insufficient clarity or support from the management team regarding the vision, and uncertainties regarding the economic benefits derived from investments in digital transformation [8, 13]. Despite the significant potential benefits offered by Industry 4.0, which include the adoption of CPS, real-time digital connectivity, and advanced technologies such as the Internet of Things (IoT), cloud computing, big data analytics, artificial intelligence (AI), and system integration, small and medium-sized enterprise (SME) manufacturers worldwide continue to exhibit a degree of caution towards its implementation. In some instances, these manufacturers may even display resistance or reluctance towards embracing Industry 4.0 concepts [14]. Many small and medium-sized enterprises (SMEs) recognize the need to identify future growth opportunities, but they often struggle to understand how to effectively seize the challenges presented by Industry 4.0. Additionally, they may find it difficult to envision how the Industry 4.0 model aligns with their existing business models. This uncertainty and lack of clarity can hinder their ability to fully embrace and leverage the potential benefits of Industry 4.0 [15, 16]. On top of the digital culture adoption, another critical challenge is on the investment-related issues for the technology pillars [17] such as IoT, cloud computing, big data analytics, cybersecurity, autonomous robot, and additive manufacturing among the SMEs as it is required for implementing Industry 4.0 and requires a massive amount of capital investment [11]. To successfully navigate the Industry 4.0 transformation, small and medium-sized enterprises (SMEs) should adopt a holistic approach that encompasses all aspects of the transformation process. The initial emphasis should be placed on ensuring organizational and personnel readiness, as this can be achieved without significant financial investment. Strategies to enhance readiness may include raising awareness about Industry 4.0, conducting thorough pain point studies to identify specific areas for improvement, and providing training programs for staff members in automation and industrial information technology related to Industry 4.0 and Cyber-Physical Systems. By focusing on these foundational elements, SMEs can lay the groundwork for a successful and smooth transition to Industry 4.0 [13, 18]. It is crucial to acknowledge and address the significant challenge posed by the lack of a clear strategy in value creation and the absence of leadership support when implementing Industry 4.0. These challenges can have far-reaching implications and contribute to other obstacles faced during the transformation process. Without a clear strategy, organizations may struggle to define their goals, align their efforts, and effectively allocate resources. Additionally, the absence of leadership support can hinder decision-making, hinder employee buy-in, and impede the necessary changes in organizational culture and practices. Therefore, it is imperative to tackle these challenges head-on, by developing a comprehensive strategy that outlines the value-creation objectives and obtaining strong leadership commitment and support. By doing so, organizations can mitigate potential hurdles and create an environment conducive to successful Industry 4.0 implementation [19].

### *Industry 4.0 adoption among the manufacturing SMEs in Malaysia*

In Malaysia, SMEs play a vital role in the country's economy, making significant contributions to the overall gross domestic product (GDP) and employment. In 2018, they accounted for 36.3 percent of the GDP and employed nearly 70 percent of the total labor workforce. With SMEs comprising 98.5 percent of business establishments in Malaysia, their adoption of advanced technologies becomes crucial for driving overall technological progress. However, the current state of technology adoption among SMEs in Malaysia is not satisfactory. Reports from the Malaysia Productivity Corporation (MPC) indicate that only 10 percent of SMEs have embraced information and communication technology (ICT) solutions. Furthermore, the Ministry of International Trade and Industry (MITI) has conducted the Readiness Assessment (RA) program, which is fully funded to assist SMEs in their digital transformation journey. Surprisingly, out of the 50,000 manufacturing SMEs in Malaysia, only 300 companies have registered for this program. These statistics highlight the existing challenges and the considerable gap in technology adoption among SMEs in Malaysia. Efforts should be made to address the barriers that hinder the adoption of advanced technologies in the SME sector. By promoting awareness, providing support, and offering tailored programs, the government, industry associations, and other relevant stakeholders can encourage greater participation and help SMEs seize the opportunities presented by digital transformation [20]. On 31 October 2018, the Prime Minister of Malaysia, had launched the National Policy on Industry 4.0 known as Industry4WRD [21]. Industry4WRD in Malaysia is a strategic response to the growing need for digital transformation in the manufacturing sector and its related services. It aims to facilitate the adoption of Industry 4.0 principles by companies in a structured and comprehensive manner, employing the Readiness Assessment (RA) standard model. This initiative primarily emphasizes three key shift factors: people, process, and technology, recognizing their pivotal role in driving successful Industry 4.0 implementation [22]. The Industry4WRD RA program offers a comprehensive framework for evaluating the capabilities and preparedness of companies in adopting Industry 4.0 technologies and processes. By utilizing a predefined set of indicators, the RA enables firms to assess their current strengths and identify areas requiring improvement. The systematic approach of the RA standard allows for a thorough analysis of SMEs in Malaysia, helping to identify gaps across various dimensions outlined by the program. These identified gaps then serve as key variables for targeted improvements during the Industry4WRD transformation [23].

### *Industry4WRD Readiness Assessment (RA) Versus Singapore Smart Industry Readiness (SIRI)*

To facilitate the manufacturing companies to have a comprehensive understanding of Industry 4.0 implementation, several readiness assessment and maturity models have been developed to assist companies to identify where are the gaps between the current situation and the standard and one of the frequently cited is the German RAMI 4.0 (Reference Architectural Model Industry 4.0) model for Industry 4.0 [24] and also "IMPULS - Industrie 4.0 Readiness" [25] both published in 2015.

