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Comparative Study of Industry 4.0 Readiness Measurement of Indonesian Companies: INDI 4.0, IMPULS and SIRI

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Abstract

The adoption of Industry 4.0 is considered to significantly increase the productivity and efficiency of the manufacturing industry in Indonesia and contribute to the national GDP to encourage global competitiveness. Currently, many measuring tools are used to assess the industry 4.0 readiness in various countries but using different aspects of the assessment. With a comparative analysis, this article will discuss the readiness of Industry 4.0 in a company that is measured using three different Industry 4.0 readiness measurement tools to find their similarities. Industry 4.0 readiness of an Indonesia company in the food and beverage sector is measured using: the Indonesia Readiness Index 4.0 (INDI 4.0) with five assessment pillars consisting of management and organization, people and culture, smart products and services, smart technology, and factory operations; IMPULS with six assessment pillars such as employees, strategy and organization, smart factories, smart operations, smart products, and data-driven services; and Smart Industry Readiness Index (SIRI) with three building blocks covering processes (operation supply chain and product life cycle pillars), technology (pillars of automation, connectivity, and intelligence) and organization (pillars of talent readiness and structure & management). The measurement results show that the company obtained an INDI score of 3.47 (level 4 or mature stage), got an IMPULS score of 3.663 (level 4 or "Expert" and entered the Leader category), and obtained a SIRI score of 1.2037. The calculation of normality with the baseline using the INDI 4.0 score by adding one pillar in the form of Data-driven Services is carried out so that the assessment pillars are similar, considering that there are differences in the range of scores and levels of the three readiness measuring tools. Although the value of Industry 4.0 readiness in a company measured using three readiness measuring tools shows different scores, the three tools indicate that the company has a similar level of readiness: the "mature" level.

Keywords
Industry 4.0 Readiness, Foods, Beverages, Company, Indonesia

1. Introduction
The manufacturing industry in Indonesia has an essential role in national economic growth. This strategic sector has proven to be a driving force for the national economy, contributing to the national Gross Domestic Product (GDP) of around 20.61 percent (Statistics Indonesia, 2020). In 2018 the Government formulated the Making Indonesia 4.0

roadmap for implementing Industry 4.0 in Indonesia. Five industrial sectors are defined as the priority focus of Making Indonesia 4.0: food and beverage, textile and apparel, automotive, chemical, and electronics. The sector was selected based on the economic impact and feasibility of implementation, such as GDP contribution, trade, the potential impact on other sectors, investment size, and market penetration speed (MOI of Indonesia, 2018).

Implementing Industry 4.0 in the Indonesian manufacturing industry is expected to increase productivity, income, business competitiveness, and customer service, optimize manufacturing processes and improve product quality. This will impact GDP growth, increase technology adoption and new job opportunities and be a game-changer for national economic growth. The Indonesia Industry 4.0 Readiness Index (INDI 4.0) was released as a guide for industry and the Government to measure industry readiness in implementing Industry 4.0 (Kementerian Perindustrian, 2020). INDI 4.0 has been used by several companies in the Making Indonesia 4.0 priority industrial sector in measuring readiness towards Industry 4.0.

Besides INDI 4.0 which is implemented in Indonesia (Almamalik, 2020; Indrawan et al., 2020; Qomariyah & Priandoyo, 2020; Simamora et al., 2020), there are several other measuring tools used in various companies and countries to measure the level of industrial readiness 4.0. The measuring tools such as: IMPULS (Axmann & Harmoko, 2020; Hamidi et al., 2018; Litchtblau et al., 2015), The Singapore Smart Industry Readiness Index (SIRI) (Lin et al., 2019; Singapore Economic Development Board, 2018), DREAMY (Carolis et al., 2018), PricewaterhouseCoopers (PwC) (Griessbauer et al., 2016) and many more. However, the Industry 4.0 readiness measurement tool uses different aspects/pillars of assessment.

