THESIS – TI185401

EMERGING TECHNOLOGIES IN SUPPLY CHAIN: MATURITY MODEL AND ASSESSMENT INSTRUMENT

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THESIS APPROVAL SHEET

Proposed to Fulfill the Requirements to Obtain
Magister Teknik (MT)
in
Institut Teknologi Sepuluh Nopember
By:

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Final Defense Date: January 23rd 2020
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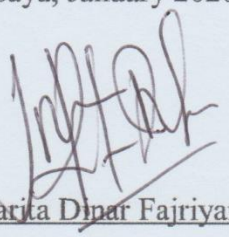

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TEKNOLOGI BARU DALAM RANTAI PASOK: MODEL KEMATANGAN DAN INSTRUMEN PENILAIAN

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ABSTRAK

Teknologi *Industry 4.0* telah dipelajari secara signifikan dan sampai batas tertentu telah diterapkan terutama oleh negara-negara maju sejak kemunculannya pada tahun 2011. Teknologi seperti Internet of Things (IoT), *Big Data Analytics, Advanced Robotics*, *Augmented Reality*, *Block chain*, dan lainnya telah diimplementasikan di berbagai level. Aplikasi mereka telah terbukti memiliki dampak signifikan pada peningkatan produktivitas dan daya saing. Di sisi lain, negara-negara berkembang masih berjuang untuk memahami teknologi canggih ini. Pada level perusahaan, beberapa telah mencoba menerapkan beberapa elemen teknologi *Industry 4.0*, beberapa masih menilai kemungkinan, sementara banyak yang mungkin tidak tahu hal yang harus dilakukan dan disiapkan. Dalam studi ini, kami mengembangkan model kematangan *Industry 4.0* yang dilakukan terutama berdasarkan tinjauan literatur. Model kematangan kemudian dikembangkan lebih lanjut menjadi instrumen penilaian skala Likert sehingga perusahaan dapat menggunakan instrumen ini untuk menilai di tingkat mana mereka telah memahami teknologi ini.

Kata Kunci: *Industry 4.0*, *Maturity Model*, *Technology Readiness*

EMERGING TECHNOLOGIES IN SUPPLY CHAIN: MATURITY MODEL AND ASSESSMENT INSTRUMENT

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ABSTRACT

Industrial 4.0 technology has been significantly studied and to some extent has been applied especially by the developed countries since its emergence in 2011. Such technologies as Internet of Things (IoT), Big Data Analytics, Advanced Robotics, Augmented Reality, Block chain, and others have been implemented at various levels. Their applications have proven to have a significant impact on increasing productivity and competitiveness. On the other hand, the developing countries are still struggling to grasp these advanced technologies. At company level, some have tried to implement some elements of industry 4.0 technology, some are still assessing the possibilities, while many probably do not know what to do. In this study, we develop a maturity model of industry 4.0, which is done primarily based on literature review. The maturity model is then further developed into a Likert-scale assessment instrument so companies can use this instrument to assess at which level they have grasp these technologies.

Keyword: Industry 4.0, Maturity Model, Technology Readiness

ACKNOWLEDGEMENT

Praises to God Almighty, Allah SWT, who has given the Author blessings to finish the research entitled “Emerging Technologies in Supply Chain: Maturity Model and Assessment Instrument”. This research is conducted as a requirement to finish the study to achieve Master Degree of Industrial and Systems Engineering from Institut Teknologi Sepuluh Nopember (ITS), Surabaya.

The Author would like to express sincere gratitude towards many people involved throughout the completion of this research, namely:

1. Author’s parents and family, especially, dr. Intan Palupi and drg. Asriningtyas Megawati who have given endless support, prayers, and guidance during the Author’s study.
2. Prof. Ir. I Nyoman Pujawan, S.T., M.Eng., Ph.D., CSCP as the Supervisor, who had given the best supervision and support. It is also because the Supervisor has become a real example of role model with a powerful network—that has inspired the Author in many ways.
3. Putu Dana Karningsih, S.T., M.Eng.Sc., Ph.D. and Niniet Indah Arvitrida, S.T., M.T., Ph.D. as the thesis examiners who gave detail corrections and advice for the better completion of research.
4. Emrah Arica, Ph.D. (SINTEF, Norway), Prof. Kannan Govindan, M.E., Ph.D. (University of Southern Denmark, Denmark), Prof. Caroline Chan, B.Eng (Hons), M.Eng., Ph.D. (RMIT University, Australia), and Prof. (FH) Mag. Dr. Reinhold Schodl (University of Applied Science BFI Wien, Austria) who had given the Author constructive feedbacks and suggestions.
5. All respondents who had helped the completion of the Pilot Survey.
6. Nurhadi Siswanto, S.T., MSIE., Ph.D., as the Head of Industrial and Systems Engineering Department and Prof. Iwan Vanany, ST., MT., Ph.D. as the Head of Postgraduate Program of Industrial and Systems Engineering Department who had given the guidance during the years of study.
7. Fellow students from all batches, especially, from MLRP program namely Mega Rahmadani, Ni Made Cyntia Utami, Dwi Handayani, Annisa Nurul Aini, Rifqi Jalu Pramudita, M. Afif Asbani and Aulia Ur Rahman who have

given the Author full support and prayers during the study. Special gratitude also for the Author's best friend, Alfian Azizi, who had helped, accompanied and supported the Author's journey during the years of study. Lastly, gratitude for all Author's best friends who have sent endless prayers, motivations, and help.

8. All lecturers, faculty members and academic staffs of Industrial and Systems Engineering Department for the knowledge, help, and guidance during the Author's study.

The Author recognized the needs for further development regarding the research. Therefore, constructive suggestions and critics will be highly appreciated. Hope this research will be useful for both academics and practitioners.

Surabaya, January 2020

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CHAPTER 1
INTRODUCTION

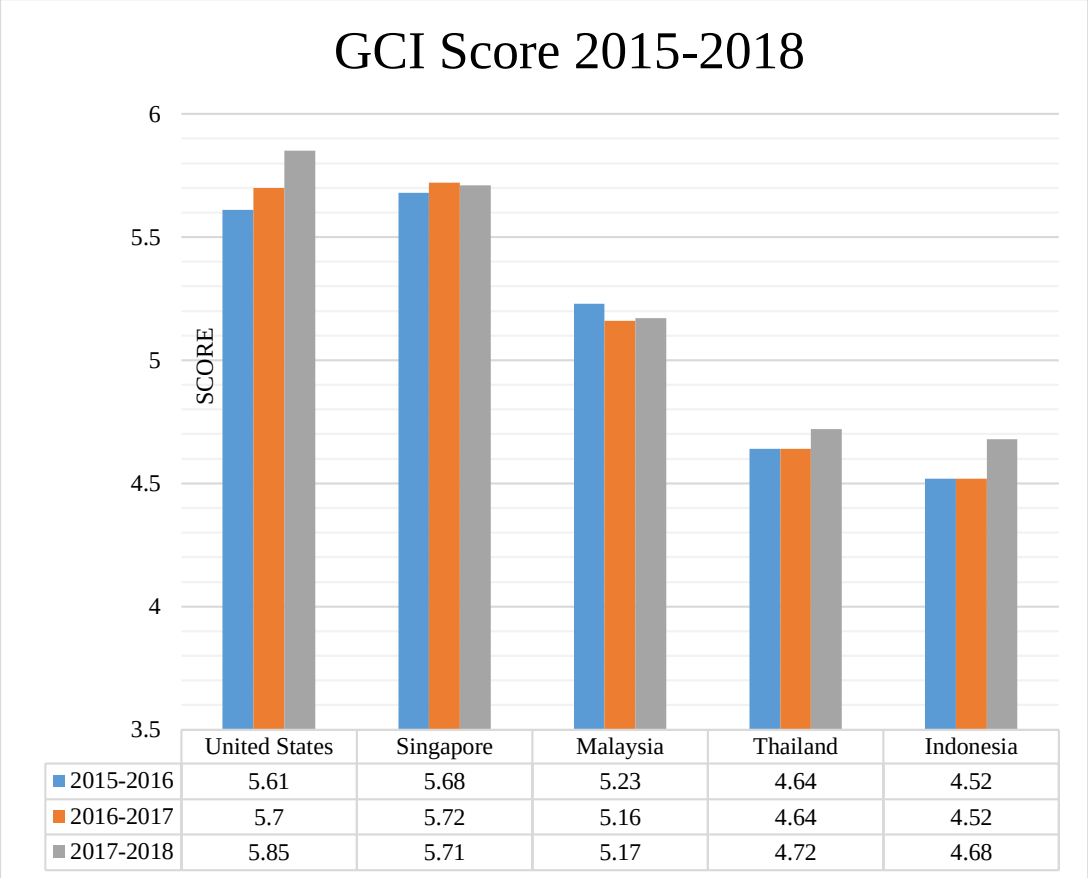
This chapter explained the background, problem formulation, research objectives, scope, and outline of the research.

1.1 Background

The Fourth Industrial Revolution (FIR) was firstly marked by the declaration of the German government regarding the term "Industry 4.0" during the 2011 Hannover Fair. The emergence of this new phase of technology was a manifestation of the adoption of internet and autonomous systems, such as the Internet of Things (IoT), Artificial Intelligence (AI), additive manufacturing, big data analytics, cloud computing, and others (Ustundag, AlpCevikcan, 2018). The emerging technologies are smart technologies that can autonomously communicate and coordinate to work together. It is no wonder that this implementation has pivotal role to develop the manufacturing and service sector due to its rapid renewal. Ustundag, AlpCevikcan (2018) also stated the significant impact that this fourth phase of industrial revolution offers regarding productivity. It is proven to increase productivity by new and wider employment opportunities. Under that impact, competitiveness level would also increase (Carayannis and Grigoroudis, 2014). This role—increasing competitive advantage—is one important point that drives a country's spirit in achieving successful implementation of emerging technologies. In this case, the World Economic Forum (WEF) reviews every country members' development. WEF has many indexes to say about productivity, technological investment/adoption, and even FIR readiness. Indonesia has several notes to consider on every assessment aspect.

Based on World Economic Forum (2017), Indonesia's Global Competitiveness Index (GCI) reached its highest value on 2017-2018 at 4.68 out of 7 and ranked 36 out of 137 countries, from which went up 5 rankings since 2016-2017 (ranked 41) under the score of 4.52—the same score with 2015-2016 ranking (ranked 37). However, Indonesia was unfortunately ranked 4th in ASEAN

(consistently from 2015-2018), after Singapore (latest score 5.85, ranked 3rd), Malaysia (latest score 5.17, ranked 23rd), and Thailand (4.72, ranked 32nd). This means Indonesia needs to excel up exponentially, regardless of the current achievement, especially associated with the progress of implementation of emerging technologies. The information of GCI score of some countries (including United States) starting from 2015 to 2018 is summarized in Figure 1.1 as follows. Different colours determine different year.



	United States	Singapore	Malaysia	Thailand	Indonesia
2015-2016	5.61	5.68	5.23	4.64	4.52
2016-2017	5.7	5.72	5.16	4.64	4.52
2017-2018	5.85	5.71	5.17	4.72	4.68

Figure 1.1 Some Countries' Competitiveness Score 2015-2018 (World Economic Forum (2017))

The metrics to find the GCI are comprised of 12 pillars and technological readiness is measured under the efficiency enhancer indicator. Technological readiness is measured by 7 sub-pillars. Those are 1) availability of latest technologies, 2) firm-level technology absorption, 3) FDI and technology transfer, 4) individuals using internet, 5) fixed broadband internet subscriptions, 6)

international internet bandwidth, and 7) mobile-broadband subscriptions. Technological readiness was trending upward globally up until 2018. However, there were some populations left behind and Indonesia was one of them. Indonesia's level of technological readiness of individual and firms had increased but insignificant—remained relatively low. In 2015-2016, Indonesia's technological readiness was ranked 85 out of 140 countries, ranked 91 out of 138 countries in 2016-2017, and ranked 80 out of 137 countries in 2017-2018.