The Industry4WRD RA model was introduced in 2018, while the Singapore Smart Industry Readiness (SIRI) model was officially launched in 2017 in Singapore. Although there are similarities between the two models, they also exhibit significant differences in terms of the key pillars, terminology, and dimensions or variables they focus on. The RA and maturity models serve as frameworks for conceptualizing and evaluating organizations in a qualitative or quantitative manner, allowing for a systematic and continuous assessment of their readiness and progress in adopting Industry 4.0 principles [25]. Since the most recent model been introduced are SIRI [26] and Industry4WRD RA [27], Table 1 below shows the comparison between the key similarities and key differences between both models.

| ***Items description*** | ***Industry4WRD Readiness Assessment (RA) Model*** | ***Smart Industry Readiness Index (SIRI)*** |
|---|---|---|
| Year released | 2018 | 2017 |
| Total layers | 3 | 3 |
| Layer 1 description (Highest level) | Shift factor / 3 Factors | Building block / 3 Building blocks |
| Layer 2 description (Middle level) | Thrust / 8 Thrusts | Pillars / 8 Pillars |
| Layer 3 description (Lowest level) | Dimension / 21 Dimensions | Dimension / 16 Dimensions |
| Layer 1 variables | People, Process, Technology | Organization, Process, Technology |
| Layer 2 variables | • Transformation Initiative,<br>• Human capital development<br>• Supply chain management<br>• Product management<br>• Operation management<br>• Asset automation (vertical integration)<br>• Asset connectivity<br>• Asset intelligence | • Structure and management<br>• Talent readiness<br>• Supply chain<br>• Product lifecycle<br>• Operations<br>• Automation<br>• Connectivity<br>• Intelligence |
| Layer 3 variables | • Industry 4.0 strategy<br>• Collaboration structure and governance<br>• Leadership<br>• Top management technology savviness<br>• Personnel Industry 4.0 competency<br>• Cybersecurity<br>• Horizontal integration<br>• Product individualization<br>• Product lifecycle management<br>• Performance management<br>• Technology management<br>• Product management<br>• Shop Floor Automation<br>• Facilities Automation<br>• Enterprise Automation<br>• Shop Floor Connectivity<br>• Facilities Connectivity<br>• Enterprise Connectivity<br>• Shop Floor Intelligence<br>• Facilities Intelligence<br>• Enterprise Intelligence | • Strategy and governance<br>• Inter and Intracompany collaboration<br>• Leadership competency<br>• Workforce learning and development<br>• Horizontal integration<br>• Vertical integration<br>• Integrated product lifecycle<br>• Shopfloor Automation<br>• Facility Automation<br>• Enterprise Automation<br>• Shopfloor Connectivity<br>• Facility Connectivity<br>• Enterprise Connectivity<br>• Shopfloor Intelligence<br>• Facility Intelligence<br>• Enterprise Intelligence |

***Table 1:*** Comparison between Industry4WRD RA (Malaysia) and SIRI (Singapore).

It is recognized that the Industry4WRD Readiness Assessment (RA) encompasses a broader range of dimensions compared to SIRI. However, it is important to highlight that the development of both the SIRI and Industry4WRD RA models is based on comprehensive information regarding dimensions, items, datasets, and methodologies. These models are rooted in sound scientific principles, and their structure and results are effectively communicated in a well-organized manner. The Industry4WRD RA, as presented in this paper, serves as a valuable reference for expanding existing models and tools, particularly due to its emphasis on manufacturing-specific organizational aspects.

### *The development of the Industry4WRD RA for manufacturing SMEs*

The concept of Industry 4.0 in Malaysia has been primarily influenced by foreign high-tech companies and large multinational manufacturing companies that have already embraced these concepts. Since the launched of Industry4WRD policy in 2018 [21], the SMEs still very slow in embracing the Industry 4.0 concepts, although these they are most likely to be the big recipient in term of special incentives introduced through the policy. SMEs are often able to deploy the digital transformation more rapidly because they can develop and implement a new IT structure from scratch more effectively [28]. The manufacturing industry in Malaysia has faced concerns in recent years as it has transitioned from being an investment destination for low-cost labor manufacturing to being challenged by emerging countries offering lower-cost alternatives [21]. Hence, the implementation of Industry4WRD will provide support to SMEs in Malaysia in adopting Industry 4.0 through a systematic and comprehensive approach using the RA model. This approach emphasizes the three key shift factors of people, process, and technology, while incorporating technology support through the eleven core enabling technology pillars. The program aims to achieve specific end goals, including improving labor productivity, enhancing the manufacturing sector's contribution to the economy, strengthening innovation capacity, and creating more opportunities for high-skilled jobs compared to the existing baseline [22, 29]. In Malaysia, small and medium enterprises (SMEs) play a significant role in the country's overall business landscape, accounting for 98.5 percent of all business establishments. The manufacturing sector, comprising 49,101 establishments, stands as the second largest contributor among SMEs, with the service sector taking the top position. The substantial presence of SMEs in the manufacturing sector highlights their potential to contribute to Malaysia's future economic development [21]. In the manufacturing sector, small and medium enterprises (SMEs) are classified as establishments with an annual sales turnover that does not exceed RM50 million or a full-time employee count that does not exceed 200 [30]. To be eligible for the fully funded Readiness Assessment (RA) program, in addition to the SME status, manufacturing companies in Malaysia must meet two additional criteria. Firstly, the company must have been in operation for a minimum of three (3) years, indicating a certain level of stability and experience in the industry. Secondly, the company must hold a Manufacturing License (ML), which serves as an official authorization for engaging in manufacturing activities. These criteria ensure that the RA program is targeted towards established manufacturing companies that have the necessary experience and legal permissions to participate in the program [27]. The Industry4WRD RA was developed through extensive consultations with various stakeholders, including ministries, agencies, academia, and subject matter experts. It underwent a verification process with international organizations to adopt best practices. The guideline and scoring criteria were tested on pilot companies from different sectors and sizes to assess their validity and effectiveness. The development process aimed to ensure a comprehensive and reliable assessment of readiness for Industry 4.0 adoption [27]. The mock-up process closely resembles the actual Readiness Assessment (RA) in terms of assessment criteria, methodology, and data computation. It serves as a representative example of the overall implementation of the Industry4WRD RA nationwide, as depicted in Figure 1 [31].