This study discusses a comparative analysis of the Industry 4.0 readiness of an Indonesian company in the food and beverage sector using three different measuring tools to find their similarities. The measuring tools used are INDI 4.0, IMPULS, and SIRI. The measurement pillars of INDI 4.0 consist of management and organization, people and culture, intelligent products and services, intelligent technology, and factory operations. The assessment pillar of IMPULS such as employees, strategy and organization, smart factories, smart operations, smart products, and data-driven services. While SIRI has three building blocks covering process (supply chain operations and product lifecycle pillar), technology (automation, connectivity, and intelligence pillar), and organization (talent readiness pillar and structure & management)

1.1 Objectives

This study aimed to compare the measurement tools for assessing the industry 4.0 readiness of an Indonesian company in the food and beverage sector using three different measuring tools to find their similarities. Comparing the results of the company's readiness measurement using different measuring tools is expected to provide an overview of a company's readiness to transform into Industry 4.0 from various perspectives. In addition, to find out the equivalence of the measurement score of Industry 4.0 readiness from different measurement tools. Companies or other parties can use the equivalent score to measure the company's readiness for business development in various countries..

2. Literature Review

2.1 INDI 4.0

As one of the strategic efforts to accelerate the implementation of Industry 4.0 in Indonesia, INDI 4.0 was released as a guideline for measuring Industry 4.0 readiness in the industry. Readiness is carried out by self-assessment of the company by measuring five pillars: Management and Organization, People and Culture, Products and Services, Technology, and Factory Operations (Perindustrian & Paryanto, 2018).

The pillars of people and culture focus on potential development, work culture, and openness to change. The management and organization pillar focuses on strategy and leadership, investment for industry 4.0, and innovation. The smart product and service pillar focuses on data analytics, data-driven services, and interface standard for the product. The smart technology pillar covers cyber security, smart equipment, connectivity, and digitization. The factory operation pillar focuses on data storage and sharing, supply chain and intelligent logistics, smart maintenance and autonomous processes. The assessment of INDI 4.0 uses levels 0-4 for the readiness level (Almamalik, 2020; Kementerian Perindustrian, 2020; Qomariyah & Priandoyo, 2020; Simamora et al., 2020).

INDI 4.0 was compiled explicitly and adapted to the industry's conditions and needs in Indonesia. Therefore INDI 4.0 has specificities, such as assessments for people and cultures. The measurements with this index are then used as

a reference in identifying challenges, determining strategies, and as a basis for determining government policies to encourage the industry to transform towards Industry 4.0 (Indrawan et al., 2020).

2.2 IMPULS

IMPULS was initiated by the IMPULS Foundation of the German Engineering Federation (VDMA). The measurement dimensions are people, strategy and organization, smart factories, smart operations, smart products, and data-driven services. The IMPULS measurement uses levels 0 – 5 for each answer to the question on the pillar. A scale of 0 indicates that the company did not carry out one or a few activities leading to industry 4.0. The IMPULS assessment uses levels 0 – 5 for each answer to the questions on the pillars. A scale of 0 indicates that the company does not carry out any activities or very few that lead to industry 4.0. In contrast, a scale of 5 indicates that the company has fully implemented the target vision and has integrated all parts of the target (Lichtblau et al., 2015).

The IMPULS measurement model is considered to have a scientific basis, able to provide a complete explanation of the dimensions, variables, and approaches (Schumacher et al., 2016). IMPULS is a readiness model that is quite popular in initializing the development process, defining resistance, and providing recommendations to overcome it (Sony & Naik, 2020).

2.3 SIRI

The Singapore Economic Development Board (EDB) developed SIRI in 2017. This measurement tool is intended to help companies take advantage of Industry 4.0 and has the potential to become a global standard for the future ((Lin et al., 2019). The Priority Matrix was developed to assist companies in prioritizing the implementation areas of Industry 4.0. In the Priority Matrix, SIRI is the basic formula for scoring the assessment matrix (EDB Singapore, 2019).

The SIRI framework consists of three layers. The first layer consists of the basic building blocks of Process, Technology, and Organization. The second layer consists of eight main pillars that are the focus for the company to be ready to develop according to industry 4.0 references. The third layer is divided into 16 assessment dimensions companies use to assess facilities in realizing their business value ((EDB Singapore, 2018; Lin et al., 2019). The building blocks of the SIRI measurement process consist of an operations pillar with a vertical integration dimension, a supply chain pillar with a horizontal integration dimension, and a product life cycle pillar with an integrated product life cycle dimension. The technology building blocks have the pillars of automation, connectivity, and intelligence, each of which has dimensions on the factory, enterprise, and facility floors. In comparison, organizational building blocks have the talent readiness pillar (learning & development dimensions and leadership competencies) and structure & management pillar (internal and intra-company collaboration and strategy & governance dimensions) ((EDB Singapore, 2019).