In 2018, WEF revised its method in defining country's competitiveness index and developed the framework so that it matches the pressing challenges of the FIR era. Thus, it was called GCI 4.0. However, Indonesia's position had not progressed dramatically. What explicitly changed was the technological readiness metric is now represented by ICT adoption. Indonesia's GCI 4.0 in 2018 is 64.9 and ranked 45 out of 141 countries (World Economic Forum, 2018). Surprisingly, Indonesia scored 64.6 and ranked 50 in 2019 (World Economic Forum, 2019).

There were two other representative indexes published by WEF regarding the readiness level of countries facing the FIR, those were Networked Readiness Index (NRI) and Readiness for the Future of Production (FOP), based on World Economic Forum (2015b, 2016b). Both indexes: NRI and FOP, talked about ICT adoption and technological readiness broken into details. NRI measured the propensity for countries to exploit the opportunities offered by the use of information and communications technology (ICT). Here are the key findings depicted in Figure 1.2. Singapore ranked 1st in 2016 with an index of 6. Meanwhile, Malaysia indexed 4.9, Thailand 4.2, Indonesia 4.0, and Vietnam 3.9. In short, these two indexes: NRI and FOP, along with another referred indexes previously showed the lack of preparation Indonesia had in terms of resources and investment in technology.

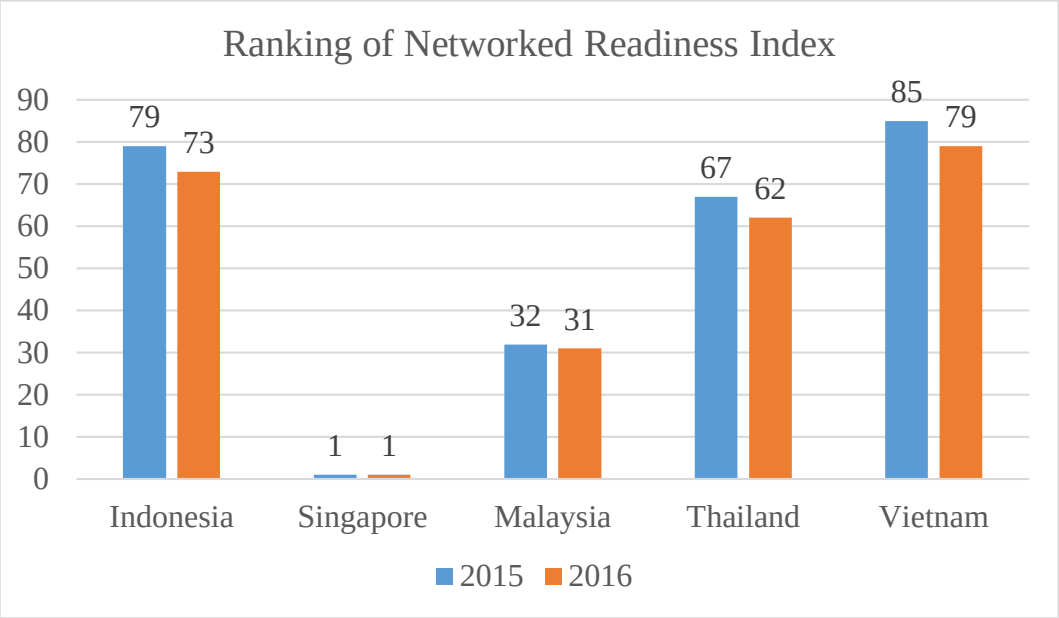


Figure 1.2 Ranking of Networked Readiness Index by WEF (World Economic Forum (2015b, 2016b))

For medium-large scale industries, currently, Indonesia has more than 24,000 industries with a variety of commodities listed in the Directory of Industrial Companies on Indonesia's Ministry of Industry website (2019). Each commodity has its own supply chain. Each of the supply chain areas, from upstream to downstream: from the procurement process, distribution to factories, production, storage (inventory), up to distribution to end customers has a wide scope and great potential for the installation of the emerging technologies. Indonesia has its options opened.

That being said, emerging technologies can widely be applied to supply chain activities. IoT for procurement activities, robots, and driverless vehicles for handling materials in warehouses, drones for package delivery or distribution activities, and block chain for tracking the status of goods—the development of this technology is remarkable. Even IoT had been applied to the scale of daily life. For example, exercise bike that allowed real-time information about activities carried out by the fitness group and continues to send heart rate data to the cloud with smarter sensors under the user's option. Real-time information is now applied in surrounding, not anymore a complex matter. Daily devices like electric

toothbrushes, refrigerators, electric meters, copiers, cellular devices, and many other appliances can be categorized as smart products because everything is now connected through Machine-to-Machine (M2M) communication. The technology had not just been "computerized", it had also equipped with a network interface. "Smart" is one of the keywords that plays an important role in interconnectivity (Mattern and Floerkemeier, 2010).

In order to be sufficiently “smart” and able to keep up with the era, there are some underlying indicators to which likely the same with the details from WEF indexes. In terms of both: 1) the amount of information and communication technologies expenditure and 2) the timeline of planning and policy launching, Indonesia was still behind some other countries. The data is shown in Figure 1.3 and Figure 1.4.

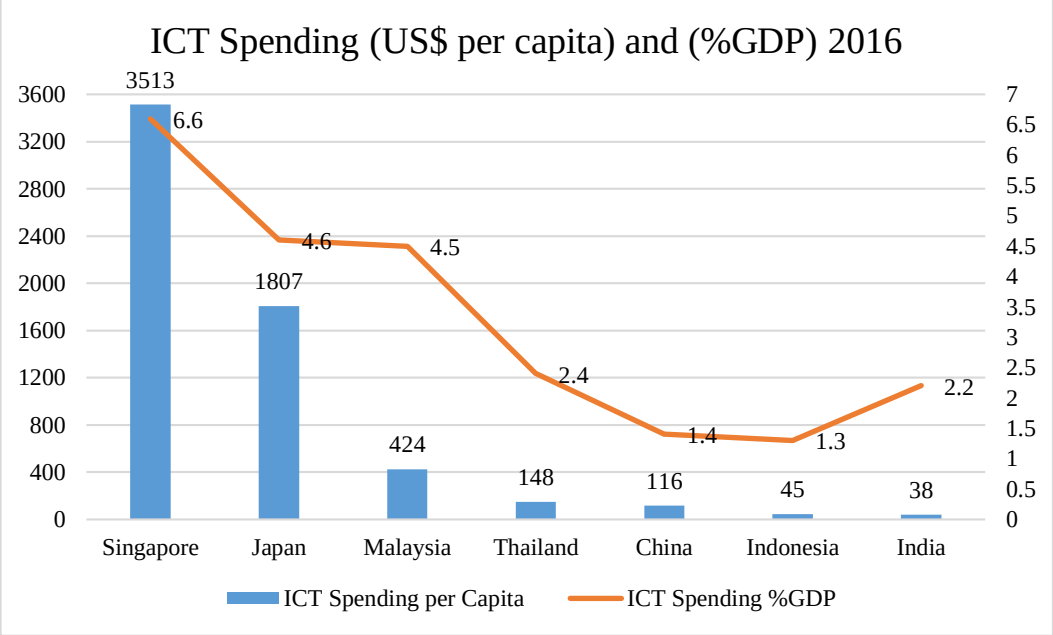


Figure 1.3 ICT Spending Year 2016 based on US$ per Capita and %GDP (Kearney (2017))

Based on the survey from AT Kearney (Figure 1.3), Indonesia had relatively low expenditure on technology needs both in terms of US$ per capita and percentage of GDP. Even though the population is very large, Indonesia was still below India viewed from the spending per capita.

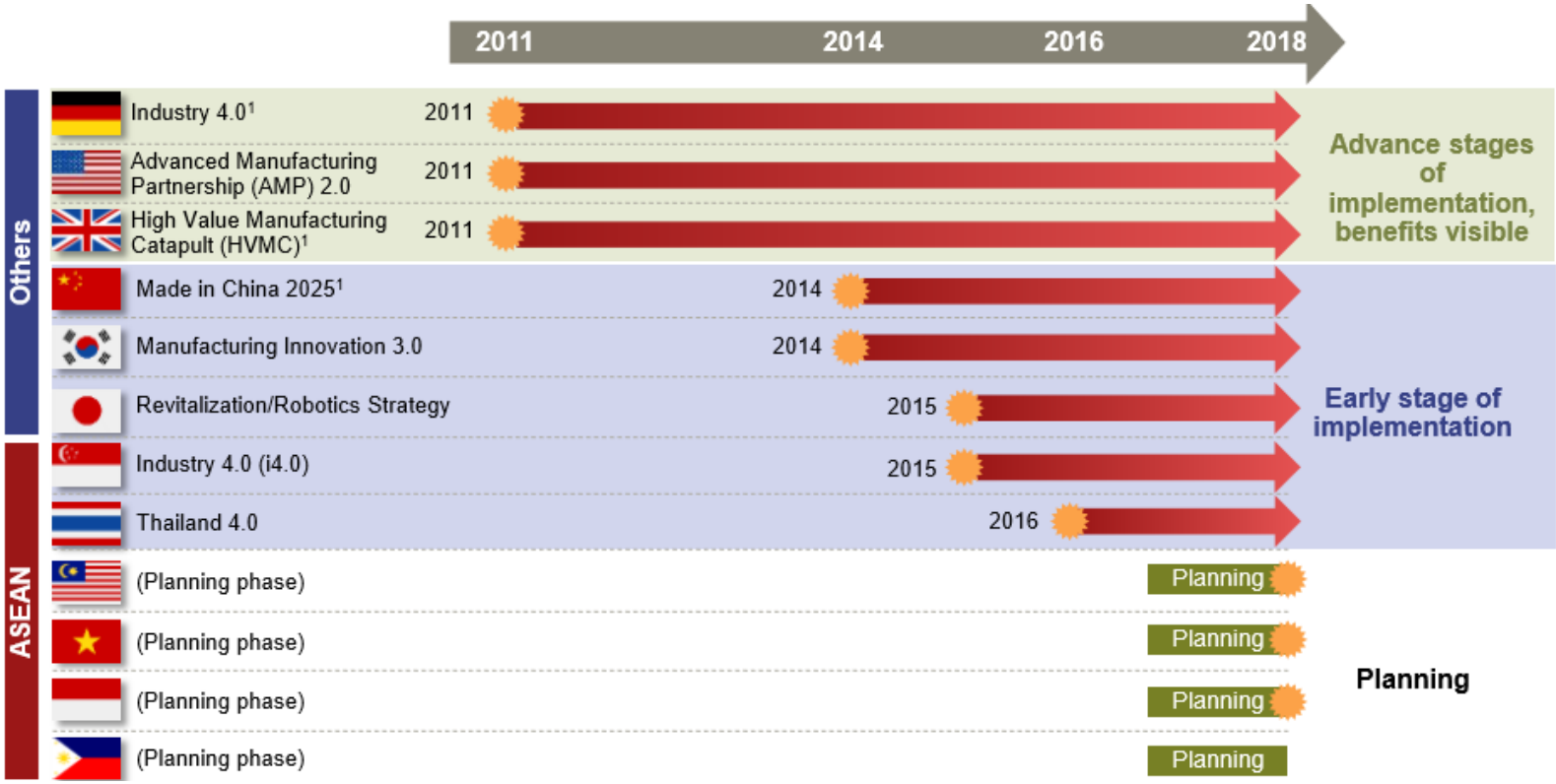


Figure 1.4 Maturity Level and Policy Launch Timeline of each Countries (Kearney (2017))

Additionally, based on Figure 1.4 from the same survey by AT Kearney, Indonesia was still in the planning phase towards the implementation of Industry 4.0 together with Vietnam, the Philippines, and Malaysia. The three levels of maturity represent a position of readiness relative to initiatives in implementing Industry 4.0. In terms of index, competitiveness ranking, and the readiness level from AT Kearney survey, and the amount of spending on technology, Indonesia was still behind Thailand in the scope of ASEAN.