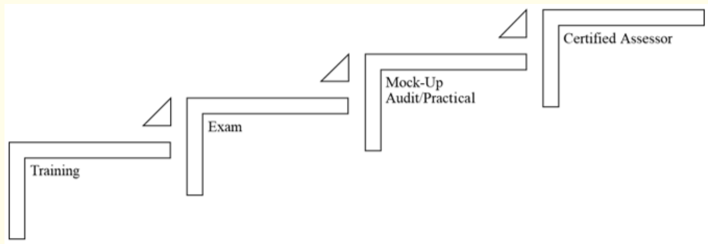


***Figure 1:*** Malaysia's Industry4WRD Policy readiness assessment (RA) Development Methodology.

This paper presents the methodology of the Industry4WRD RA model for assessing manufacturing SMEs in Malaysia regarding their adoption of Industry 4.0. The model aims to systematically identify the current baseline, gaps, and profiling of Industry 4.0 adoption. It serves both scientific and practical purposes. Scientifically, it provides reliable data on the adoption of Industry 4.0 by manufacturing SMEs, considering the three key shift factors of People, Process, and Technology, along with eight thrust areas and twenty-one dimensions. Practically, the model helps RA assessors and company personnel assess the status of Industry 4.0 adoption and evaluate the effectiveness of transformation strategies. A voluntary SMEs company participated in the mock-up exercise, as depicted in Figure 1. The second part of this paper focuses on presenting the results of the Industry4WRD RA case study for two SMEs, namely A and B. These SMEs voluntarily participated in the mock-up exercise of the RA assessor qualification program. The case study examines the outcomes of the Industry4WRD RA assessment conducted on these SMEs, providing insights into their readiness and adoption of Industry 4.0 practices [32] organized by MITI and Penang Skills Development Centre (PSDC) in 2019. This paper will provide a quantitative data comparison of the Industry4WRD RA results for two manufacturing companies, focusing on all factors and dimensions that are critical to the study. The RA model serves both scientific and practical purposes and is presented through key findings in the area of Industry 4.0 strategy, which falls under the people dimension. The quantitative data aims to establish the current baseline of Industry 4.0 implementation for the two manufacturing SMEs, considering the three key shift factors, thrusts, and dimensions outlined in the Industry4WRD RA model. The case study is intended to guide future researchers in identifying areas for improvement based on critical findings from the RA. Root cause analysis (RCA) can be conducted for each dimension that requires improvement out of the twenty-one dimensions assessed. Problem-solving tools, such as fishbone analysis, can be utilized to identify causes and effects, thereby transforming problems into measurable program goals and objectives. This approach will help elevate the standards of each assessed dimension, emphasizing a more comprehensive approach [33]. The case study presented in this paper not only contributes to the understanding of the Industry4WRD RA model but also serves as an educational resource for practitioners, including academia, industry players, and government agencies. It will further support the overall success of the Industry 4.0 transformation agenda in Malaysia. This Industry4WRD RA case study in manufacturing SMEs is a valuable guide for expanding existing studies and enriching the database on the subject of Industry 4.0.

## Research Methodology

### *Industry4WRD methodology- Part I*

This section of the paper focuses on three key shift factors, eight thrusts, and twenty-one dimensions, as depicted in Figure 2. Using a specific SME company that participated in the mock-up RA, examples are provided to demonstrate the proposed RA methodology and processes. The RA model is structured into three interconnected layers represented by rings. The inner ring consists of the three key shift factors: People, Process, and Technology. The middle ring represents the division of each shift factor into thrusts, and the outer ring represents the division of each thrust into dimensions.

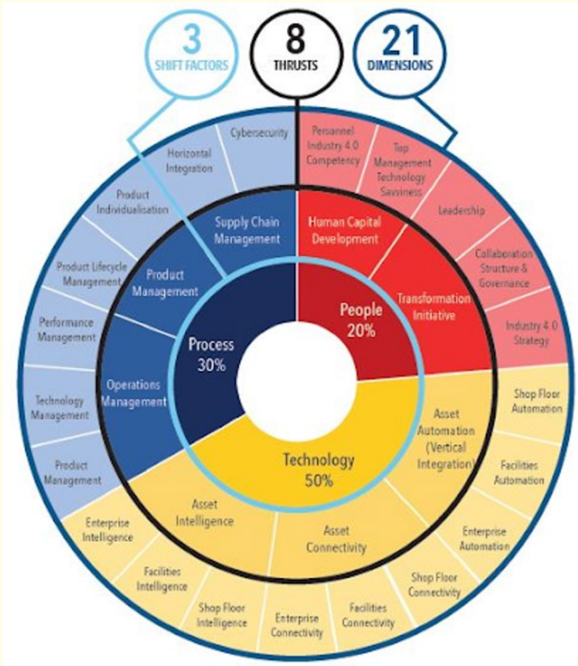


***Figure 2:*** Malaysia's Industry4WRD Policy RA introduced model by MITI.

The People shift factor focuses on the strategies related to leadership roles and employee competency. It encompasses two thrusts: human capital development and sustainable transformation initiatives. Five dimensions are outlined under these thrusts, including personnel Industry 4.0 competency, top management technology savviness, leadership, collaboration structure, and governance. The Process shift factor pertains to the management systems involved in operations, supply chain, and product life cycle. It emphasizes smart solutions related to Industry 4.0 core technology pillars, strategic public-private partnerships, security, sustainability, and product co-creation. Seven dimensions are outlined under this shift factor, including production management, technology management, performance management, product lifecycle management, product individualization, horizontal integration, and cybersecurity.