In addition, SIRI also has a Learn, Evaluate, Architect, and Deliver (LEAD) framework as a learning guide for companies to understand the concepts of Industry 4.0. At the same time, it measures the company's current condition and identifies gaps and the future needs of Industry 4.0 (EDB Singapore, 2018; Lin et al., 2019). SIRI readiness level is different from INDI 4.0 and IMPULS. The level classification in SIRI is focused on each pillar and does not provide weighting for calculating the value of each pillar, like INDI 4.0. The pillar comparison between the three measuring instruments is shown in Figure 1.

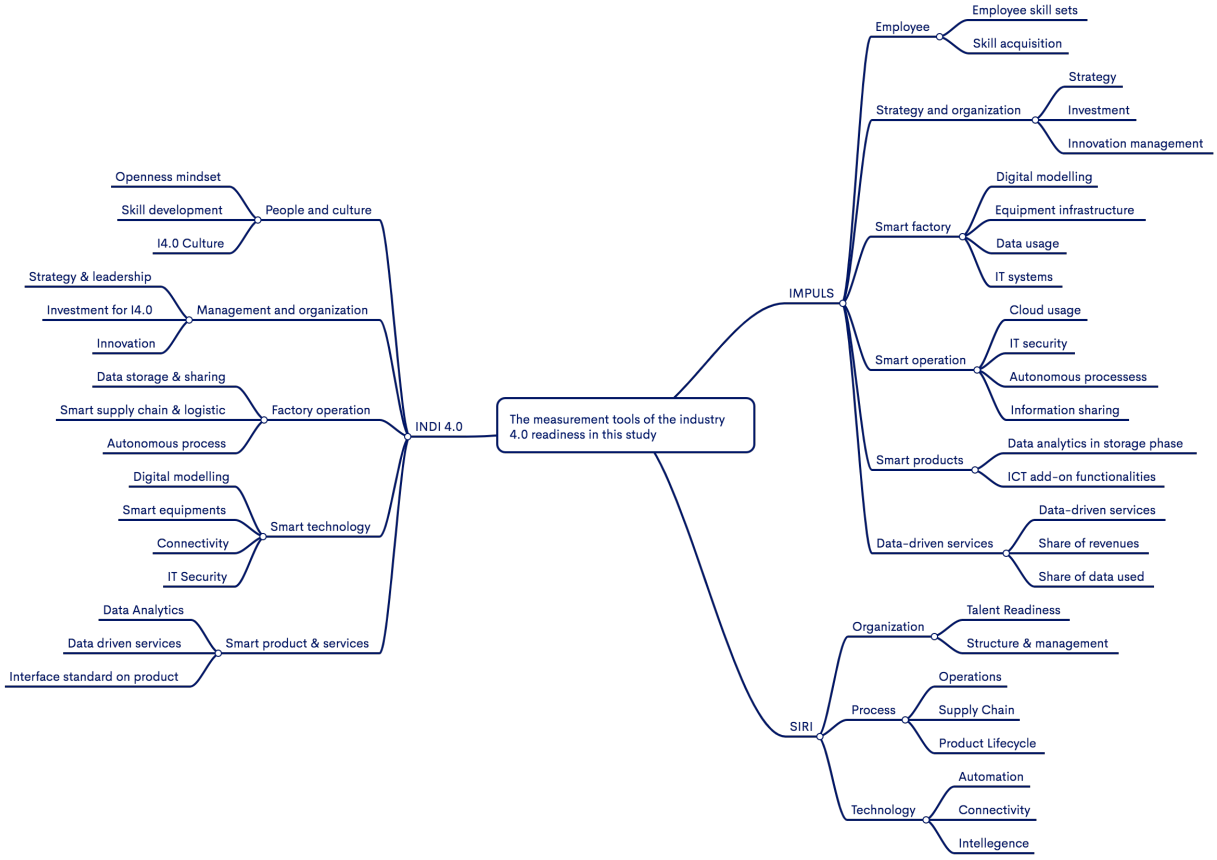


Figure. 1. The measurement tools of the industry 4.0 readiness in this study
(Kementerian Perindustrian, 2020; Litchtblau et al., 2015; Singapore Economic Development Board, 2018)