Nevertheless, Indonesia is seen to have great potential to hit the fourth phase of the industrial revolution. In late 2018, Indonesia had set planning initiatives undertaken by the Ministry of Industry, named "Making Indonesia 4.0". The Ministry had set four big targets in 2030 and 5 industrial sectors that are focused on applying emerging technologies. The target is to become the Top 10 global economic powers based on Gross Domestic Product (GDP), doubling the ratio of productivity to cost, driving net exports to 10% of GDP, and budgeting 2% of GDP for development research. Indonesia, based on studies conducted by McKinsey, had adopted a self-check program to formulate its framework named Indonesia 4.0 Readiness Index (INDI 4.0), launched on mid-2019, a maturity model that had been tested to 328 industries and five of them were appointed as the *lighthouses*. This framework, however, showed a centralized focus on five sectors of industries: chemical, food and beverages, textile, and automotive (Kementerian Perindustrian, 2019)**.** The most prepared industry based on the results of INDI 4.0 was the engineering, procurement and construction industry with the INDI level of 2.74. This industry was followed by the textile industry with the INDI level of 2.51. The industry with the lowest preparedness level was the metal industry with the INDI level of 1.57. Meanwhile, the average score was 2.14 under the moderate-readiness level. How moderate does the readiness level of firms in Indonesia taken place knowing that all competitiveness indexes from WEF showed the same behaviour (which are lacking in technological readiness, ICT adoption, and investments)?

Indonesia also launched SINDI on late 2019, an ecosystem for the manufacturing industry in Indonesia to create a network of communication and

sharing regarding together facing Industry 4.0. However, it had not affected Indonesia's competitiveness indexes. Figure 1.5 shows the summary of milestones.

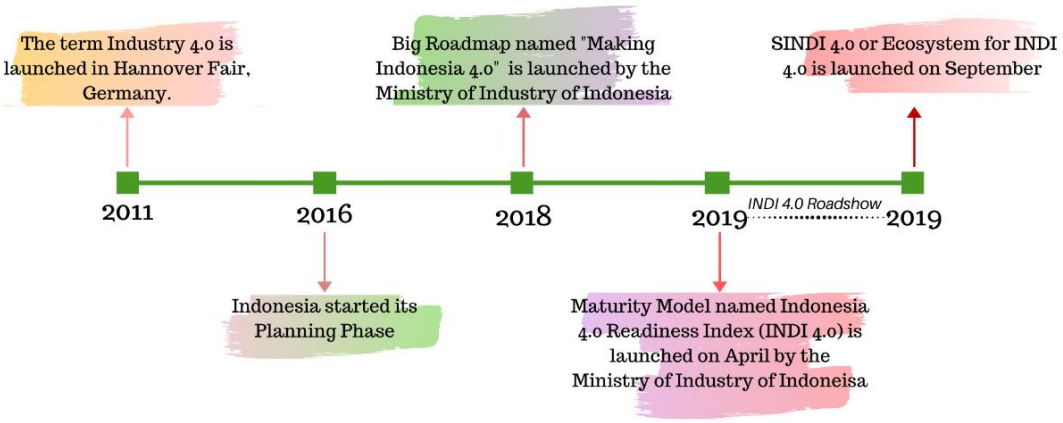


Figure 1.5 Milestones of Indonesia in the 4th Industrial Revolution

Maturity Model (MM) is a technique that aims as a guideline for a business to measure the relative comparison from the current condition towards its objectives and act as a metric to do benchmark and audit (Proença and Borbinha, 2016). The model has levels from lowest to highest, each level defines the position in which an organization has or has not fully achieved the targeted goals and of course with some evaluation criteria. Knowing that the significance of this maturity model is proof to where the industry is currently at, for a whole country level: the framework should be generic that it can be used flexibly to 24,000 industries composed from varied sectors: not only 5.

Thus, this research intended to explore the application of emerging technologies in supply chain area and to develop a comprehensive and robust maturity model because it accommodated information about the readiness level and its suitability with the needs or targets of each industry player. Specifically, this research focused to make the most representative/suitable maturity model for developing countries, in this case Indonesia, after analyzing several preceding maturity models. This research accommodated an extensive literature review to have strong fundamental and knowledge awareness regarding the current implementation of Industry 4.0 in real industries. Aside from that, the literature also

focused to review extensively the list of preceding maturity models, as a preliminary foundation to be able to minimize the 'limitation trend' in a maturity model. That being said, there were some common limitations such as: 1) segmented to specific function of areas or specific FIR technology, 2) lack of validation, 3) lack of model performance test (regarding relevancy, applicability, etc.).

The readiness level of firms in Indonesia are still unclear. There is not enough literature regarding any survey assessing the Industry 4.0 maturity levels of manufacturing industry in Indonesia, nor any academic paper developing maturity model in Indonesia. Also, having said that the 65% GDP contributor (the 5 focused sectors for INDI) have an average score of 2.14 (moderate readiness) but the assessment instrument is kept closed (confidential) and WEF indexes showed a contrast, this research developed a maturity model that is slightly custom but inclusive. In this case, the levels are not up to Advanced/Mature level. Otherwise, Absence until Moderate level are broken down into some representative levels that are more inclusive.

The highlight of the position of this research is that it has wide area to assess within a company, different from the preceding maturity models. Most of the previous models only assessed a specific process in the supply chain, such as only the manufacturing operation, delivery process, etc. This research has close naming to Supply Chain 4.0: assessing wholly up and down the stream. Moreover, the proposed model is not only segmented to 5 manufacturing sectors but generic. In addition to close the gap, some previous researchers have not accommodated double validation, model combination, and model performance test.

The validation incurred expert and web-based pilot survey under the Likert Scale scoring method. Gap analysis is taken into account to assess the variance of each industry. By attempting to minimize the above limitations and gaps, there are two outputs from this paper: the proposed maturity model and the assessment instrument.

1.2 Problem Formulation

Based on the aforementioned background, the problem going to be explored in this research is to have a proposed development of Industry 4.0 maturity

model based on various preceding models and literature review of emerging technologies—knowing that the usage trend may suggest the feasible technologies to apply for companies at early implementation phase. It is also intended to preliminary map out (with Pilot Survey) where do companies in Indonesia lay among the maturity levels through the assessment instrument. Specifically, to do the gap analysis regarding what pillars do they lack and how far they are towards their expected target.

1.3 Objectives of Research

The objectives that are going to be achieved in this research is a specific elaboration of problem formulation as follows:

1. To develop maturity model and assessment instrument based on the analysis of preceding maturity models (model structure, assessment, and support)
2. To use the assessment instrument to do pilot survey to map and find out the preliminary position of each respondent
3. To analyze the result of pilot survey through the gap analysis and model performance for model launch

1.4 Scope of Research: Limitations

The scope used to describe the boundaries of this research is explained as the limitations below:

1. This research is limited to the pilot survey until the model is valid to launch. Thus, it is not yet intended for a massive survey
2. Targeted respondents are workers in manufacturing companies operating in Indonesia. Manufacturing company is a business entity that operates machinery, equipment and labor in a process to convert raw materials into finished goods that have a sale value. It includes processing industry (B2B such as pulp industry) until consumer goods industry (B2C).
3. The SCOR process used is limited until Deliver process, not until Return and Mitigation processes.

1.5 Research Contribution

The main contribution of this research is the development of model/instrument making to measure specifically the early implementation phase of Industry 4.0 in Indonesia, due to a few academic paper handling this topic taking case in Indonesia. Other expected contributions would be:

- Filling the gap between progressive countries' research regarding the emerging technology adoption and lack of research regarding what happens in developing countries.
- Contributing key considerations and evaluations for companies in developing countries to restrain the prohibiting factors hindering them to adopt any emerging technologies

1.6 Research Outline

This subchapter explained the research outline used in this research report, which is explained as follows:

CHAPTER 1 INTRODUCTION

Introduction explained about the background of the research, the problem formulation aimed to be solved, the objectives planned to be accomplished, the expected contributions, the scope/the limitation used as the system under discussion, and the research outline as the report systematically brief-described in order per chapter.

CHAPTER II LITERATURE REVIEW

Literature review explained about the literature used to process the following chapter. This is used as the basis to solve the problem formulation with the detail explanation about the conceptual thinking. The literature review is taken from research journal, paper, books, reports, news or press releases, and other qualified resources.

CHAPTER III RESEARCH METHODOLOGY

Research methodology explained about the systematical thinking regarding the steps to do the research starting from the literature review until the closure. It provides thorough comprehension about the research procedure.

CHAPTER IV MODEL DEVELOPMENT

Model development explained the core process and has two outputs: the model and assessment instrument. The logic followed the flowchart in Research Methodology.

CHAPTER V PILOT SURVEY ANALYSIS

This chapter explored and analysed the result of the Pilot Survey in form of gap analysis. It can be seen from the best performing companies, dimension analysis and company gap analysis.

CHAPTER VI CONCLUSION

The conclusion explained the summary of findings and recommendation for future research and the research object. The conclusion is obtained from the result of data processing and analysis regarding the problem formulation and objectives of research.

CHAPTER 2
LITERATURE REVIEW

Extensive literature review is carried out under three big branches of focus, (with a brief explanation on the methodology for the literature review): emerging technology, maturity model, and gap definition. The first section mainly pointed out state-of-the-art of each technologies including the real-life examples. The second section described the significance of each preceding maturity model. The third section exposed the research position.

2.1 Methodology for the Literature Review

The guidelines to conduct literature review was inspired by G. Wang *et al.* (2016). Here is how the literature review is obtained.

a. The preceding maturity models incorporated are within the range of 2014-2019 because it depicts the growing trend in researches during that period (not much literature during 2011, the year in which term Industry 4.0 firstly released, until 2013).
b. The main material used in this research is a book published by Springer Series in Advanced Manufacturing under the title of Industry 4.0: Managing The Digital Transformation (Ustundag, AlpCevikcan, 2018).
c. The supporting materials are from journals based on Science Direct, Springer Link, IEEE Explore, ASME, and EconStor. The keywords used are the name of each technology pillar in Industry 4.0, “Industry 4.0”, “Industry 4.0 Maturity Model”, “Maturity Model 4.0”, etc.
d. Press releases, valid news articles, and reports regarding the real applications of the emerging technologies. The keywords used is “application of (technology name) in (company name)” such as “application of AR in Zara”. In doing this literature, the real applications shown in Table 2.1 is not the product of the technology provider, but the companies adopting the technology.