The Technology shift factor focuses on the application of technology advancements in automation, connectivity, and intelligence. It is measured in three areas: shop floor, facilities, and enterprise. Nine dimensions are outlined under this shift factor, including shop-floor automation, facilities automation, enterprise automation, shop-floor connectivity, facilities connectivity, enterprise connectivity, shop-floor intelligence, facilities intelligence, and enterprise intelligence. The RA enables organizations to measure their readiness for Industry 4.0 adoption and formulate relevant strategies. It can be conducted through self-assessment or by a third party. The RA activities include interviews with top management and employees, observation of shop-floor activities, documentation review, and evidence-based tasks. It is crucial for the organization to be open, participative, cooperative, and approachable to ensure a comprehensive and reliable RA result. The RA uses a rubric band scoring guideline to assess each dimension. Table 2 provides an example of the scoring criteria for the entire RA, comprising a total of twenty-one scoring criteria. Each dimension is categorized according to its respective thrust and shift factor. There are five assessment bands with scores ranging from zero (lowest) to five (highest).

| Band | | Description |
|---|---|---|
| 0 | Unfamiliar | Management is unfamiliar with the concept of the Fourth Industrial Revolution and/or Industry 4.0 product requirements and/or technology trends. (Traditional leaders) |
| 1 | Reactive | Management is aware of the changes brought by the Fourth Industrial Revolution and/or Industry 4.0 but adopts a wait and see the approach of peers before responding or depend on external parties before developing initiatives. |
| 2 | Beginner | Management has a strategic perspective and critical analysis of opportunities and threats posed by the Fourth Industrial Revolution and/or Industry 4.0. Have plans to be early adopters. (Fast follower) |
| 3 | Strategist | Management understands the application of the latest technology and trends. Management has a sustainable plan for early adoption, which is efficiently organized and resources coordinated to ensure a successful implementation. (Pacesetter) |
| 4 | Forward-looking | Management can independently adapt and apply its organizational transformation framework based on changing needs and technology trends, with a clear vision for Industry 4.0. A sustainable implementation plan is continuously reviewed and monitored. Management is actively engaged with each personnel group. |

***Table 2:*** RA rubric scoring bands and description (Dimension-Leadership).

The RA results will be summarized in a concise manner that reflects the organization's level of readiness for Industry 4.0 implementation and identifies areas for improvement. A radar or spider-web chart will be utilized to visually represent the results of the assessment for all twenty-one dimensions or variables. The same chart will be used again in the next phase of the RA to plot the dimensions or variables once improvements have been made to close the gaps. During the assessment results deliberation, emphasis will be placed on dimensions that require attention, providing justifications and remarks on the current state of the assessed organization. The RA report will also outline opportunities for improvement in each dimension, highlighting the benefits that can be realized through closing the gaps and fully embracing Industry 4.0 concepts. Furthermore, the RA report will include proposed action plans that outline steps to be taken to address the identified gaps. These action plans will underscore the benefits that can be achieved by implementing the proposed improvements and fully integrating Industry 4.0 principles into the organization's operations.

| Shift factor | Thrusts |
|---|---|
| Technology (50 %) | Asset automation (vertical integration) |
| | Asset connectivity |
| | Asset intelligence |
| Process (30 %) | Operations management |
| | Supply chain management |
| | Product chain management |
| People (20 %) | Human capital initiative |
| | Transformation development |

***Table 3:*** Industry 4.0 RA Thrust Criteria Weightage.

The Industry 4.0 RA model assigns weightage to the thrust criteria of each shift factor based on the level of implementation complexity, as indicated in Table 3. The final score of the RA is calculated using formulas ranging from number one (1) to five (5). Based on this final score, the overall results are summarized and interpreted according to Table 4.

$$Point\ scored\ for\ shift\ factor, C = \frac{Total\ point\ scored\ for\ all\ dimensions}{Number\ of\ dimensions\ for\ shift\ factor} \quad (1)$$

$$Technology, x_{technology} = \frac{C}{4} x\ 50\ \% \quad (2)$$

$$Process, x_{process} = \frac{C}{4} x\ 30\ \% \quad (3)$$

$$People, x_{people} = \frac{C}{4} x\ 20\ \% \quad (4)$$

$$\text{Overall RA Score (Results)} = (x_{tech} + x_{process} + x_{people})\ \% \quad (5)$$

| ***Readiness profile*** | ***Percentage scored*** | ***General descriptions*** |
|---|---|---|
| Conventional | 0 % to 20 % | The operation remains “as is” with no intention or initiative to embark on Industry 4.0 initiative. |
| Newcomer | 21 % to 40% | Have interest in pursuing Industry 4.0 but with none or very minimal efforts. |
| Learner | 41 % to 60 % | Have the interest to pursue a pilot project for Industry 4.0 in operation. Planning and strategies, efforts, either simple or scattered initiatives exist. Ready for minor system adoption. |
| Experienced | 61 % to 90 % | Have undertaken small to medium scale Industry 4.0 initiatives in operation as well as horizontal integration. Ready for major system adoption. |
| Leader | 91 % to 100 % | Have implemented large scale Industry 4.0 initiatives (company-wide) and system integration. |

***Table 4:*** The overall RA profile and scoring for the company.

### *Industry4WRD case study methodology - Part II*

The readiness assessment (RA) case study in this paper follows the rubric scoring guideline for all twenty-one dimensions based on the Industry4WRD RA model and methodology (Figure 2). The case study process, depicted in Figure 3, includes on-site RA at the two SMEs, comprehensive coverage of all dimensions with quantitative scoring, documentation of critical findings for each dimension, analysis of the final Industry 4.0 profiling summary score, and sharing of results with the SMEs. Once the SMEs agree, the case study is reported in this paper and considered closed. The entire process took approximately two weeks for each SME, with the most time-consuming task being the rubric scoring process for all twenty-one dimensions, including detailed findings to justify the scores. Data analysis, discussion of results, and conclusions were also part of the process. The report was approved by both SMEs upon the first submission without any modifications to the findings and scoring. The RA was conducted by a certified assessor who completed the Industry4WRD certification program at PSDC and received training from the master trainer, Mr. Ts. Azhar Bin Md Nayan, the Technical Advisor at PSDC.