3. Methods

The method used in this study is comparative analysis (Figure 2). Phase I identifies readiness measurement tools in the transformation of Industry 4.0, which will be compared: INDI 4.0, IMPULS, and SIRI. Phase II identifies comparative analysis criteria (dimensions of each measuring tool). Next is Phase III, measuring the Industry 4.0 readiness of PT G using three measurement tools. PT G is one of Indonesia's companies engaged in the food and beverage sector by processing fresh milk. The food and beverage sector was chosen because it is one of the priority industries for Making Indonesia 4.0.

In phase III, the industrial readiness 4.0 of PT G was measured using the available INDI 4.0 questionnaire to get the score and level of INDI 4.0. The industrial readiness 4.0 of PT G was also measured using the IMPULS measuring tool through a self-assessment available online at https://www.industrie40-readiness.de/?lang=en. Measurements indicate the level of each dimension on a scale of 0 to 5. Finally, the industrial readiness 4.0 of PT G is measured using the SIRI measuring tool through self-assessment, which is available online at https://www.siri.gov. sg/self-assessment.

The measurement results are a 4.0 industrial readiness score at PT G on each measurement tool. The scoring scores were then normalized to the baseline INDI 4.0. This is due to the difference in the range of scores between the three measuring instruments, so it is necessary to normalize to the basic score (INDI 4.0 score). The results of normalization scores of INDI 4.0, SIRI, and IMPULS are overlaid on a radar chart to illustrate the comparison of the scores of each pillar on the three measuring instruments (Figure 2).

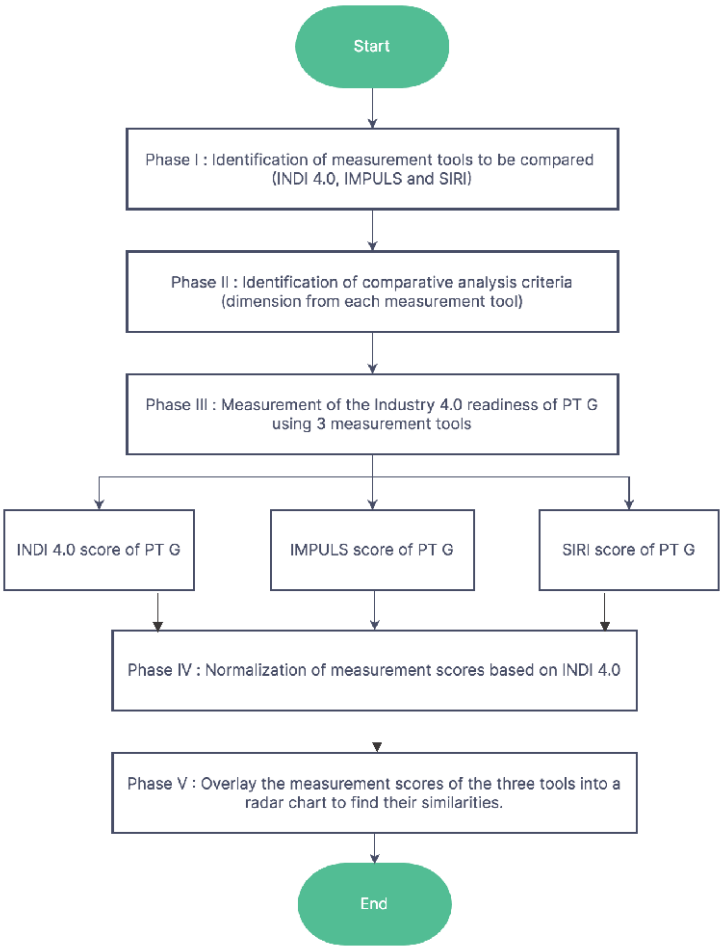
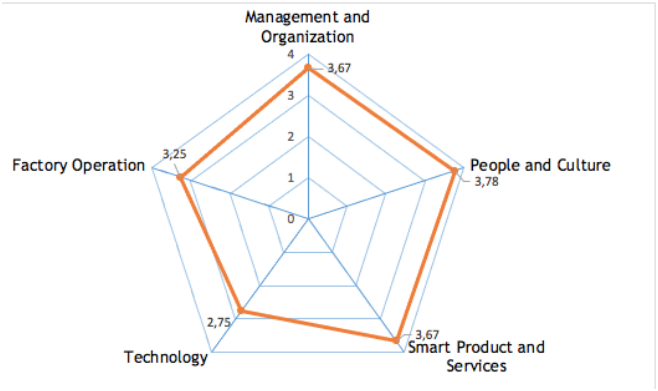