2.2 Emerging Technologies

The Nine Pillars of Industry 4.0 has set clear emerging technologies in this FIR. Those are, as shown in Figure 2.1 below, big data analytics, additive manufacturing, autonomous robotics, cloud computing, Internet of Things (IoT), cybersecurity, augmented reality, system integration, and simulation. This section carries out each technologies' definition, state-of-the-art, framework, and real life examples.

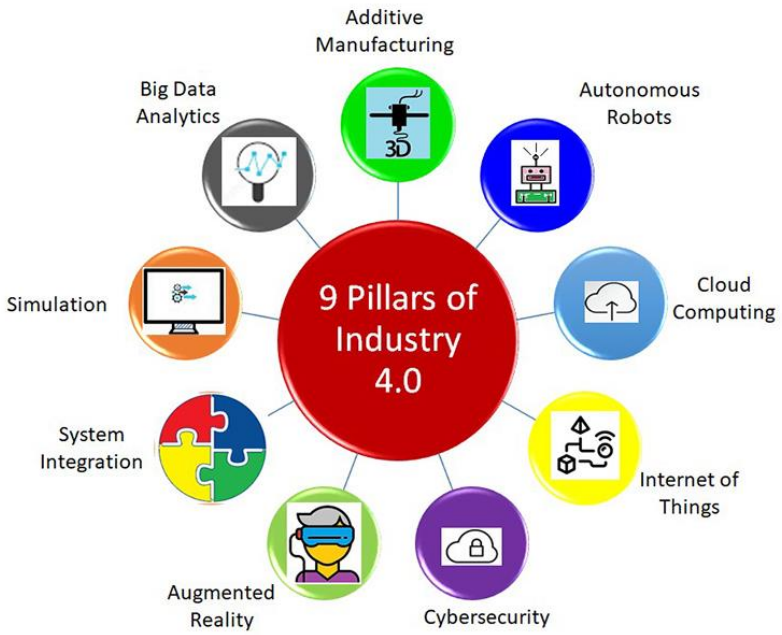


Figure 2.1 The Nine Pillars of Industry 4.0 (Source: Centre of Extension Education)

2.2.1 Big Data Analytics and Artificial Intelligence (AI)

The focus of big data analytics is more on defining "what will happen" rather than "what has happened", thus the data acts as a prediction and estimation of future possibilities or unknown events. The use of massive technology causes high volumes, high speeds, and complex data: Big Data (Lee, Bagheri and Kao, 2015). What defines "big" data can simply be put by 3 V's: Volume, Velocity, and Variety. The development is fast that now it is more common for 7 V's to be heard and accepted, those are Volume, Velocity, Variety, Variability, Veracity, Visualization, and Value. Not stopping there, there are also 10 V's, even a satire 42

V's of big data (Farooqi *et al.*, 2019). Figure 2.2 shows 7 V's that defines what is big data.

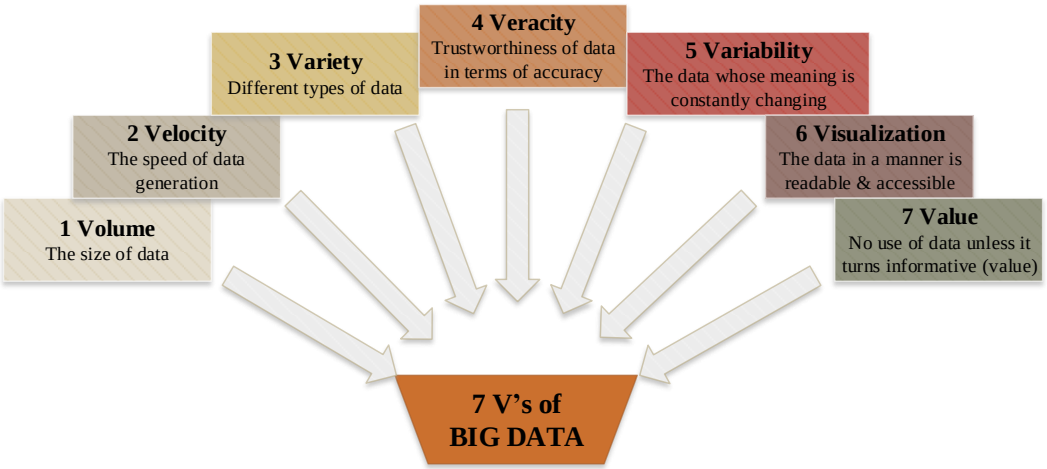


Figure 2.2 Own work processed from Khourdif, Alami and Bahaj (2018)

Because of a growing trend, big data shifts its use from data collection to analysis and results of data processing/outcomes (Esmaeilian, Behdad and Wang, 2016). In general, it includes three subtopics.

1 Descriptive Analysis: summarizes data and reports past conditions. This analysis responds the inquiry "What occurred and why?" and extract information from raw data (Delen and Demirkan, 2013). It is often to be said as "diagnostic analysis".

2 Predictive Analysis: forecasting phase. The output of descriptive analysis becomes one of the inputs as well as several algorithms and techniques in building predictive models. The analysis responds the question "What will occur and why?" (Delen and Demirkan, 2013).

3 Prescriptive Analysis: business value through better strategic and operational decisions. This analysis is about giving guidance and advice. It is likewise a predictive analysis that answers the question "What should I do and why?"

To have a better understanding in big data and able to manage and architect it better, Tekiner and Keane (2013) have made a 3 main stages with 7 layers of

processes (does not necessarily fulfilled completely) of big data framework as shown in Figure 2.3 below the explanation.

- Stage 1: Data selection and filtering

  Filtering data from multiple data sources is the first stage in big data framework. This remarks the major source of adding value from the data. Which data to proceed to stage 2 needs careful sorting and is different between companies.

- Stage 2: Data analysis and modelling

  Data sorted from stage 1 becomes the input for stage 2. In this stage, the data is processed to find relationships, correlations, predictions, and any other patterns. It needs data transparency between the technical and business level (the one the data originates or data source and the system/analyst).

- Stage 3: Data organization and interpretation

  It deals with modelling the information sources and mapping it while interpreting the meaning. Henceforth, it builds new information.

Researchers have used various tools to help the data analysis and modelling stage. G. Wang *et al.* (2016) researched the popular techniques for Supply Chain Analytics (SCA). The resulting taxonomy is broken down to three big branches: statistical analysis, simulation, and optimisation. Tan *et al.* (2015) used deduction graph as part of optimisation tools to assist SPEC company (a case study) to manage the production under two manufacturing departments with different competence sets. It overcomes the information connectivity problem. The proposed data analytic technique enable firms to utilise big data to gain competitive advantage by enhancing their supply chain innovation capabilities.

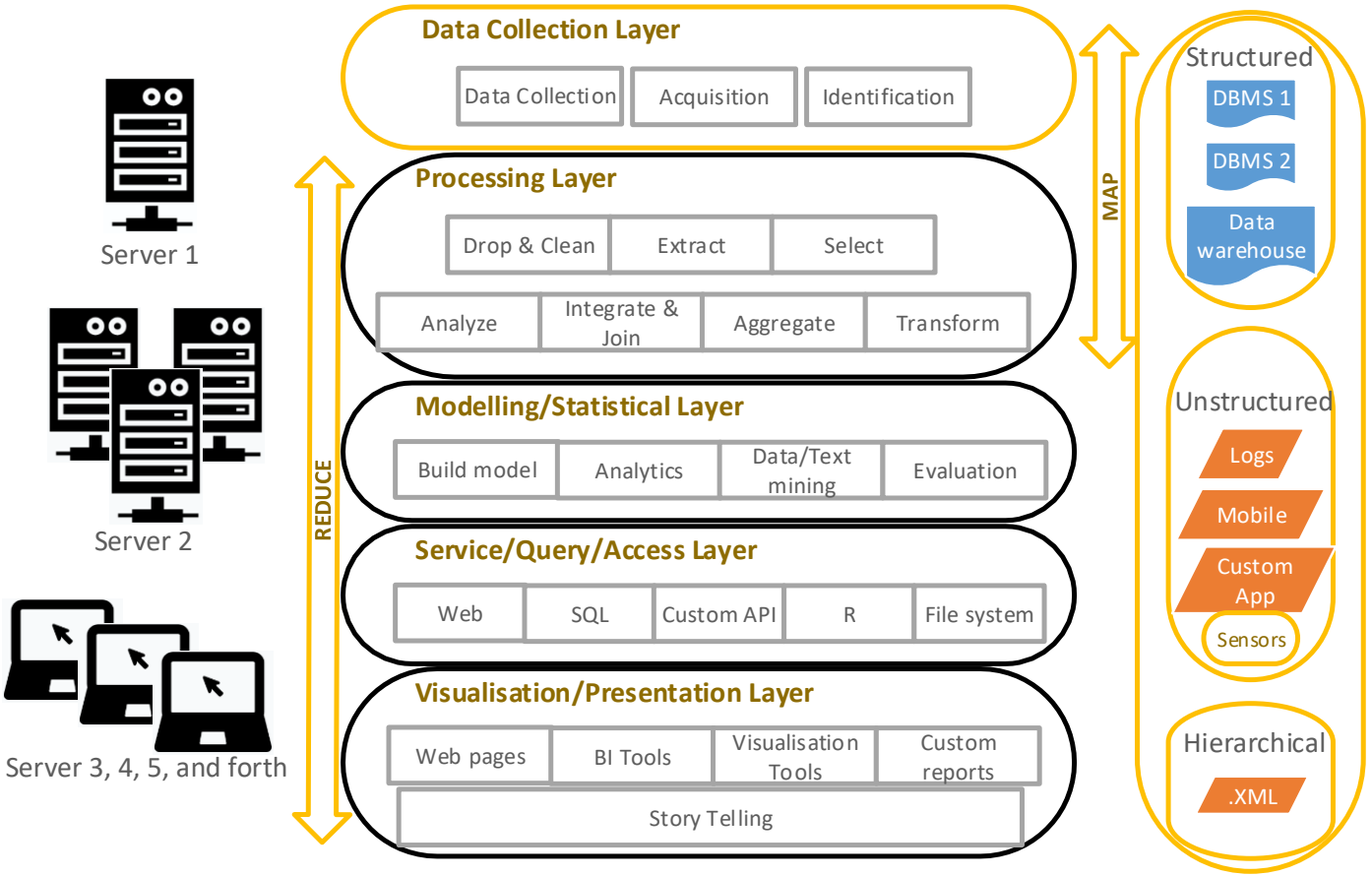


Figure 2.3 Big Data Framework (Own work processed from Tekiner and Keane (2013))

Previous researches on Big Data, beside the research on techniques mentioned previously, showed its widespread application. Big Data, if combined with IoT, can be powerful to change urban populations at different levels. Hashem *et al.* (2016) mentioned the possible applications of big data to support to build smart city are through diverse tools and methods such as smart grid, smart healthcare, smart transportation, and smart government. Meanwhile, Gepp *et al.* (2018) outlines the use of big data technique statistical tools in auditing—which area was considered not as widespread as other related field in using big data analytics. A possible explanation regarding that is that auditors are reluctant to use techniques that are far ahead of those adopted by their clients. However, greater alignment and future opportunities for big data in auditing is exposed in that paper.

Big data analytics is also applicable to use in term of "reducing data". Rehman *et al.* (2016) stated that "big data reduction at the customer end in which early data reduction operations are performed can achieve multiple objectives: (a) lower the service utilization cost, (b) enhance the trust between customers and enterprises, (c) preserve customers' privacy, (d) enable secure data sharing, and (e) delegate data sharing control to customers".

