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Research Paper

Evaluation of Human Resources Pillars in Industry Readiness Index to Transform towards Industry 4.0

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Abstract

Developed countries have implemented Industry 4.0 in the process and manufacturing industry sectors. Industry 4.0 transformation will positively impact the industry and the country. Indonesia introduced a guide for the industry in transforming to Industry 4.0 in its action for Making Indonesia 4.0. The Indonesia Industry 4.0 Readiness Index (INDI 4.0) is presented to assist the industry in carrying out transformations, with the pillar of human resources as the highest parameter. It is necessary to conduct an early evaluation of the industry to introduce INDI 4.0. This research aims to evaluate the level of industry readiness in transforming to Industry 4.0. The method in this study used a survey of Small and Medium Industries (SMI=IKM) in Bogor City. Three SMIs were selected for interviews according to INDI 4.0 guidelines and Toolbox Industrie 4.0. The evaluation results using the INDI 4.0 guidelines show that SMI A has a higher level of readiness, followed by SMI C and B. In line with the results of the INDI 4.0 assessment, Toolbox Industrie 4.0 also has the same results. SMI A has a higher level of readiness, followed by SMI C and B. In Toolbox Industrie 4.0, there is no element of assessment for human resources due to cultural differences between Germany and Indonesia, which still require special attention for human resources.

Keywords *human resource readiness, INDI 4.0, toolbox industrie 4.0, small and medium industry*

INTRODUCTION

Industry 4.0 technology has been massively applied and developed in various forums and sectors to support the sustainability of industrial activities (Lahane et al., 2023). Industry 4.0 was introduced at the Hannover Automation Exhibition (Hannover Messe) 2016 under Industrie 4.0 (Meyer, 2019). Industry 4.0 initially did not directly refer to the fourth industrial revolution but rather to strategies for developing new technologies in the manufacturing industry to provide solutions to megatrends, such as mass customization, digitalization, and very short product life cycles (Patil et al., 2023). The descriptions, strategies, and scope of Industry 4.0 began to be explained more specifically, and the concept emerged that Industry 4.0 was an evolution from the previous industrial revolution (Klingenberg et al., 2022). The first industrial revolution started with the invention of the steam engine; then, a second revolution occurred, marked by mass production and electrical energy system. , the third industrial revolution began after the discovery of computers and robotics that were used to support industrial automation technology (Klingenberg et al., 2022). Industry 4.0 begins with the development of Internet technology that is implemented in production systems or often called Cyber-Physical Systems (CPS) or Industrial Internet of Things (IIoT) (Klippert et al., 2020). Industry 4.0 is also expected to increase the competitiveness of SMIs in Indonesia (Lookman et al., 2023). Increasing competitiveness can be done by increasing the efficiency of the production process, improving product quality and developing the potential of

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existing human resources (Ali et al., 2023). Some of these aspects can be pursued by transforming into Industry 4.0 through the Making Indonesia 4.0 program (Hasbullah et al., 2021). The Indonesia Industry 4.0 Readiness Index (INDI 4.0) is a reference specifically designed to assess the industry's readiness level to transform into Industry 4.0 (Musyarofah et al., 2022). In the INDI 4.0, human resources are the pillar with the highest percentage compared to the other four pillars in calculating the value of the level of industry readiness for transformation (Indrawan et al., 2019). It is necessary to carry out an assessment of the industry for the level of readiness in transforming into Industry 4.0. In particular, the condition of the assessment results on the human resources pillar will be compared to the other pillars. This study aims to determine the level of industry readiness in transforming to Industry 4.0 and evaluate the pillars of human resources according to the INDI 4.0 guidelines.