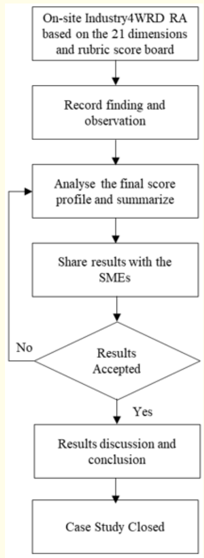


***Figure 3:*** Malaysia's Industry4WRD Policy RA - Case Study Flow.

Table 5 presents the two SMEs that voluntarily participated in this case study. They are referred to as SME A and SME B throughout the results discussion and conclusion in this paper. Both companies meet the definition of SMEs in terms of annual revenue or sales turnover not exceeding RM50 million and total employees not exceeding 200. The table compares the company name, location, annual revenue or sales, total employees, and the date of the mock-up conducted. SME A focuses on packaging materials and technology, while SME B specializes in precision tooling and metal engineering. They are selected to represent different products within the manufacturing sector since the same RA criteria and methodology are applied to all SMEs in Malaysia. Notably, SME B demonstrates almost double the annual revenue and total employees compared to SME A, highlighting a key differentiator in terms of company size within the SME category. Both SMEs are considered medium-sized SMEs according to the definition provided by SME Corp [30].

| ***Description*** | ***SME A*** | ***SME B*** |
|---|---|---|
| Factory Location | Bukit Minyak Penang | Perai Penang |
| Annual Revenue (RM) | RM23 million (FY2018) | RM47 million (2018) |
| Total Employees (headcount) | 91 person | 190 person |
| Industry4WRD RA mock-up date | 26 November 2019 | 25 October 2019 |

***Table 5:*** SMEs - Company profile comparison.

During the RA process, quantitative data is collected based on the scores assigned to each assessed dimension using the rubric scoreboard. Table 6 provides an example of the rubric scoring for the Industry 4.0 strategy dimension, which is part of the People shift factor. The overall assessment includes twenty-one dimensions that align with the Industry4WRD readiness assessment (RA) model introduced by MITI. The RA criteria model is structured with three interconnected layers of rings, representing the shift factors, thrusts, and dimensions of Industry 4.0 adoption [27].

| Band | | Description |
|---|---|---|
| 0 | None | Enterprise has no strategies for Industry 4.0. The organization has no current or future intention of upgrading to a smart factory. |
| 1 | Formalized | Enterprise has strategies but not up to Industry 4.0. The organization has plans to establish a smart factory as a strategic focus. |
| 2 | Early adopter | Enterprise has a transformative strategy for Industry 4.0. A sustainable plan for a smart factory is being developed or has been developed using a forward-thinking approach. The plan is implemented at least in one functional area. |
| 3 | Strategist | Enterprise has a transformative strategy for Industry 4.0. A sustainable plan with sufficiently allocated resources for a smart factory has been implemented. Business activities have achieved sustainable growth and profitability through the implementation plan. |
| 4 | Forward-looking | The implemented transformative strategies and sustainable plan for a smart factory are constantly reviewed and improved to account for the latest technology, business model, and practices advancements. |

***Table 6:*** Industry 4.0 strategy dimension - Rubric Scoring Band and Description.

The overall Industry4WRD RA results will be presented in several main sections within the final report. These sections include an overview of the company profiles, key performance indicators (KPIs) of the companies, RA results for the People shift factor, RA results for the Process shift factor, RA results for the Technology shift factor, key summaries of the overall results, the company's readiness profile, an improvement plan, and a proposal for a proof-of-concept (POC). The final RA report will provide an assessment of the organization's current level of Industry 4.0 implementation and identify areas for improvement. In this particular paper, a radar chart is used to visually represent the results of the RA for all twenty-one dimensions, allowing for a comparison between SMEs A and SMEs B in terms of their current baseline performance. The final score of the RA is calculated by assigning weighted percentages to each factor and using the computation formula ranging from one to five, as mentioned earlier. The overall results and final score will determine the Industry 4.0 readiness profile for both SMEs A and SMEs B, which will be evaluated according to the criteria presented in Table 7 [31].

$$Point\ scored\ for\ shift\ factor, C = \frac{Total\ point\ scored\ for\ all\ dimensions}{Number\ of\ dimensions\ for\ shift\ factor} \quad (1)$$

$$Technology, x_{technology} = \frac{C}{4} x\ 50\ \% \quad (2)$$

$$Process, x_{process} = \frac{C}{4} x\ 30\ \% \quad (3)$$

$$People, x_{people} = \frac{C}{4} x\ 20\ \% \quad (4)$$

$$\text{Overall RA Score (Results)} = (x_{tech} + x_{process} + x_{people})\ \% \quad (5)$$

## Results and Discussions

### *Results from the Industry4WRD methodology - Part I*

The results of the RA scoring bands for each of the twenty-one dimensions, representing the three key shift factors of people, process, and technology, were obtained from the mock-up run conducted at SME A. These scores are presented using a radar (spider-web) chart, as depicted in Figure 4. The second part of the results showcases the overall RA profile of the company, which is determined after calculating the overall score using the formula outlined in Table 8. This formula assigns values ranging from one to five.

| *Readiness profile* | *Percentage scored* | *General descriptions* |
|---|---|---|
| Conventional | 0 % to 20 % | The operation remains "as is" with no intention or initiative to embark on Industry 4.0 initiative. |
| Newcomer | 21 % to 40% | Have the interest to pursue Industry 4.0 but with none or very minimal efforts. |
| Learner | 41 % to 60 % | Have the interest to pursue a pilot project for Industry 4.0 in operation. Planning and strategies, efforts, either simple or scattered initiatives exist. Ready for minor system adoption. |
| Experienced | 61 % to 90 % | Have undertaken small to medium scale Industry 4.0 initiatives in operation as well as horizontal integration. Ready for major system adoption. |
| Leader | 91 % to 100 % | Have implemented large scale Industry 4.0 initiatives (company-wide) and system integration. |