Figure 2. Flowchart of research method

4. Results and Discussion

4.1 INDI 4.0 Measurement Result

Assessment results from the questionnaires that PT G has filled out are obtained as shown in Figure 3. The highest score of PT G from the five pillars of INDI 4.0 is on the "People and Culture" pillar, and the lowest score is on the "Technology" pillar. The pillar of "People and Culture" gets the highest score because all employees of PT G already have a good culture which is in line with the transformation to Industry 4.0: disciplined, open-minded, dedicated, and high work ethic. In addition, employees of PT G have become accustomed to continuous improvement, critical, flexible, open to technological change, and willing to learn new technologies. PT G also has regular training programs related to Industry 4.0 (Figure 3).



(a)

INDI Pillar	Level	Weight	Average
Management and Organization	3,67	0,175	3,47
People and Culture	3,78	0,300	
Smart Product and Services	3,67	0,175	
Technology	2,75	0,175	
Factory Operation	3,25	0,175	

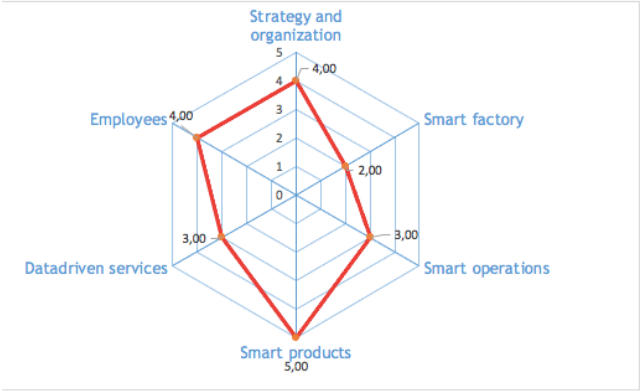
(b)

Figure 3. The results of the INDI 4.0 measurement at PT G: (a) radar chart; (b) INDI 4.0 score of PT G

While the "Technology" pillar got the lowest score because PT G only implemented cyber security for the scope of IT systems. More than 75% of digitization is implemented at PT G. The technology used at PT G varies, such as the robot industry, the Industrial Internet of Things (IoT) industry, computer networks, RFID, and others. Machine to Machine (M2M) connectivity via the internet/intranet in the infrastructure and connectivity between the company's internal systems and the company already exists and continues to be implemented. From the measurement results, PT G is in the mature readiness stage to transform to Industry 4.0 (level 4), scoring 3.47 on a scale of 0-4.

4.2 IMPULS Measurement Result

The result of readiness measurement using IMPULS on the available platform gets the highest score on the "Smart Products" pillar and the lowest score on the "Smart Factory" pillar (Figure 4). The pillar of "Smart Products" at PT G gets the highest score because PT G's products already have additional ICT-based functions and features such as RFID, GPS, and condition monitoring. So it is ready for Industrial 4.0 applications. The production process can be improved with physical products equipped with ICT components for data collection, production process knowledge, and communication skills with the system. It is possible to provide new services through communication between consumers and producers (Litchtblau et al., 2015).



(a)

IMPULS Pillar	Level	Weight	Avarage
Strategy and organization	4,00	0,254	3,663
Smart factory	2,00	0,143	
Smart operations	3,00	0,102	
Smart products	5,00	0,185	
Datadriven services	3,00	0,138	
Employees	4,00	0,179	

(b)