Meanwhile, AI is a technology that resembles human intelligence, depicted in computer responses. It resembles how human brains work, programmed from experiences. It can be stated as a digital program behaving in a way human used to, which involves continuous learning. It definitely helps the success of big data analytics through its computational capability and programmable learning in recognizing and processing data. All AI is composed from machine learning, and almost all machine learning is built on neural networks (deep learning).

i. Machine Learning

   Machine Learning is a subfield from computer science (technically from AI) which gives computers the "ability to learn without being explicitly programmed" (Samuel, 1969). Machine learning is important for industry 4.0 since it enables autonomy to software. It is one of predictive analysis that can predict: what will happen and why.

ii. Deep Learning

Deep Learning is the subset from machine learning, it often refers to deep artificial neural networks: a set of algorithms that have set new records in accuracy for many important problems, such as image recognition, sound recognition, recommender systems, natural language processing etc.

The real implementation of big data is during design and manufacturing processes such as the support for the successful digital manufacturing as Lidong and Guanghui (2016) mentioned. MapReduce and Google File System (GFS) are the programming model to run big data as the example of implementation used by Google (Chen, Mao and Liu, 2014).

2.2.2 Internet of Things (IoT)

Industry 4.0 initially started with the presence of Cyber-Physical Systems or CPS (transformative technology to manage systems that are interconnected between physical assets and computing capabilities) and the Internet of Things or IoT (a framework of interconnectivity between sensors and machine networks). By using IoT, various signals such as motion, vibration, pressure, heat, etc. can be extracted. Not only those signals, IoT also enable to collect and exchange data using electronics, software, and network connectivity. This technology has various applications such as smart agriculture, smart city, smart life or wearable technologies, smart health, smart factory, etc (Ustundag, AlpCevikcan, 2018).

In short, IoT is an advancement that enables a system to communicate autonomously to each other under a set of activities that creates big data for further analysis. Here are some examples of IoT.

iii. Embedded Systems (Cyber Physical System) using sensors and actuators: 1) Smart Factory, 2) Smart Product, 3) Smart City, and 4) Smart Life: wearable technologies such as smart watch, lenses, smart shirt, etc.

iv. Digital Traceability (advanced sensors: RFID, RTLS) and actuators

v. Mobile technologies

All of the above examples of IoT have the same basic framework within them. It usually starts with a sensor or any physical sensing/data gathering devices

which data are transferred to an actuator to literally actuate regarding what reaction is needed. That remarks the gateway for the following action in the middleware sent through an internet. The middleware is the bridge that manages the sensed "thing" from the physical layer to communicate with the application layer. Lastly, the application layer direct the input onto applications that can be used by the consumer to send commands to real word objects over the Internet via gadgets, website, mobile application, etc. Figure 2.4 has the summary.

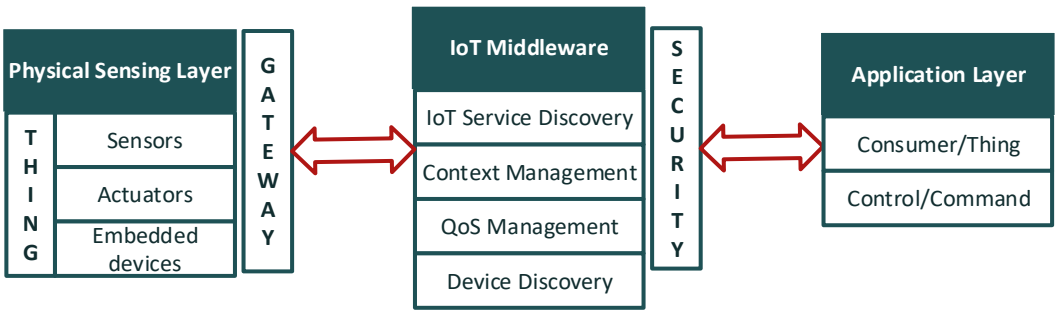


Figure 2.4 IoT Basic Framework (Kotonya and Uviase (2018))

Researches have shown the use of IoT in building "things" smartly. From the smallest scale of "things"—household, IoT can play a role. Javed *et al.* (2016) presented Smart Pantry, which used IoT integrated with cloud computing, the technology would monitor the pantry and alert the user, either via text or webapp, about shortages and recommend products for a grocery list. The system uses an Arduino microcontroller to collect weight information about products in the pantry, a Raspberry Pi microcomputer equipped with a camera to take pictures of the pantry, and a gateway server to process this information to be sent to the central server. Bigger scale—Smart Transportation, Handte *et al.* (2016) presented the Urban Bus Navigator (UBN), an IoT enabled navigation system for urban bus riders, which provides micro-navigation and crowd-aware route recommendation. Even Gooch *et al.* (2015) presented the possible involvement of citizens in smart city project.

Advanced Forming Research Center (AFRC) and University of Strathclyde have used an Android tablet to control CNC machine over an internet using an IoT interface named BAUTA (Lee, 2018). In field of fluid power, Alt, Malzahn, and

Schmitz (2019) mentioned that Plug-and-Produce business model is proposed to realize the real-time communication, CPS base system, for the electro-hydraulic actuator (EHA).

2.2.3 Virtualization Technologies

Virtual technology displays information virtually where improved perceptions are accessed and manipulated. Examples are Augmented Reality (AR) and Virtual Reality (VR). One example for VR is like the sport-game that is head mounted. It is not far different from AR which complements the human senses because it can provide more comprehensive information that cannot be understood by humans, such as a smartphone camera, head mounted display (HMD), projection devices, with 3D models, speech instructions, scanners lens, etc. (Ustundag, AlpCevikcan, 2018). It is widely implemented in the manufacturing sector, including production, assembly, maintenance, etc. Generally, VR requires three support: application, rendering system, and operating system, as shown in Figure 2.5 below.

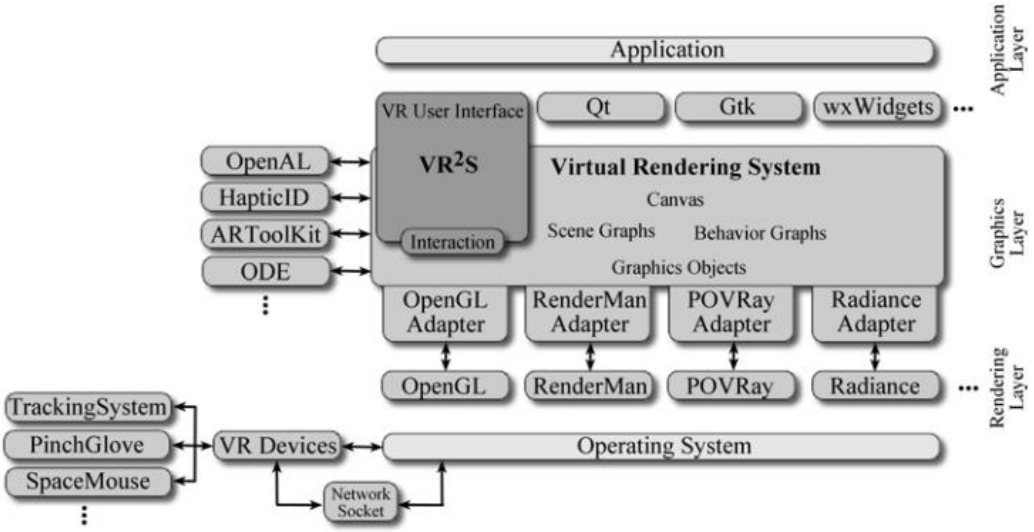


Figure 2.5 Generic VR Framework (Steinicke, Ropinski and Hinrichs (2005))

Daqri, a smart helmet, is one of the real implementation of AR and it presented a high-performance multimedia and data visualization (Ustundag, AlpCevikcan, 2018). In field of logistics, DHL has applied AR to its warehouse

where the workers heading to work and pick by vision. At the storage, the worker merely scans the bar code with smart devices like glasses, which emits codes telling where to go, how many to pick, and where to place next (Ustundag, AlpCevikcan, 2018). Beside DHL, AirBus military generating assembly instruction in its shopfloor using AR namely Project MOON (Servan *et al.*, 2012).

2.2.4 Cloud Computing

It is a cloud-based operating that includes computing, that frees the company from setting up basic hardware and software infrastructures and the associated investments. Cloud computing is an on-demand delivery of computational power, data storage resources, software, and other IT resources through a platform via the internet (Ustundag, AlpCevikcan, 2018)**.** Cloud computing enables centralized information for industry 4.0 applications and offers a platform collaboration to advance and refine research for entire industry gains. Everything is a service in a cloud computing (e.g. SaaS or Software as a Service, PaaS or Platform as a Service, and IaaS or Infrastructure as a Service).

Saas uses the web to deliver applications that are managed by vendor and the client accesses the interface. IaaS is self-service to access, monitor, and manage remote datacentre infrasrtuctures, such as storage, networking, and networking services. Instead of having to purchase hardware, users can purchase IaaS based on needed consumption. PaaS is used for applications and other features while providing cloud components to software. What developers provide with PaaS is a framework they can build upon to develop or customize applications. In summary it is shown in Figure 2.6 below.

The real world implementation has touched widespread areas such as long ago in 2008 came the deal between Google and salesforce.com to share critical documents without having to download/install hardware/software (Buyya, Yeo and Venugopal, 2008). Besides, now, there are numerous cloud platforms such as Kamatera, phoenixNAP, Amazon Elastic Compute Cloud, Microsoft Live Mesh, Sun Grid, GRIDS Lab Aneka, VMWare, etc. Elkay Manufacturing Company has long used cloud-based solutions for their stainless steel business since 2012 (Xu, 2012). Cloud-DPP (Cloud-based Distributed Process Planning) as the result of

effort between KTH and Sandvik, Sweden, able to generate any adaptive-to-changes machining process plans (Wang, Törngren and Onori, 2015).

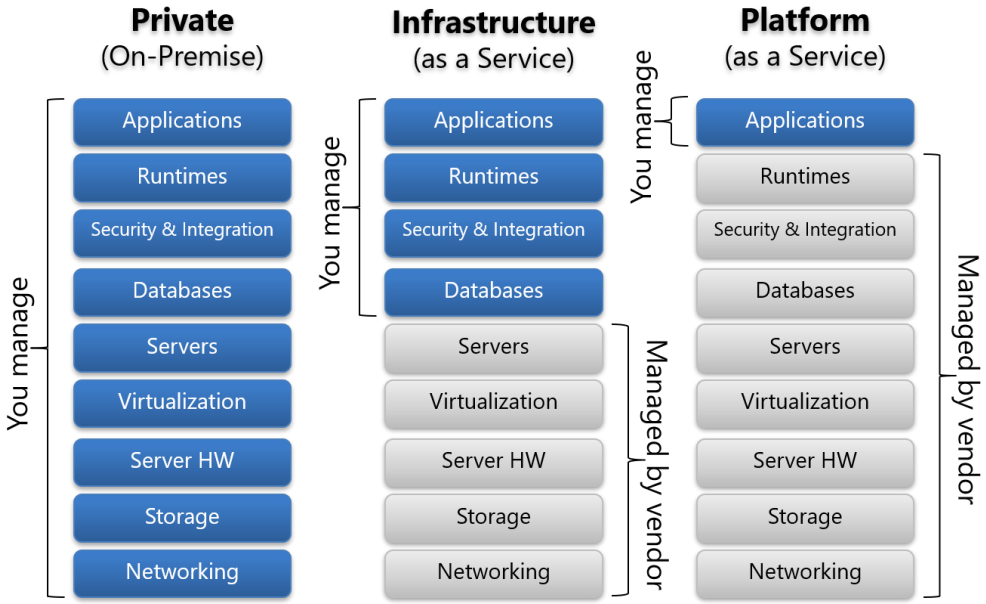


Figure 2.6 Cloud Service Models (Chou (2018))

2.2.5 Autonomous Robotics

Sophisticated robotics is useful for reducing costs in a system, with regard to how to handle dangerous and risky tasks for humans to produce under faster processes and more accurate results. Some advances in robots are face sensors, artificial intelligence, internet of robotic things, cloud robots, cyber-physical robots. (Ustundag, AlpCevikcan, 2018). In supply chain, this technology is implemented in operations such as the assembly process, manufacturing process, and more towards operations that occur in incoming logistics.