LITERATURE REVIEW

Industry 4.0

Industry 4.0 is very attached to the technology introduced by Germany. The terminology of the Industrial Revolution 4.0 means that a level of revolution has been arranged in the industrial field with four stages of change (Unterberger and Müller, 2021). The stages of change described include the first industrial revolution with steam engine technology (Groumpos, 2021). The second is the existence of mass production, which is characterized by the use of conveyors identical to the production level with a relatively large capacity (Fakhimi et al., 2022). The development of computer technology is very helpful for humans in carrying out activities. This development initiated the third industrial revolution (Bigliardi et al., 2020). Computer technology has contributed greatly to the development of mechatronics, so robotic technology is present, which has been implemented so far (Dairath et al., 2023). The fourth industrial revolution begins when the technologies created in the third industrial revolution can be connected and interact (Castelo-Branco et al., 2022). Humans, as regulators of the course of activity in the industry, make the architecture of the industrial Pattern 4.0 has a structure of vertical and horizontal connections (Nakagawa et al., 2021). Cyber-Physical Systems and the Internet of Things play a very important role in supporting machine-to-machine (horizontal) or human and machine (vertical) connections (Antonino et al., 2022). These connections are expected to provide *lean processes*, reduce production costs, and increase disruptive *revenue* (Javaid et al., 2022). One of the key technologies that play an important role in the transformation of Industry 4.0 is cloud computing, big data, and data analysis (Khan et al., 2023). The data processing results will come on stage in Supervisory Control and Data Acquisition (SCADA) as activity process control in the industry (Lin and Nadjm-Tehrani, 2023). The whole activity will be monitored by a working system for tracking and collecting relevant real-time data with the production process goods manufacturing in the so-called industry with the Manufacturing Execution System (MES) (Peiris et al., 2023). In this stage, autonomous decision-making can also be done directly by the machines in this technology (Shojaeinasab et al., 2022). MES is monitored using an integrated system used by the company's top management to integrate all resources in the industry (Anaya and Qutaishat, 2022). An ERP system will facilitate the planning and management of company resources so that all changes can be quickly adjusted in industrial activities (Shen et al., 2016). In general, Industry 4.0 describes a growing trend towards automation and data exchange in technology and processes in the manufacturing industry.

Indonesia Industry 4.0 Readiness Index (INDI 4.0)

Making Indonesia 4.0 is a road map for increasing the productivity and competitiveness of the national industry in facing the industrial revolution 4.0 (Efendi, 2022). Industry transformation 4.0 benefits industrial companies by reducing costs and downtime, increasing machine and equipment performance, increasing the speed of production operations and product quality, and being compatible with health protocols (Pratama, 2022). The Ministry of Industry is preparing for this through the INDI 4.0 assessment to accelerate industry players to transform towards Industry 4.0 (Mahfudz and Dharma, 2021). INDI 4.0 is a reference standard to measure the level of readiness of companies to transform into Industry 4.0 (Hasbullah et al., 2021). INDI 4.0 was initiated by a team from the Industrial Research and Development Agency, Ministry of Industry, involving experts, industry players, academics, and consultants. The INDI 4.0 assessment uses five pillars as parameters for the level of industry readiness in transforming to Industry 4.0 (Figure 1). The five pillars are People and Culture, Management and Organization, Products and Services, Factory Operations, and Technology (Tanjung et al., 2021).

Toolbox Industrie 4.0

Industry 4.0 is another challenge that must be faced by the industry, which usually starts with a lack of knowledge needed to implement Industry 4.0. Several approaches have been developed to support the industry in applying the Industry 4.0 concept. Industry 4.0 guidelines (guiding principles for the implementation of industry 4.0 in the industry) have been established by the German Engineering Industry Association or Verband Deutscher Maschinen-und Anlagenbau (VDMA) known as Toolbox Industrie 4.0 (Wang et al., 2018). The Toolbox Industrie 4.0 (Figure 2) is organized into six application layers and five performance classes (Roman et al., 2021). The application layer denotes the possible implementation areas for Industry 4.0, while the performance classes identify potential implementation possibilities (Chong et al., 2018). The higher the performance class, the closer to industrial vision 4.0 (Wang et al., 2018a). This strategy aims to identify industry 4.0 competencies in the industry being assessed. Toolbox Industrie 4.0 has two structures: product and production (Wang et al., 2016). The Product Toolbox's structure includes integrating sensors, communications/connectivity, data storage and information exchange functions, monitoring, IT services related to products, and business models around products (Peukert et al., 2020). While the Production Toolbox contains data processing in production, communication between machines, the network of all companies with production, ICT infrastructure, human-machine interface, and batch efficiency (Wang et al., 2018b).