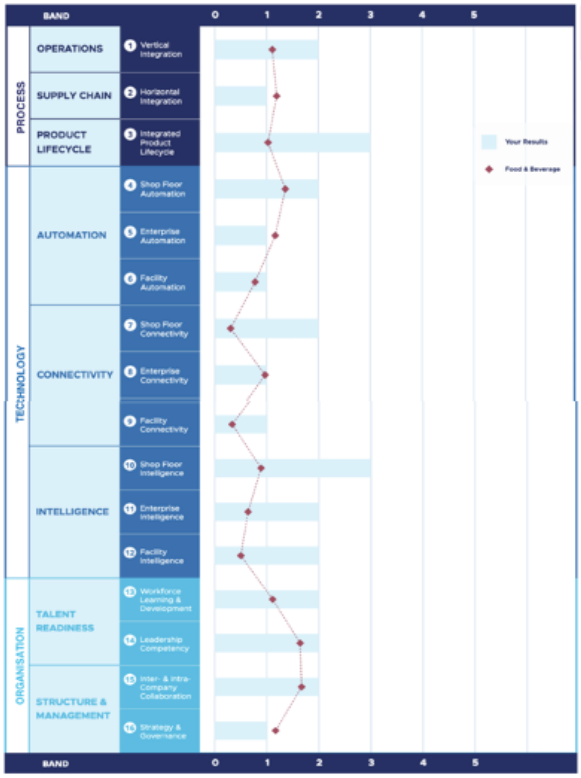
Figure 4. The results of the IMPULS measurement at PT G: (a) radar chart; (b) IMPULS score of PT G

The "Smart Factory" pillar has the lowest score (Figure 4), so the IMPULS platform recommends that PT G integrate the company's current systems into its IT infrastructure and consider these factors when purchasing a new system. This will benefit PT G in intelligent data collection, storage, and processing. With the smart factory concept, the information conveyed is confirmed, and the resources used are more efficient. This requires real-time cross-company collaboration between production, information systems, and human resources (Litchtblau et al., 2015).

IMPULS score of PT G is 3,663, which is at level 4 "Expert" and is in the Leader category. It means that PT G massively implements Industry 4.0 on technology, processes, and organization and is far ahead of other companies that are benchmarks for companies on the IMPULS platform.

4.3 SIRI Measurement Result

The measurement results of PT G with SIRI got the highest score on the "Organization" aspect and the lowest on the "Technology" aspect (Figure 5). PT G, which has an extensive network of cooperation in marketing its products, gets the organizational aspect a high score. In addition, PT G has more than 500 employees with high skills and work ethics and can adapt to technological changes. This aspect is important and relevant in facing increasingly fierce competition in the Industry 4.0 era. PT G must adjust its organizational structure and processes so its workforce can keep pace (EDB Singapore, 2018).



SIRI Pillar	Equivalent Pillar	SIRI Score	Average Score
Structure and Management	Strategy and organization	1,50	1,2037
Talent Readiness	Employees	1,50	
Product Lifecycle	Smart products	2,00	
Technology	Smart factory	0,78	
Operation	Smart operations	1,00	
Supply Chain	Datadriven services	1,00	

Figure 5. The results of the SIRI measurement at PT G

While the lowest score is on the "Technology" aspect, especially on the automation and connectivity pillars (Figure 5), this is because of cyber security at PT. G is only found in the scope of IT systems. Connecting requires safe and strong cyber-physical security in various aspects of the organization. The automation system that has been implemented at PT G is expected to become more flexible to be able to place manufacturers in a more competitive position. Also able to adapt to the rapidly changing needs of customers (EDB Singapore, 2018). The average score of all SIRI pillars (Utomo & Setiastuti, 2019) from PT. G is 1.2037.

4.4 Overlay on Radar Chart

After each measuring instrument's PT G readiness score was obtained, normalization was carried out on the INDI 4.0 score as a baseline. This considers the difference in the range of scores and levels of the three measuring instruments, as shown in Table 1.

Table 1. Normalization results of SIRI scores and IMPULS scores into the INDI 4.0 scores

INDI 4.0 Pillars	INDI 4.0 Score	IMPULS Score	SIRI Score	Notes

	(as baseline)	(normalized)	(normalized)	
Strategy and organization	3,67	4	4	
Employees	3,78	3,95	4	**Highest score**
Smart products	3,65	4	4	
Smart factory	2,75	1,98	2,07	**Lowest score**
Smart operation	3,25	2,96	2,67	
Datadriven services (as equivalent pillar)	3,65	4	2,67	

The results of the normalization of each measuring tool are then overlaid on the radar chart (Figure 6). The pillars used for normalization and overlay are the INDI 4.0 pillars: Strategy and Organization, Employees, Smart Products and Services/Products, Technology/Smart Factory, and Factory Operations/Smart Operations. One pillar is added for an equal assessment of the three measuring tools: Data-Driven Services. Scores for the Data-Driven Services pillar on INDI.4 are assigned the same score as the Products and Services pillar because the scoring elements in these pillars are similar (Figure 6).