Figure 2.7 below shows a general framework of autonomy in robotics. It begins with defining the task the robot is intended to perform. It is done by defining the variables attached to the tasks. It is continued with its subcomponents under the aspect definition. Then, the limit between human intervention and robot autonomy is defined, followed by categorizing robot autonomy into details, until the relationship of each state of autonomy with the HRI variables is assessed.

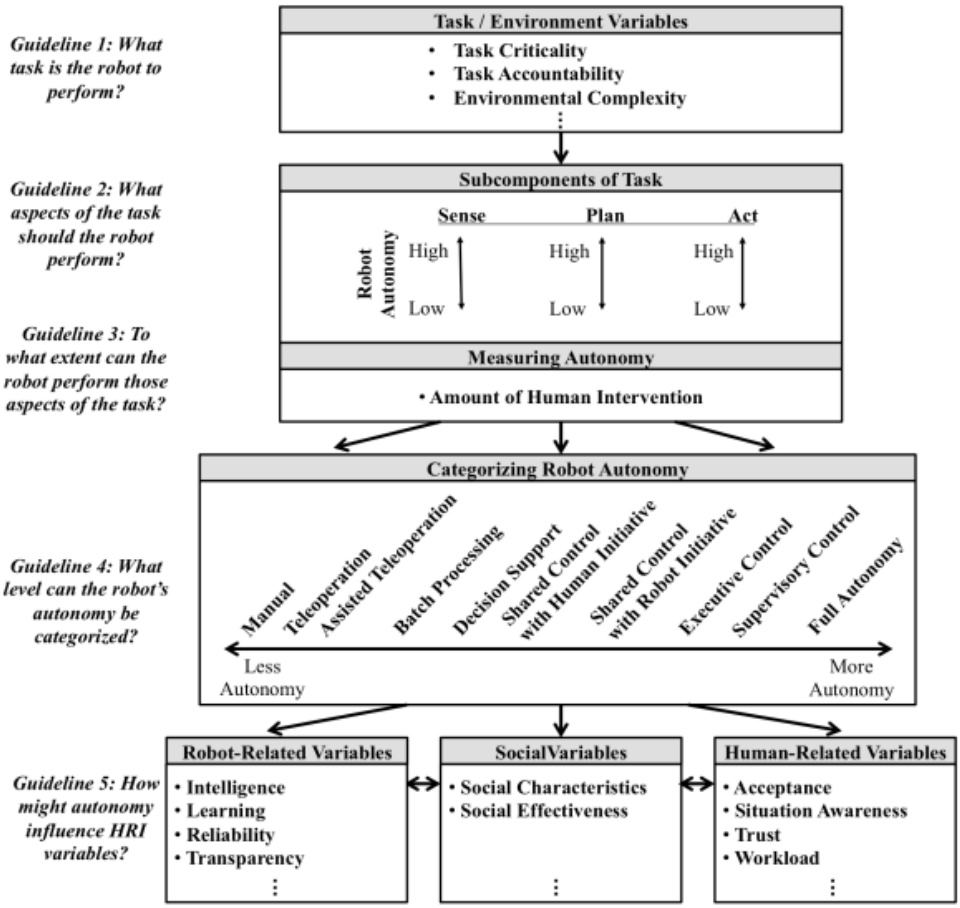


Figure 2.7 Taxonomy to Robot Autonomy (Beer, Fisk and Rogers (2014))

The real implementation is a robot named Yumi (ABB manufacturing operations) that has flexible parts-feeding mechanism, location detection system, advanced motion control adaptive towards ABB Contact (2014). Another implementatioin is Kuka KR Quantec Robot that can deliver the ordered KANBAN boxes from the warehouse rack. Another advanced robotics are such as workerbot by pi4, HRP4 Kawada Industries, SpotMini Boston Dynamics, hanson robotics Sophia, etc.

2.2.6 Additive Manufacturing (AM)

Additive manufacturing uses 3D Computer Aided Design (CAD) or commonly called 3D printing. This technology helps decision makers by producing prototypes or layers by layers (Ustundag, AlpCevikcan, 2018). This makes it

possible to create complex and custom geometries that cannot be produced using conventional manufacturing techniques. It is clear that this is also widely applied in the manufacturing sector. Figure 2.8 shows an approach to 3D printing design. It is broken down to three big stage (product concept as the input): functional analysis, product structuration (laying out the product, functional interface, and AM contextualization), and part design to define the geometries.

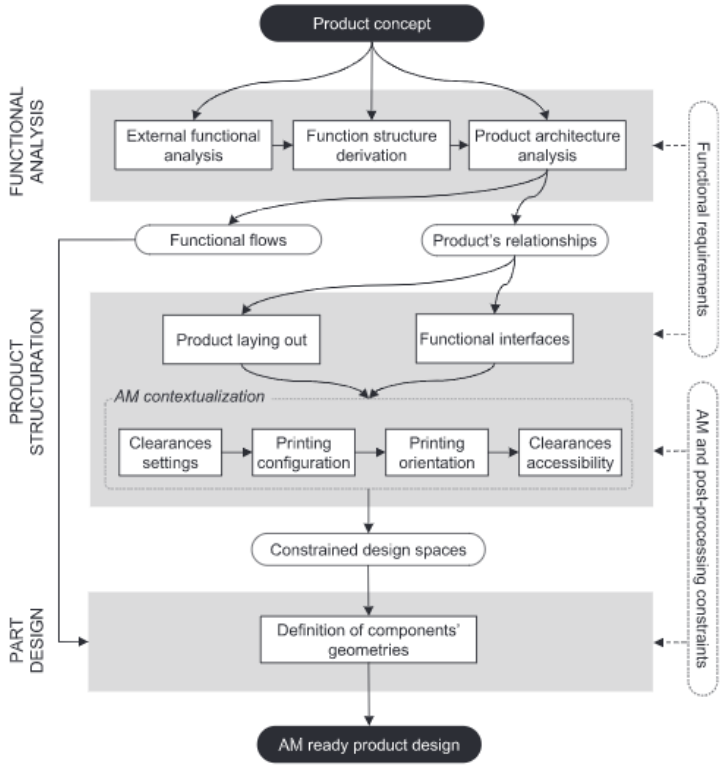


Figure 2.8 Additive Manufacturing Design Approach (Sossou *et al.* (2018))

Real example is ARBURG GmbH that unites injection moulding and additive manufacturing (VDMA, 2016). It is linked with Allrounder injection moulding machine to create high volume plastic products. Besides manufacturing sector, in automotive, CRP Technology (Italy) to has produced parts using AM: MotoGP 250R air boxes, camshaft covers for MotoGP engines, F1 gearboxes, motorbike supports, and dashboards (Guo and Leu, 2013).

2.2.7 Horizontal and Vertical integration

Vertical integration applies to the versatile and reconfigurable structures within the factory plant and the extent to which they are fully integrated in order to achieve agility. Meanwhile, horizontal integration deals with each tier integration within the supply chain. In order to optimize system performance and send it into the cloud, the industrial network gathers Big Data. This coordination mechanism creates the framework of the smart factory. Therefore, the manufacturing systems are designed as self-organized structure that integrates every physical objects each other through smart networks. Besides, cloud based systems enable vertical partners to integrate each other through shared platforms. The product and process flows would be visualized and tracked by SC members (S. Wang *et al.*, 2016)

2.2.8 Cybersecurity

Cybersecurity is that part of Information Security which specifically focuses on protecting the Confidentiality, Integrity and Availability (CIA) of digital information assets against any threats or cyber-attacks, which may arise from such assets being compromised via (using) the Internet. The perfect example of technology that serves cybersecurity is blockchain.

Cybersecurity usually resulted as response to risk. Hence, a company needs to breakdown its cyber or any related risks in order to plan the cybersecurity strategy, framework, policies, and standards (CGI, 2019). Below is the basic framework of what cybersecurity does.

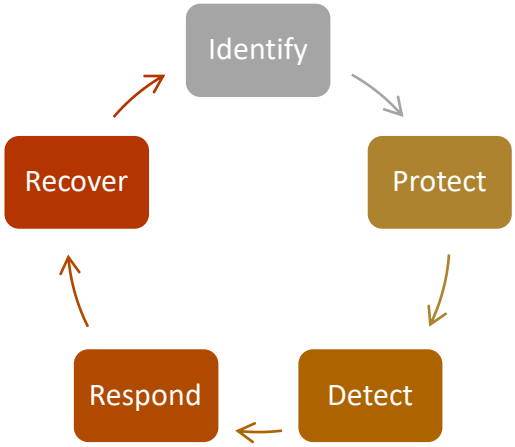


Figure 2.9 Cybersecurity Framework (Gurudutt (2018))

It is started from ‘Identify’ process, derived from the risk event in the company relating with cyber. Whenever the risk event occurs, the security would protect what was attacked at the moment. Meanwhile, the system would detect to better comprehend the situation. The output from the Detection process become the input to the Respond process. It actuates the command and lastly does the recovery.

One implementation of cybersecurity is the CodeMeter by Wibu-Systems AG that IP protection mechanisms prevent illegal copying, data theft, reverse engineering of software, and product counterfeiting, Freud detection, and cyber-attack identification (Ustundag, AlpCevikcan, 2018).

2.2.9 Simulation

Before the realization of new paradigm, system should be tested and reflections should be carefully considered. Thus, diversified types of simulation including discrete event and 3D motion simulation can be performed in various cases to improve the product or process planning (Kühn, 2006). For example, simulation can be adapted in product development, test and optimization, production process development and optimization and facility design and improvement. Another example could be given from Biegelbauer (2004) study that handles assembly line balancing and machining planning that requires to calculate operating cycle times of robots and enables design and manufacturing concurrency.

In the perspective of Industry 4.0, simulation can be evaluated as a supportive tool to follow the reflections gathered from various parameter changes and enables the visualization in decision-making. Therefore, simulation tools can be used with other fundamental technologies of Industry 4.0. For instance, simulation based CAD integration ensures the working of multiple and dissimilar CAD systems by changing critical parameters. Additionally, simulation can reflect what-if scenarios to improve the robustness of processes. Especially for smart factories, virtual simulation enables the evaluation of autonomous planning rules in accordance with system robustness (Tideman, 2008). One exact example is Siemens Tecnomatix Plant Simulation, it enables to simulate production facilities, lines, and processes up until the complex process such as robotic path planning, signal definition based on real HW, Boolean and analog logic, etc (Rodič, 2017).

The above nine pillars of Industry 4.0 can widely be applied to supply chain activities either strategic (SC strategy, product design and development) or operational (demand planning and customer service, marketing, procurement, warehousing, production, and logistics), here is the summary of emerging technologies implementation table obtained from various resources.