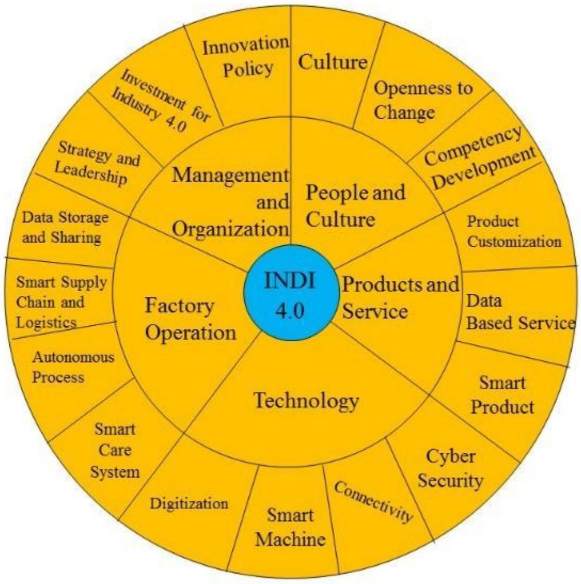

Figure 1. The 5 pillars in INDI 4.0 assessment (Ministry of Industry, Republic of Indonesia, 2018)

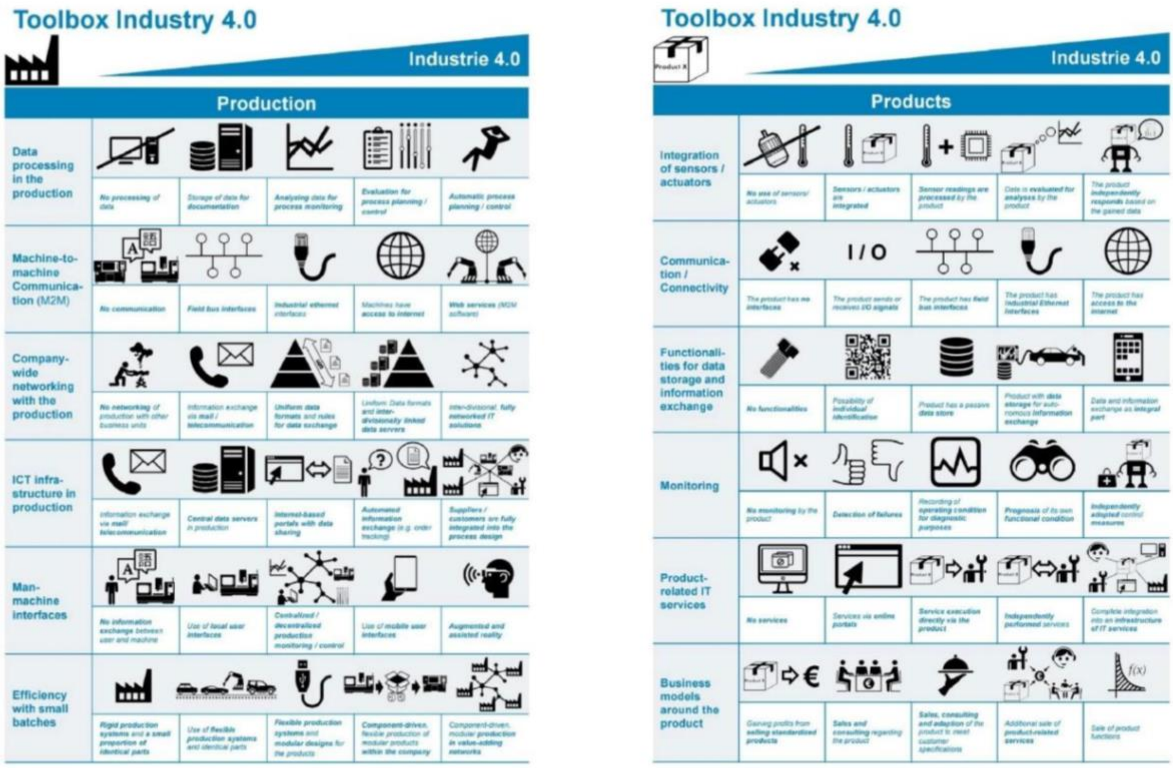

Figure 2. Toolbox industrie 4.0 guideline from VDMA (Anderl, 2016)

METHODOLOGY

Research Method

The implementation phase begins with determining the industries to be visited to assess INDI 4.0 and analyzing the level of industry readiness for transformation. The selected industry has been decided on the Small and Medium Industries scale in the Bogor area. The selected industries are SMIs A, B, and C. After determining the selected industries, a survey directly to the location is carried out to validate the presence and activity of the industry. In conducting the survey, an agreement was made on a time and date for conducting interviews by the INDI 4.0 guidelines. Interviews were conducted by filling out a questionnaire following the guidelines on INDI 4.0 and Toolbox Industrie 4.0.

In the INDI 4.0 Guide, each pillar will be measured from level 0 to level 4. Level 0 describes if the industry still needs to become familiar with Industry 4.0 or is not ready to transform to Industry 4.0. Level 1 is familiar with Industry 4.0 and has a transformation plan for Industry 4.0. Level 2 indicates that the industry has moderate readiness to transform. There is already support for technology, management, and factory operations to Industry 4.0. Level 3 indicates that the industry has started implementing Industry 4.0 but has yet to be in all lines of operations. Level 4 indicates that the industry has implemented part of Industry 4.0 and is ready to transform to Industry 4.0 massively.

Each pillar is weighted respectively: People and Culture 30.0%, Management and Organization 17.5%, Products and Services 17.5%, Factory Operations 17.5%, and Technology 17.5%. The value of each pillar is a combination of the values of each field in that pillar. The weighting on people and culture is given a greater value than the other pillars because, in Indonesia, the success or failure of the industrial transformation towards Industry 4.0 depends on the culture and readiness of the people who will later carry out the transformation.