***Table 7:*** The overall RA profile and scoring for the SMEs.

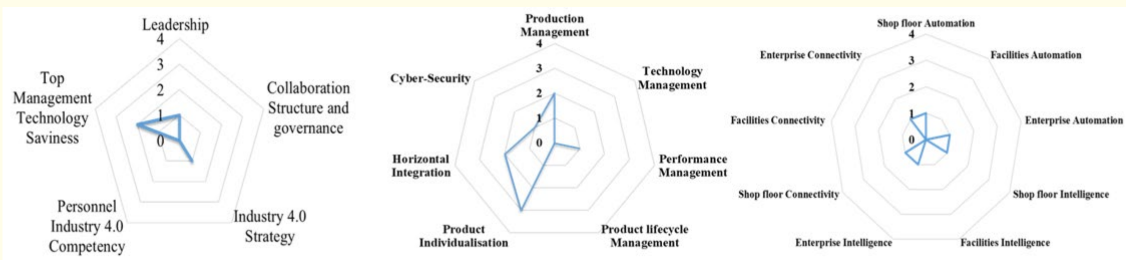


***Figure 4:*** RA results using radar (spider-web) chart for three key shift factor and its dimension.

| *Shift Factor* | *Total Dimension (Variables)* | *Total Point Score* | *C Value* | *Percentage (Formula 1 to 5)* |
|---|---|---|---|---|
| *People, $x_{people}$* | 5 | 4 | 0.80 | 4% |
| *Process, $x_{process}$* | 7 | 9 | 1.29 | 10% |
| *Technology, $x_{technology}$* | 9 | 6 | 0.67 | 8% |
| Overall RA Score (Results) | 21 | | | 22% |

***Table 8:*** Overall RA results and score.

### *Results from the Industry4WRD case-study methodology - Part II*

In this second part of the results, the quantitative and qualitative findings of the case study are presented in Table 9 for the Industry 4.0 strategy dimension. This dimension serves as an example to represent the overall assessment of the twenty-one dimensions conducted during the Industry4WRD RA case study at both SME A and SME B. The table provides a comprehensive overview of the results obtained for this particular dimension, including the quantitative score and corresponding qualitative remarks for each company.

| Dimension | SME A | | SME B | |
|---|---|---|---|---|
| | Quantitative Score | Qualitative Finding | Quantitative Score | Qualitative Finding |
| Industry 4.0 Strategy | Score = 1 of 4 (Formalised)<br><br>Description:<br><br>Enterprise has strategies but not up to Industry 4.0. The organization has plans to establish a smart factory as a strategic focus. | • The company does not have a documented Industry 4.0 Strategy and action plan on Industry 4.0 transformation.<br><br>• The current strategy that the company is exploring is to purchase a machine to machine connectivity devices to enable real-time communication among machines on the shop-floor.<br><br>• The strategies to enhance the current production with automation, connectivity, and intelligence are not yet available as the company is in the midst of identifying an external consultant to assist in the development of Industry 4.0 strategy.<br><br>• It is seen that the current strategy in place is to gain more awareness of Industry 4.0 with the assistant from consultant, VA Partners, and visit to the factory in Shenzhen China. | Score = 1 of 4 (Formalised)<br><br>Description:<br><br>Enterprise has strategies but not up to Industry 4.0. The organization has plans to establish a smart factory as a strategic focus. | • The company aware of the importance of implementing Industry 4.0 in its manufacturing process, but there is no evidence that the strategy had been established toward Industry 4.0.<br><br>• The simple roadmap has been presented during the assessment, but it is not conducive and too general without any specific target and proper activities to support the transformation.<br><br>• The task force needs to be formalized and given an authority to strategize the implementation Industry 4.0. |

***Table 9:*** Quantitative rubric scoreboard and Qualitative finding during RA for SME A and SME B.

In the second part of the results, a detailed analysis of the quantitative results will be presented, focusing on the scoring bands obtained for each of the twenty-one dimensions representing the key shift factors of people, process, and technology. The results obtained from the assessment conducted during the mock-up run at SMEs A and SMEs B will be visualized using a radar chart, as depicted in Figure 5. This chart provides a visual representation of the performance of each company across the different dimensions, allowing for a comprehensive comparison of their readiness levels in relation to Industry 4.0 adoption.

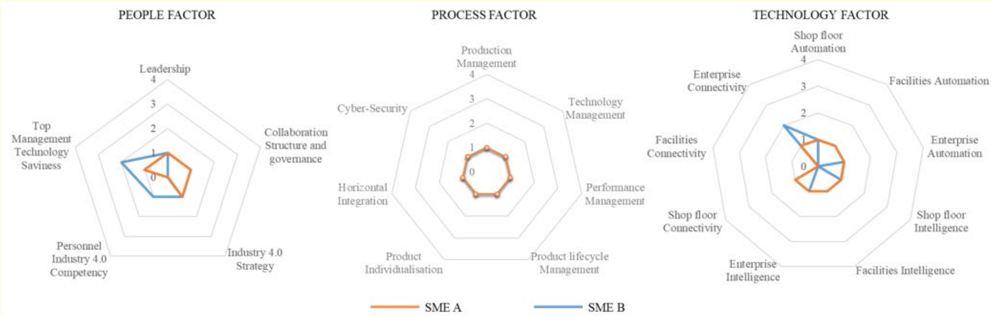


***Figure 5:*** C-Value comparison for three key shift factor and its dimension for SME A & B.

In the third part of the results, a radar chart will be presented to illustrate the C-Value for each of the shift factors (people, process, and technology) for both SMEs A and SMEs B. This radar chart, shown in Figure 6, provides a visual representation of the weighted percentage value assigned to each shift factor, highlighting the relative importance of each factor in the overall Industry4WRD RA. Additionally, the overall Industry 4.0 RA profile for both SMEs A and SMEs B will be tabulated, incorporating the computed scores using the formula one to five mentioned earlier. The tabulated results can be found in Table 6.