Table 2.1 Real Applications of Emerging Technologies in Several Companies

No	Company	Technology	Application
1	Zara	RFID, IoT	Sales tracking data using RFID microchip tagged in clothes updated realtime in Inditex central data processing center. (Hansen, 2012) RFID enables the stockist determine which items need replenishment and where to locate, which has made their inventory and stock takes 80% faster than before (Inditex, 2015).
		Big Data Analytics, AI	Collaborating with Jetlore and El Arte de Medir (Spanish big data company) to have AI-powered consumer behaviour prediction platform. Zara tailors its collections based on the exact ZIP code and demographic that a given location serves (Hansen, 2012).
		Robotics	Use robots in retail backrooms to search for orders and deposit them in drop boxes for in-store collection (RetailWire, 2018).
		Augmented Reality	AR application for shopper: showing models wearing selected looks from its ranges when a mobile phone is held up to a sensor within a store or designated shop windows and allows customers to click through to buy the clothes (Sandler, 2018).
2	Unilever	Big Data Analytics	Strategic analytics initiative called Project iQ with its solution partner, MindTree, help tracking and improve shelf-availability reducing stockouts (Ackerman and Padilla, 2013).
		Cloud Computing	Using Google Cloud to precisely target its consumers and implemented Global People Data Centres (PDC) for customer engagement center (Sheth, 2019).
		AI	Collaborating with Pymetrics, a specialist in AI recruitment, to create an online platform, which means candidates can be initially assessed from their own homes, in front of a computer or mobile phone screen (Marr, 2018).
		Robot	Unilever's Gloucester (ice cream) factory uses bespoke packaging automation robot pick and place and unloading system by Linkx (2019).
		3D Printing	Unilever has cut lead times for prototype parts by 40% since introducing Stratasys' PolyJet 3D printing technology into its manufacturing process (Stratasys, 2015).
		Augmented Reality	Unilever launches its on-pack AR on the eco-refill packaging for the Cif detergent. Consumers can refill their already used spray bottles with an "eco-refill" (Reiner, 2019).
3	Toyota	Simulation	Collaborating with Global Institute for Motor Sport Safety to use virtual human modeling to simulate exactly what a body goes through during collisions in racing situations (Toyota, 2015).
		Cybersecurity	PASTA:Portable Automotive Security Testbed with Adaptability developed by Toyota InfoTechnology Center, a platform allowing researcher/engineers to freely construct in-vehicle networks. PASTA would contribute to accelerate research, education, and information sharing of vehicle cybersecurity as an open and handy platform which has typical physical attack surfaces (GitHub, 2019).

No	Company	Technology	Application
		Robot, VR	Toyota Research Institute uses VR to train robots as in-home helpers (Fisher, 2019).
4	Samsung	Cloud Computing	Kinaxis provides RapidResponse technology for Samsung to integrate planning functions especially S&OP, Master Planning & Scheduling (Kinaxis, 2018)
5	Siemens	IoT	MindSphere, open IoT operating system from Siemens with access to Amazon Web Services (AWS) and Microsoft Azure and Alibaba public cloud services (Siemens, 2019).
6	Schneider Electric	Virtualization Technologies	Schneider electric EcoStruxure Augmented Operator Advisor: reduce mean time to repair, superimpose the current data and virtual objects onto a cabinet, machine, or plant (2017).
		IoT	Schneider Electric RFID OsiSense: Eliminated 128 daily fork truck miles and eliminated $500,000 in Work in Progress (WIP) inventory with a 33% first-year ROI (2019).
		Simulation	Schneider Electric integrated Simio simulation with their real-time manufacturing execution systems (2018)
7	Colgate Palmolive	Virtualization Technologies	Realwear HMT-1 device is used by Colgate Palmolive's workers to enhance performance such as noise cancellation prior to voice recognition (RealWear, 2018).
8	Elkay Manufacturing	Cloud Computing	Elkay Manufacturing Company cloud-based solutions for their stainless steel manufacturing (2012).
9	AirBus	Virtualization Technologies	AirBus military generating assembly instruction in its shopfloor using AR namely Project MOON (Servan *et al.*, 2012)
10	Apple	Cloud Computing	Apple iOS used Amazon S3 and Microsoft Azure in 2014, and 2016 started using Google Cloud Platform (2018).
		Simulation	Amazon, Apple, Michelin, Toyota, IBM, ABB, Ford, etc. used FlexSim for their 3D simulation modelling (FlexSim, 2019).
11	Nestle	Cybersecurity	Nestle and Carrefour used blockchain platform of IBM Food Trust for product traceability (Nestle, 2019).
12	Nestle	Cybersecurity	Nestle open new blockchain pilot with OpenSC (Open Supply Chain by BCG) to trace milk from producers in New Zealand to factories and warehouses in the Middle East (Nestle, 2019).
13	GEP	Robot	Robotic Process Automation (RPA) in Procure-to-Pay solution by GEP (2019) for transaction and contract management.
14	DHL	Virtualization Technologies	DHL applied AR Pick-by-Vision: workers scans the bar code with smart glasses with codes telling where to go, how many to pick, and where to place next (2018).
15	DHL	Cybersecurity	DHL Supply Watch: supplier monitoring to mitigate risk by DHL Resilience 360 (2019).
16	ABB	Robot	Yumi (ABB manufacturing operations) that has flexible parts-feeding mechanism, location detection system, advanced motion control adaptive towards ABB Contact (2014).
17	Wibu Systems AG	Cybersecurity	CodeMeter by Wibu Systems AG (2018)

No	Company	Technology	Application
18	PINC AIR	Robot	PINC AIR Hardware: autonomous drone-tech with AI, and RFID for inventory and yard check and replace traditional rolling ladder (PINC, 2019).
19	Boston Dynamics	Robot	Handle, robots for logistic by Boston Dynamics for loading and unloading activities (2019).
20	La Poste France	Big Data Analytics	Supported by Sopra ISD, La Poste Courrier has proposed its platform solution based on the Big Data. It is a new version of search engine using CloudView technology (Zhong *et al.*, 2016).
21	Nippon Express Co. Japan	Big Data Analytics	NEC currently launched a project based on OpenFlow network control technology to manage its Big Data as a datacenter over cloud networks so as to improve efficiency and reduce operating costs (Zhong *et al.*, 2016).

Source: Author's Work of Literature Review

2.3 Literature on Industry 4.0 Maturity Model

Extensive literature review on the preceding maturity model is carried out. The information regarding the model structure (author, year published, country, origin, dimension, and level) is seen in the following Table 2.2. There are four classifications of origin of the author: 1) Government, 2) Practitioner, 3) Research institute/Academics, and 4) Consulting companies. These 31 models are published in the range of 2014 until 2019. The following narrative explained some of the models regarding its contribution to the proposed model and some strengths and weaknesses.

2.3.1 INDI 4.0 by Ministry of Industry of Indonesia

This model is the main reason this research shows its contribution. Launched on April 2019, it has been tested to 328 manufacturing companies in Indonesia. It only focuses on five priority sectors:

1. Food and beverage
2. Textile and garment
3. Automotive
4. Electronics
5. Chemical

Based on the reasons that these five industry sectors contribute 60% to the manufacturing GDP, 65% to the total manufacturing export, and 60% manufacturing labor in Indonesia. It is depicted in a sector prioritization matrix under the feasibility versus impact axis (Antara, 2019).

Meanwhile, Indonesia has launched a framework named Making Indonesia 4.0, in which one of the goals set is to be the big 10 of world economy in 2030. 2030 is more than a decade to be able to focus more than only 5 industry sectors for its maturity to be assessed. Moreover, the average score of those 328 companies is 2.14, which is in Moderate Readiness, with this detail: average score of Technology is 1.95, 2.06 for Factory Operation, 2.12 for Management and Organization, 2.16 for People and Culture, and 2.41 for Products and Services. The questionnaire is not publicly accessible. Thus, it is hard to measure further: how good and how bad is total average score of 2.14 (Kementerian Perindustrian RI, 2019b).

Again, this model is the main reason this research shows its contribution. Indonesia needs “accessible” model to assess, inclusively, companies operating in Indonesia. Additionally, there is no academic paper with the case study specifically assessing manufacturing industry in Indonesia.

2.3.2 Industrie 4.0 by IHK

A local government in Germany develops this model. The questionnaire is accessible online, self-assessment method, using German language. What can be taken from this model is the final report interface. It reports every dimension maturity model along with the explanations. It has details for each questions in each dimensions.

Besides, the assessment method is 5-tiered Likert Scale, the same with its Maturity Levels, which consist of 5 levels. However, in each questions, the options are not in an ordinal naming of scale. Instead, it is described. In addition, each options has its additional information as the elaboration to prevent any misperception from the respondent.

2.3.3 IMPULS by IW Consult

IMPULS Foundation has established Industry 4.0 Readiness online self-check for businesses. The author is IW Consult, subsidiary of the Cologne Institute for Economic Research and Institute for Industrial Management at RWTH Aachen University. This model is advised and commissioned by IMPULS Foundation of German Engineering Federation (VDMA). IMPULS has 6 dimensions and 6 levels.

The interesting thing about IMPULS is that it has good model support in terms of questionnaire accessibility and the quality of report. The model structure is also interesting, since the assessment is not purely Likert Scale. It accommodates questions such as the list of technologies that the respondent has, the investment plan, etc. and it is custom regarding either type of industry sector, mechanical or manufacturing. However, the targeted company is limited to only those two and the algorithm remains black box.

2.3.4 Proposed Industry 4.0 Maturity Model by Kartal Yagiz Akdil, Alp Ustundag and Emre Cevikcan

The Proposed Industry 4.0 Maturity Model, 2018 are done by academics from Turkey. It incorporated the previous studies: IMPULS, Digital Operations Self-Assessment by PwC, the Connected Enterprise Maturity Model by Rockwell Automation, and Industry 4.0 Maturity Model by Schumacher et al (2016). Under varioius associated fields such as production, logistics, procurement, R&D, after sales service, promotion, human resources, IT, smart finance, business models, etc., the dimensions are:

1. Smart products and services
2. Smart business processes, the sub-dimensions are: smart production and operations, smart marketing and sales operations, and supportive operations
3. Strategy and organization

The example mentioned in the model applied to retail sector in Turkey. The questionnaire is accessible. The interface is complete and detail, that being said, the questionnaire is divided into each sub-dimension and showed each principles and technologies related on each sub-dimension. Likert scale is used, however, the questionnaire is not uniformly Likert scale. Listing technologies and comparing conditions are also incorporated.

The remaining preceding maturity models are summarized in Table 2.2. Table 2.2 column showed the model structure consisting the model name, published year, author, origin of the author, country of author, dimension, and level. The origin of author here, after diving the literature, is classified into academics and/or research institute, government, practitioner, and consulting companies.

31 relevant preceding Industry 4.0 maturity models are collected and analyzed further for the proposed model discussed in the chapter of model development. As mentioned previously that the models are within the range of 2014-2019 because it depicts a growing trend in this topic during that period. There is not much literature during 2011, the year in which the term Industry 4.0 firstly released, until 2013. Here is the summary table.