The toolbox Industry 4.0 was also used to determine the Industry 4.0 readiness index of the SMIs. In this experiment, the toolbox Industry 4.0 was conducted by scoring approach. Based on both product and production aspects, we identify the performance index of each application by scoring from 1-5 because it has five levels of performance. The lowest score indicates the low performance of that application. The highest score indicates the high performance of that application.

FINDING AND DISCUSSION

In Industry 4.0, assessment requires initial data as a description industry profile. Ideally, the industry that will transform is an industry that is already strong in carrying out its business activities. It is needed because the organization should support transforming readiness (Hajoary, 2023). The following is a brief profile of SMIs A, B, and C in the Bogor area.

Table 1. Brief Profile of SMIs

Profile	**Small and Medium Industry**		
	A	**B**	**C**
Industrial Sector	food and beverage	food and beverage	food and beverage
Total Employees	30-299	20	37
Annual Income	500 millions-10 billions	8 billion	50-500 million

Table 1 shows a brief profile of SMIs A, B, and C that have been evaluated. The three SMIs have more than ten employees, so they have carried out quite complex activities relating to their competencies for Industry 4.0 transformation readiness (Gajek et al., 2022). The existence of a large dominant annual income for the three SMIs indicates that *the cash flow* that runs in the industry is fine (Mioduchowska-Jaroszewicza, 2022). This cash flow also indicates that the industry has sustainability (Chiu et al., 2022). All industries evaluated are included in the food and beverage sector category because the dominating SMI sectors in Bogor City are the culinary sector.