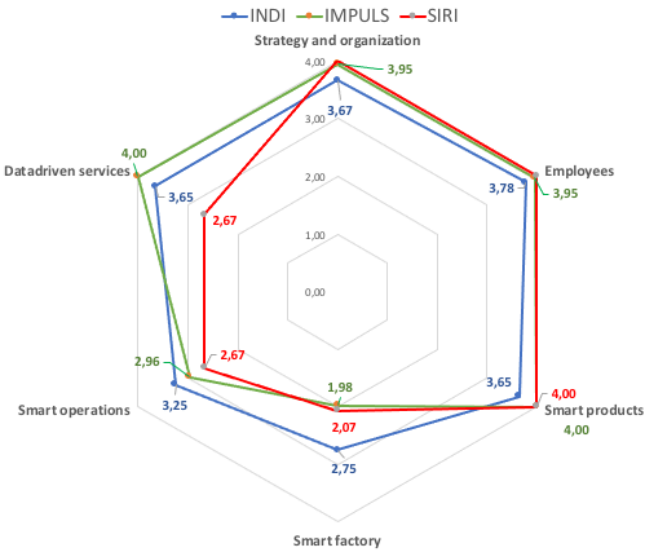


Figure 6. Overlay assessment results of PT. G using INDI-IMPULS-SIRI

The normalized score for the 4.0 industry readiness assessment from PT G shows a different score, even though there are similar trends/score patterns for each pillar. This is due to differences in the assessment elements on each pillar of the measuring instrument. For example, in the "Strategy and Organization" pillar, IMPULS and INDI 4.0 assess strategic, investment and innovation policies. However, SIRI assesses organizational strategy, management, and collaboration within and between companies.

Similarly, the “Smart Factory” pillar shows three different scores. INDI 4.0 assesses cybersecurity, digitization, intelligent machines, and connectivity, while IMPULS assesses cloud usage, IT security, autonomous processes, and information sharing. In contrast to SIRI, which assesses automation, connectivity, and intelligence on the shop floor, enterprise, and facility. However, overall there are similarities in 3 measuring tools: the highest score on the “Employee” pillar and the lowest score on the “Smart Factory” pillar.

The equivalence of pillar 3 measuring instrument readiness for Industry 4.0 can be seen in Table 2. Pillars INDI 4.0 and IMPULS are almost the same (equivalent), while pillar SIRI tends to differ from pillar two other measuring tools (Table 2).

Table 2. The Pillar Equivalence of 3 Industry 4.0 Readiness Measurement Tools

INDI 4.0 Pillar	IMPULS Pillar	SIRI Pillar	Notes
Management and Organization	Strategy and Organization	Structure and Management	-
People and Culture	Employees	Talent Readiness	-
Product and Services	Smart Product	Product Lifecycles	INDI 4.0 and IMPULS emphasize smart products more, while SIRI emphasizes
Technology	Smart Factory	Technology	In SIRI, technology scores are the average of 9 dimensions in automation, connectivity, and intelligence from each shopfloor, enterprise, and facility
Factory Operation	Smart Operations	Operations	-
Data-driven Services	Data-driven Services	Supply Chain	In INDI, data-driven are given the same value as the "Product and Services" pillar, while in SIRI, the equivalent of integrated data on the supply chain pillar.

5. Conclusion

The results of the comparative analysis to measure the Industry 4.0 readiness of PT G using three different measuring tools show different scores on each pillar that have been validated based on the normalization of scores against the baseline. This is due to differences in the assessment elements in each pillar of the measuring tools. However, the three measuring tools show that the company is at the same maturity level: mature (Expert) in implementing Industry 4.0.

By comparing the level of readiness of the same company with different measuring tools, the advantages of each measuring tool used by the company in developing its business can be seen. At the same time, the shortcomings of the measuring tools used today can be complemented by other measuring tools

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