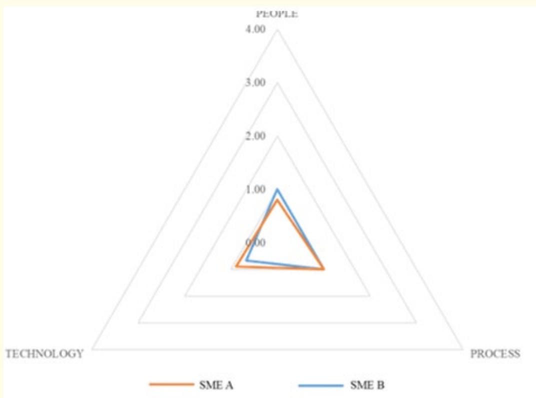


***Figure 6:*** C-Value comparison for three key shift factor and its dimension between SME A & B.

| ***Shift Factor*** | ***Thrust Weightage %*** | ***Total Dimension (Variables)*** | ***Total Point Score*** | | ***C-Value*** | | ***Percentage (Formula 1 to 5)*** | |
|---|---|---|---|---|---|---|---|---|
| *People, $x_{people}$* | 20% | 5 | 4 | 5 | 0.80 | 1.00 | 4% | 5% |
| *Process, $x_{process}$* | 30% | 7 | 7 | 7 | 1.00 | 1.00 | 8% | 8% |
| *Technology, $x_{technology}$* | 50% | 9 | 8 | 6 | 0.89 | 0.67 | 11% | 8% |
| Overall RA Score (Results) | 100% | 21 | | | | | 23% | 21% |
| Industry 4.0 RA Profile | | | | | | | New Comer | New Comer |

***Table 10:*** Comparison for RA results and score between SMEs A and SMEs B.

## Conclusions

### *The Industry4WRD methodology - Part I*

This research study is valuable in improving the implementation of the Industry 4.0 readiness assessment model. Its objective is to present the methodology for conducting the assessment and analyzing the results. The findings indicate that the readiness assessment methodology effectively enables companies to evaluate their preparedness for Industry 4.0 transformation. This is achieved through the assessment of twenty-one dimensions using scoring bands and the determination of an overall readiness profile based on five categories. The results highlight the following key points:

- The highest C-Value obtained in the assessment is four (4), indicating a relatively high level of implementation in certain areas. However, all three factors (people, process, and technology) have C-Values lower than the average of two (2), suggesting that there are gaps in the implementation of Industry 4.0 concepts. These results highlight the need for further improvements and efforts to bridge the gaps in various aspects of Industry 4.0 adoption.
- The Industry 4.0 readiness assessment (RA) methodology reveals that the company's weakest factor is its people, as indicated by a final score of 4 percent. Within the people factor, the lowest scores are observed in personnel Industry 4.0 competency, collaboration structure, and governance, with both dimensions scoring zero points. These findings highlight the need for significant improvements in developing personnel competency related to Industry 4.0 and establishing effective collaboration structures and governance practices within the organization.

Both companies have achieved the "Newcomer" readiness profile, with an overall final score of 23 percent for SME A and 21 percent for SME B. This indicates that both companies have shown an interest in pursuing Industry 4.0 implementation but have not put significant efforts into adopting the necessary practices and technologies. The "Newcomer" profile suggests that the companies are in the early stages of their Industry 4.0 journey and need to invest more in developing capabilities and strategies to fully embrace Industry 4.0 concepts and benefits.

### *The Industry4WRD case-study methodology - Part II*

The Industry4WRD Readiness Assessment (RA) program and policy aim to guide organizations in assessing their readiness for Industry 4.0 implementation and developing strategic projects to enhance efficiency, market responsiveness, and customer focus. This paper and case study provide valuable insights into Industry 4.0 readiness among manufacturing SMEs in Malaysia and beyond. The systematic assessment framework and methodology presented offer a comprehensive overview of the assessment process and comparison between two SMEs, A and B. The results enable companies to understand their current readiness baseline and provide valuable inputs to government agencies, academia, system integrators, and solution providers. Root cause analysis can be conducted for dimensions scoring below the average of two, identifying areas for improvement. By implementing targeted improvement plans, companies can increase their scores and ultimately achieve an Industry 4.0 RA profile of 91 percent or higher, becoming market leaders in Industry 4.0 implementation.

The results also show that:

- Both companies SMEs A and SMEs B have scored the same at band one (1) for the Industry 4.0 strategy dimension because the strategy does not relate to the Industry 4.0 plan.
- Both SMEs A and SMEs B, despite having differences in terms of annual revenue/sales and number of employees, scored within the range of 21-23 percent, categorizing them as 'Newcomers' in terms of their readiness profile. This indicates that both companies are at a similar level of readiness for Industry 4.0 implementation, regardless of their size.
- The C-Value for both SMEs A and SMEs B is below the average score of two (2) for all three shift factors. To improve their overall readiness profile, it is necessary to increase the C-Value beyond the current baseline. This can be achieved by conducting a root cause analysis (RCA) to identify the underlying reasons for the lower scores and implementing corrective actions to improve performance accordingly.

- Based on this case study, it is evident that both SMEs A and SMEs B have an interest in pursuing Industry 4.0. However, it is also observed that their efforts towards implementation are either minimal or non-existent. This finding highlights the need for further research to explore and understand the reasons behind this lack of effort and explore strategies to encourage and support SMEs in their Industry 4.0 adoption journey.