Figure 3 shows that SMI A has the largest area, followed by SMI C and SMI B. The highest points in industry A are obtained in the factory operation pillar. This situation is reasonable because company-related data has been stored in the cloud. SMI A has implemented a barcode system in the supply chain and logistics of the company. SMI A also has an integrated logistics system between the company and vendors or suppliers. SMI A implements corrective engine maintenance. According to the CEO, the automation process implemented in SMI A is 25%. The highest score on the pillar of the assessment results for SMI C is the people and culture pillar, with a value of 1.8. this score is followed by the technology pillar with a score of 1.2. Besides that, the other three pillars are in the range of 0-0.25. According to the scores on the people and culture pillars as well as the technology pillars, SMI C is committed to transforming into Industry 4.0. In addition, this commitment has also been proven by a technology score that is higher than the other three pillars below it. SMI C has used an application that can connect between machines using the Internet, but it still needs to be upgraded. SMI C has computer network technology; databases; the Internet; barcodes; cloud storage; a simple robot, and an online control system. SMI B has the smallest score because the management and organization pillars and the technology pillars have a score of zero. The two pillars and the product and service pillars, factory operations and people and culture, also score between 0.5-0.75. This condition indicates that SMI B has low initiative towards the industrial transformation plan 4.0. Both technology and personal commitment to transformation are important for industry 4.0 transformation readiness (Ed-Dafali et al., 2023).

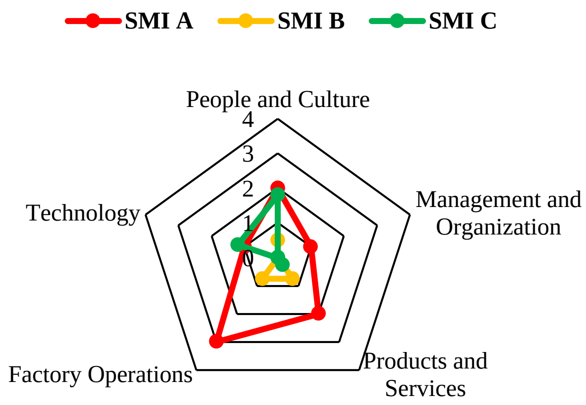

Figure 3. Assessment results based on INDI 4.0 procedure

Table 2. Total Score for INDI 4.0 Assessment

Pillars	Small and Medium Industry		
	A	B	C
People and Culture	0.6	0.15	0.54
Management and Organization	0.175	0	0
Products and Services	0.35	0.131	0.044
Factory Operations	0.525	0.131	0
Technology	0.175	0	0.21
Total	**1.825**	**0.413**	**0.794**
Levels	**2**	**0**	**1**
Readiness	**Moderate Readiness**	**Not Ready**	**Initial Readiness**

The calculation of the total score for the final results for each industry can be seen in Table 2. SMI A has a total score of 1.825 with level 2, which is a moderate level of readiness. SMI C has a total score of 0.794 with level 1, which is the initial level of readiness. In comparison, SMI B has a total score of 0.413 with a level of 0 which is an industry not ready to transform to industry 4.0. As described in Figure 2, the total score of each pillar is multiplied by the percentage of each of these pillars (Ministry of Industry, Republic of Indonesia, 2018). The people and culture pillar has the highest percentage, which is 30%, while the other four pillars have a percentage of 17.5%. The results obtained in Table 2 follow the assessment results in Figure 3; namely, SMI A is more dominant in being ready to transform. With a score of 1.825, SMI A already has a personal initiative profile that supports transformation. The factory operation pillar also has an integrated logistics system. Therefore, it is natural for SMI A to be declared to have a moderate level of readiness at level 2. SMI C also has automation technology connected to the Internet on a technological aspect. However, the factory management and operations pillars still need to support the transformation to Industry 4.0. Therefore SMI C, which has a score of 0.794, is declared an initial level of readiness with level 1.

In contrast to SMI B, overall, it has a score in the range of 0-0.1. These results have been used to state that Industry B still needs to be ready to transform. This is in line with existing personnel in SMI B needing to take the initiative in transforming to Industry 4.0. The low commitment of people in SMI B to transform will affect the other pillars to get a high score. However, the management and team members must adjust their business performance due to the more complex and dynamic business and manufacturing environment, especially for customization products in the era of Industry 4.0 (Govindan and Arampatzis, 2023).

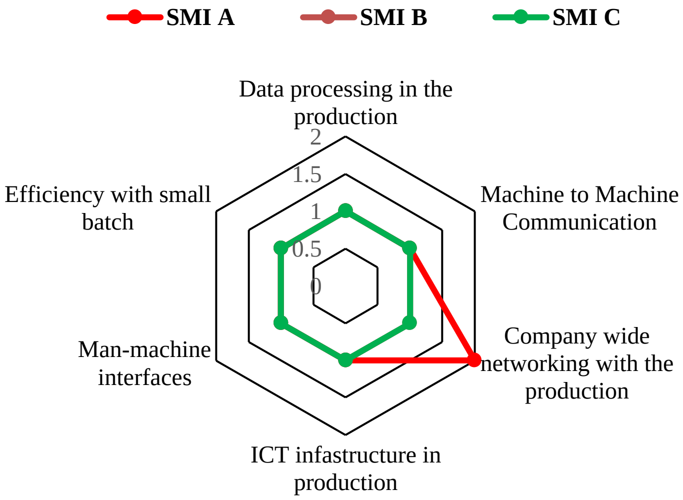

Figure 4. Assessment result for production aspect based on toolbox industrie 4.0

Based on the assessment results using the Toolbox Industrie 4.0 from VDMA, both SMIs A, B, and C have a score of 1 only on elements application Company-wide networking with the production in industry A, which has a score of 2. This means that from a VDMA point of view, SMIs A, B, and C still have application performance levels that are far from implementing Industry 4.0. When viewed from the application used as a parameter to assess the level of industry readiness in transforming to Industry 4.0, there is a difference between INDI 4.0 and Industry 4.0 Toolbox. In VDMA, it is directly stated the types of images or implementations that show the performance of each application/parameter in the toolbox (Winkelhake, 2022). Whereas the questionnaire owned by INDI 4.0 tends to be more flexible and intends to explore as much as possible for implementation under the fields in each pillar of INDI 4.0. In VDMA, the lowest value for each application's performance is scored by 1, indicating that the application has not performed. Assessment of VDMA, which consists of five performance levels in each application, can be interpreted as a score of 1-5 from lowest to highest performance (Anderl, 2016). If it is viewed at INDI 4.0, the lowest score is 0, and the highest is 4 (Efendi, 2022). Based on the production aspect, there is no human resource element in Toolbox Industrie 4.0 (Peukert et al., 2020). This is significantly different from the assessment in INDI 4.0, which gives the highest score for the human resources pillar (Hasbullah et al., 2021).

Figure 5 shows that SMI A, B, and C have a score of 1, except for SMI A for two applications and SMI C for one application. In SMI A, the application of business models around the product has a score of 4, and the monitoring application has a score of 2 on the product aspect. This shows that SMI A has a higher readiness level than SMI B and C. Meanwhile, in SMI C, the application of business models around the product has a score of 2. According to the product aspect, the industry's highest to lowest readiness levels in transforming to Industry 4.0 are SMI A, C, and B, respectively. When viewed from the point of view of the importance of the human resource element, the product aspect in the Toolbox Industrie 4.0 method does not present this element (Roman et al., 2021). So it can be seen that Toolbox Industrie 4.0 does not have an element of human resources to serve as an assessment parameter (Chong et al., 2018).