The adoption of Industry 4.0 through the Industry4WRD RA model and policy can greatly benefit Malaysia's manufacturing industry, particularly SMEs. It enhances productivity, develops a skilled workforce, boosts innovation capabilities, improves global competitiveness, and contributes to GDP growth. By embracing advanced technologies and driving innovation, SMEs can remain relevant and competitive in a rapidly evolving business landscape. The implementation of Industry 4.0 practices leads to increased productivity, reduced costs, and optimized operations. It also creates opportunities for upskilling and reskilling, attracting investments, and driving economic growth. Overall, Industry 4.0 adoption plays a crucial role in Malaysia's manufacturing sector's success and its contribution to the country's economy.

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## References

1. A Rojko. "Industry 4.0 Concept: Background and Overview". International Journal of Interactive Mobile Technologies (iJIM) 11.5 (2017): 77-90.
2. W Schroeder. "Germany's Industry 4.0 strategy: Rhine capitalism in the age of digitalisation". Friedrich Ebert Stiftung (2016): 0-16.
3. I Castelo-branco, F Cruz-jesus and T Oliveira. "Computers in Industry Assessing Industry 4.0 readiness in manufacturing: Evidence for the European Union". Comput Ind 107 (2019): 22-32.
4. G Nick and F Pongrácz. "How to Measure Industry 4.0 Readiness of Cities". 140.2 (2016): 136-140.
5. Kagermann W Wahlster and J Helbig. "Recommendations for implementing the strategic initiative INDUSTRIE 4.0". Final report of the Industrie 4.0 WG (2013).
6. M Brettel., et al. "How Virtualization, Decentralization and Network Building Change the Manufacturing Landscape: An Industry 4.0 Perspective". International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering 8.1 (2014): 37-44.
7. M Haseeb., et al. "Industry 4.0: A Solution towards Technology Challenges of Sustainable Business Performance". Soc Sci 8.5 (2019): 154.
8. B Ślusarczyk. "Industry 4.0 - Are We Ready?". Polish Journal of Management Studies 17.1 (2018): 232-248.
9. JM Müller and K-I Voigt. "The Impact of Industry 4.0 on Supply Chains in Engineer-to-Order Industries the Impact of Industry 4.0 on Supply Chains in Engineer-to-Order Industries the on Supply Chains in Industries An Exploratory Study The Impact Impact of of Industry on Supply". IFAC-PapersOnLine 51.11 (2018): 122-127.
10. B Chen., et al. "Smart Factory of Industry 4.0: Key Technologies, Application Case, and Challenges". IEEE Access 6 (2017): 6505-6519.
11. S Vaidya, P Ambad and S Bhosle. "Industry 4.0 - A Glimpse". Procedia Manuf 20 (2018): 233-238.
12. S Erol., et al. "Tangible Industry 4.0: A Scenario-Based Approach to Learning for the Future of Production". Procedia CIRP 54 (2016): 13-18.
13. MC Türkeş., et al. "Drivers and barriers in using industry 4.0: A perspective of SMEs in Romania". Processes 7.3 (2019): 1-20.
14. J Ka and O Id. "SME ' s versus ' Industry 4.0 ': extended case study based on results of initial research in Polish conditions" (2019).
15. J Ganzarain and N Errasti. "Three stage maturity model in SME's towards industry 4.0". Journal of Industrial Engineering and Management 9.5 (2016): 1119-1128.

16. C Leyh., et al. “SIMMI 4.0-a maturity model for classifying the enterprise-wide it and software landscape focusing on Industry 4.0”. Proceedings of the 2016 Federated Conference on Computer Science and Information Systems, FedCSIS 8 (2016): 1297-1302.
17. M Rüßmann. “Future of Productivity and Growth in Manufacturing”. Boston Consulting (2015).
18. C Faller and D Feldmüller. “Industry 4.0 Learning Factory for regional SMEs”. Procedia CIRP 32 (2015): 88-91.
19. J Nagy, J Ol and E Erdei. “The Role and Impact of Industry 4.0 and the Internet of Things on the Business Strategy of the Value Chain — The Case of Hungary”.
20. R Tan. “SMEs still not ready for fourth industrial revolution”. (2019).
21. M. Ministry of International Trade and Industry (MITI), “Industry4WRD: National Policy on Industry 4.0”. (2018).
22. COVERSTO Ry. “Malaysia”. (2019): 6-9.
23. M Hanafiah Ahmad, G Nawanir and M Rashid Ab Hamid. “Multi-Approach Formulation in Dynamic Personality-Situation Interaction for Personnel Selection”. KnE Social Sciences (2019): 872-891.
24. ZVEI. “The Reference Architectural Model Industrie 4.0 (RAMI 4.0)”. Frankfurt: German Electrical and Electronic Manufacturers’ Association (2015).
25. A Schumacher, S Erol and W Sihn. “A maturity model for assessing Industry 4.0 readiness and maturity of manufacturing enterprises”. Procedia CIRP 52 (2016): 161-166.
26. E Singapore. “smart industry readiness index. The priotisation matrix”.
27. M. Ministry of International Trade and Industry (MITI). “Industry4WRD Readiness Assessment”.
28. F Othman. “Jurnal Teknologi”. (2016).
29. P Lavinsaa., et al. “Industry 4.0 Technology Re-Engineering Impacts on Strategy Agility and SME Competitiveness in”. Advances in Economics, Business and Management Research 141 (2020): 52-55.
30. S Corp. “SME Definitions”. (2018).
31. MPC. “Readiness Assessment Industry4WRD”.
32. M. Ministry of International Trade and Industry (MITI), “Guidelines for Selection of Industry4wrd Readiness Assessment (Ra) Assessing Bodies and Assessors”.
33. SS Li and LC Lee. “Using fishbone analysis to improve the quality of proposals for science and technology programs”. Res Eval 20.4 (2011): 275-282.

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