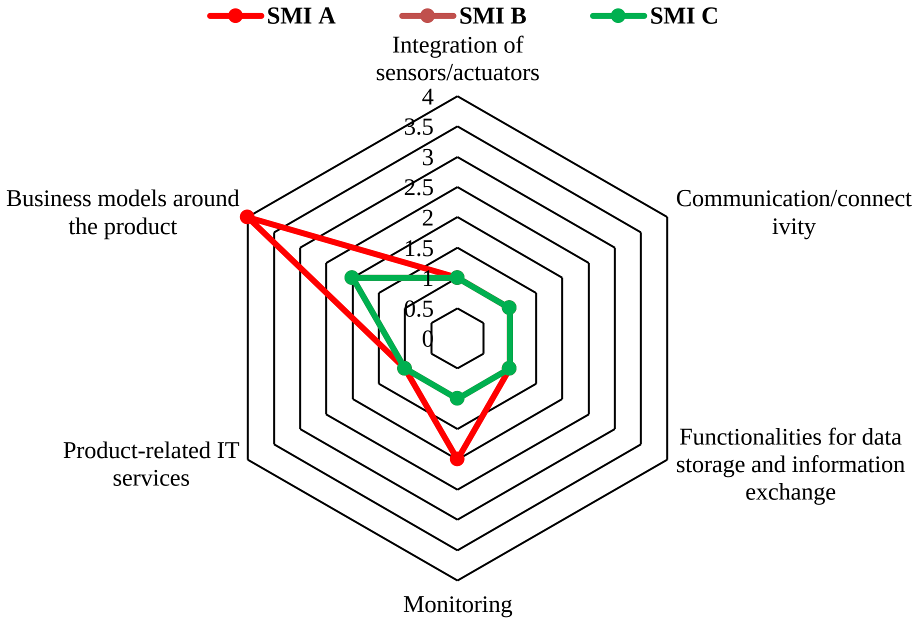

Figure 5. Assessment result for product aspect based on toolbox industry 4.0

Despite having different parameters and model approaches between the INDI 4.0 and the Toolbox Industrie 4.0, the two methods for the level of readiness of SMIs A, B and C in transforming to Industry 4.0 have the same assessment results. From the two methods, the highest to lowest score on the level of industry readiness for transformation is SMI A, C, and B. Regarding the element of human resources; the Toolbox Industrie 4.0 method does not have these parameters (Wang et al., 2018a). It is very well realized that in Indonesia, the formation of commitment to humans as industrial activity actors still need to be strongly encouraged (Niswaty et al., 2021). The cultural differences between Indonesia and Germany as pioneers of Industry 4.0 may still be very different in terms of commitment to transforming Industry 4.0 (James et al., 2022). Therefore, the assessment using INDI 4.0 still requires human resources, even though this pillar is given the highest score for calculating industry readiness in transforming (Hasbullah et al., 2021). It will support humans in conducting an industry 4.0 transformation (Bretz et al., 2022).

CONCLUSIONS AND FURTHER RESEARCH

Based on the results, it concluded that both INDI 4.0 and Toolbox Industrie 4.0 performed a similar result in the industry 4.0 readiness index, although they have different assessment methods. The two assessment methods show that the level of industry readiness in transforming to Industry 4.0 from the most ready to not ready is SMI A, C, and B. Therefore, both INDI 4.0 and Toolbox Industrie 4.0 can be used to measure the level of readiness of the industry to transform into Industry 4.0. The Toolbox Industrie 4.0 does not have an element of human resources in applications for performance evaluation in transforming towards Industry 4.0. Whereas INDI 4.0 still requires an element of human resources as a pillar with the highest score to measure the level of industry readiness in transforming because it sees the culture of a society in Indonesia which is still very different from Germany as the pioneer of industry 4.0

Further research is highly recommended to evaluate industries with a larger productivity scale. This experiment was limited by the availability of a competent assessor who is an expert in Industry 4.0 technology. They should have updated information on technology development, especially for the assessor with an information technology background. This experiment contributes to an initial assessment of SMI for industry 4.0 transformation and their assistance during transformation.

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