Table 2.2 Preceding Maturity Models

Model No	Model, Published Year	Author	Origin, Country	Dimension	Level
1	Indonesia 4.0 Readiness Index (INDI 4.0), 2019	Ministry of Industry of Indonesia	Government, Indonesia	1-Management and organization 2-People and culture 3-Products and services 4-Technology 5-Factory operation	Level 1 – Early stage Level 2 – Medium maturity Level 3 – Mature Level 4 – Industry 4.0 enabler
2	Industrie 4.0 by Munchen und Oberbayern, 2015	IHK (Chamber of Industry and Commerce) for Munich, Germany	Government, Munich, Germany	1-Smart products 2-Smart manufacturing 3-Smart organization 4-Smart technology	Level 1 – Low, Level 2 – Medium, Level 3 – High
3	IMPULS—Industrie 4.0 Readiness, 2015	IW Consult (subsidiary of Cologne Institute for Economic Research) and Institute for Industrial Management at RWTH Aachen University. Advised and commissioned by IMPULS Foundation of German Engineering Federation (VDMA)	Research institute, Germany	1-Strategy and organizations 2-Employees 3-Smart products 4-Smart factory 5-Smart operations 6-Datadriven services	Level 0 – Outsider Level 1 – Beginner Level 2 – Intermediate Level 3 – Experienced, Level 4 – Expert Level 5 – Top performer
4	Digital Maturity Model 4.0, 2016	Forrester	Research industry, USA	1-Culture 2-Organization 3-Technology 4-Insight	Level 1 – Sceptic Level 2 – Adopters Level 3 – Collaborative Level 4 – Differentiators

Model No	Model, Published Year	Author	Origin, Country	Dimension	Level
5	Industry 4.0 Maturity Test, 2019	Connected Production	Practitioner, Germany	1-Research and Development 2-Production 3-Logistics and warehouse management 4-Administration 5-Distribution 6-Customer service	Level 1 – Manual Level 2 – Digitization Level 3 – Networking Level 4 – Structuring Level 5 – Automation Level 6 – Predictability Level 7 – Autonomization
6	Evaluation of Digital Maturity of the Company, 2019	Firma4.cz	Practitioner, Czech Republic	1-Leadership, human potential, openness of corporate culture to digitalization 2-Business model, customer orientation and digital product 3-Operating model, digital value creation environment and digital control 4-Technology 5-Working with data and data culture	5 levels without naming
7	Capability Maturity Model Integration (CMMI) Version 2, 2018	CMMI Institute with a group of industry, government, and Software Engineering Institute (SEI)	Practitioner, Czech Republic	Focus and process areas are diverse depend on which CMMI: CMMI-DEV, CMMI-SVC, CMMI-ACQ	Level 1 Initial Level 2 Managed Level 3 Defined Level 4 Quantitatively managed Level 5 Optimizing
8	Proposed Industry 4.0 Maturity Model, 2018	Kartal Yagiz Akdil, Alp Ustundag and Emre Cevikcan	Academics, Turkey	1-Smart products and services 2-Smart business processes 3-Strategy and organization	Level 0 – Absence Level 1 – Existence Level 2 – Survival Level 4 - Maturity

Model No	Model, Published Year	Author	Origin, Country	Dimension	Level
9	Industrie 4.0 Maturity Index, 2017	Acatech	Academics, Germany	1-Resources 2-Organizational structure 3-Information system 4-Culture	Level 1 – Computerization Level 2 – Connectivity Level 3 – Visibility Level 4 – Transparency Level 5 – Predictive capacity Level 6 – Adaptability
10	Industry 4.0 Readiness Assessment Tool, 2017	The University of Warwick in association with Crimson&Co	Academics, UK	1-Products and services 2-Manufacturing and operations 3-Strategy and organization 4-Supply chain 5-Business model 6-Legal consideration	Level 1 – Beginner Level 2 – Intermediate Level 3 – Experienced Level 4 – Expert
11	System Integration Maturity Model Industry 4.0 (SIMMI 4.0), 2017	Leyh et al.	Academics, Germany	1-Vertical integration 2-Horizontal integration 3-Digital product development 4-Cross sectional technology criteria	Level 1 – Basic digitization Level 2 – Cross department digitization Level 3 – Horizontal and vertical digitization Level 4 – Full digitization Level 5 – Optimized full digitization
12	Industry 4.0 Maturity Model, 2018	Andreas Schumacher, Tanja Nemeth, and Wilfried Sihn	Academics, Austria	1-Technology 2-Products 3-Customer and partners 4-Value creation process 5-Data & information 6-Corporate standards 7-Employees 8-Strategy and leadership	No specific naming on maturity level, rather, depicted on a scale from 1 to 4 for each dimensions.

Model No	Model, Published Year	Author	Origin, Country	Dimension	Level
13	Industry 4.0 Maturity Model, 2016	Andreas Schumacher, Selim Erol, and Wilfried Sihn	Academics, Austria	1-Strategy 2-Leadership 3-Customers 4-Products 5-Operations 6-Culture 7-People 8-Governance 9-Technology	5 levels without naming.
14	Digital Readiness Assessment Maturity Model (DREAMY), 2017	*Anna De Carolis, Marco Macchi, Elisa Negri, and Sergio Terzi*	Academics, Italy	1-Process 2-Monitoring and control 3-Technology and organization	ML1 Initial ML2 Managed ML3 Defined ML4 Integrated and interoperable ML5 Digital-oriented
15	360 Digital Maturity Assessment (DMA) Problem Based Learning (PBL), 2018	U. Berger, C. Moller, B. Vejrum Waehrens, M. Bockholt	Academics, Denmark	1-Governance 2-Technology 3-Connectivity 4-Value creation 5-Competence	None Basic Transparent Aware Autonomous, Integrated
16	Digitalization Maturity Model, 2018	Luca Canetta, Andrea Barni, Elias Montini	Academics, Switzerland	1-Strategy 2-Processes 3-Technologies 4-Products & services 5-People	Absence Novice Intermediate Expert

Model No	Model, Published Year	Author	Origin, Country	Dimension	Level
17	Delivery Process Maturity Model 4.0 (DPMM), 2018	Björn Asdecker and Vanessa Felch	Academics, Germany	Order processing, Shipping, Warehousing. With 15 SCOR process elements in total	Stage 1 - Basic digitization Stage 2 - Cross-department digitization Stage 3 - Horizontal and vertical digitization Stage 4 - Full digitization Stage 5 - Optimized full digitization
18	IoT Technological Maturity Assessment Scorecard, 2017	Bjørn Jæger and Lise Lillebrygfjeld Halse	Academics, Norway	Either or not companies have three characteristics of 4.0-enabled-object: Embedded PLC-element, associated global unique identifier, and global connectivity	Level 1-3.0 maturity Level 2-Initiall to 4.0 maturity Level 3-Connected Level 4-Enhanced Level 5-Innovating Level 6-Integrated Level 7-Extensive Level 8-4.0 maturity
19	Maturity Levels for Logistics 4.0, 2018	Marjan Sternad, Tone Lerher, and Brigita Gajšek	Academics, Slovenia	1-Purchase logistics 2-Internal logistics 3-Distribution logistics 4-After sales logistics	5 levels without naming (onely Basic, Second, Third, Fourth, Fifth)
20	Simulation and Optimization (SMO) Maturity Model, 2017	A. Goienetxea Uriarte, A. H.C. Ng, M. Urenda Moris, M. Jägstam	Academics, Sweden	Either or not companies are aware, apply, and optimize the use of simulation	Novice Beginner Advanced beginner Intermediate Competent Expert

Model No	Model, Published Year	Author	Origin, Country	Dimension	Level
21	Industry 4.0-MM, 2017	Ebru Gökalp, Umut Şener, and P. Erhan Eren	Academics, Turkey	1-Asset management 2-Data governance 3-Application management 4-Process transformation 5-Organizational alignment areas	Level 0 Incomplete Level 1 Performed Level 2 Managed Level 3 Established Level 4 Predictable Level 5 Optimizing
22	Three Stage 4.0 Maturity Model in SME's, 2016	Jaione Ganzarain, Nekane Errasti	Academics, Spain	Multi perspective map of the overall strategy in all stages: Vision, Roadmap, Projects	Initial Managed Defined Transform Detailed business model
23	Digital Readiness Assessment, 2019	EY	Consultant, Sweeney	1-Strategy, innovation & growth 2-Customer experience 3-Supply chain & operations 4-Technology, risk & cyber security 5-Finance, legal & tax 6-People & organization	Not described
24	Big Data & Analytics Maturity Model, 2014	IBM	Consultant, UK	1-Business strategy 2-Information 3-Analytics 4-Culture and execution 5-Architecture 6-Governance	Ad hoc Foundational Competitive Differentiating Breakaway
25	Blockchain Maturity Model, 2017	KPMG	Consultant, Netherlands	1-Access and user management 2-Authorization and provisioning management 3-Data management 4-Interoperability 5-Scalability and performance 6-Change management	Level 1 Initial Level 2 Managed Level 3 Defined Level 4 Quantitatively managed Level 5 Optimizing

Model No	Model, Published Year	Author	Origin, Country	Dimension	Level
				7-Privacy, Security	
26	Data Maturity Model, 2018	Accenture	Consultant, Ireland	1-Strategy and governance 2-Architecture 3-Development 4-Regulation and ethics 5-User support	Ad hoc Organize Tactical Critical Industrial
27	Transforming and Digitizing Maturity Quest, 2017	Accenture	Consultant, Ireland	1-Design of business transformations 2-Characteristics of Latin America for business transformation 3-Execution of business transformations	Beginner Intermediate Master
28	Digitalisierungs Index, 2018	Deutsche Telkom	Consultant, Germany	1-Relationship with customers 2-Productivity in the enterprise 3-Digital offers and business models 4-IT and information security and data protection	Maturity level depicted as a discrete index point.
29	Digital Quotient, 2015	McKinsey	Consultant, USA	1-Strategy 2-Culture 3-Organization 4-Capabilities	No maturity level described.

Model No	Model, Published Year	Author	Origin, Country	Dimension	Level
30	Digital Acceleration Index, 2019	BCG	Consultant, Boston, USA	1-Business strategy driven by digital 2-Digitizing the core: Customer offer & go-to-market, operations, support function 3-New digital growth 4-Enablers: Changing ways of working, leveraging the power of data & technology, integrating ecosystem	Level 1 – Digital passive Level 2 – Digital literate Level 3 – Digital performer Level 4 – Digital leader
31	Industry 4.0 Self-assessment, 2015	PwC	Consultant, London	1-Digital business model and customer access 2-Digitization of products and service offerings 3-Digitization and integration of vertical and horizontal value chain 4-Data and analytics as core capability 5-Agile IT architecture 6-Compliance, security, legal, and taxes 7-Organization, employee, and digital culture	Level 1 – Digital novice Level 2 – Vertical integrator Level 3 – Horizontal collaborator Level 4 – Digital champion

2.4 Research Position

Below is the table showing the preceding maturity models together with the current research position. This subchapter shows the gap and the development that this research complied.

Table 2.3 Research Position

No	Model, Published Year	Author	Origin, Country	Target	Assessment Method, Scoring Formula	Roadmap or Recommendation	Questionnaire Accessibility	Origin of Model
1	Indonesia 4.0 Readiness Index (INDI 4.0), 2019	Ministry of Industry of Indonesia	Government, Indonesia	5 manufacturing sectors: FNB, textile, chemical, automotive, and electronics.	N/A, N/A	N/A	N/A	McKinsey
2	Proposed Industry 4.0 Maturity Model	Kartal Yagiz Akdil, Alp Ustundag and Emre Cevikcan	Academics, Turkey	Retail sector	N/A, scoring formula available (mean)	N/A	Available	Merge of journals, main referee: University of Warwick Maturity Model)
3	IMPULS—Industrie 4.0 Readiness, 2015	IW Consult. Advised and commissioned by IMPULS Foundation of the German Engineering Federation (VDMA)	Research institute, Germany	Manufacturing industry and mechanical engineering	Likert scale, N/A	Available	Available	-
4	Industrie 4.0 Maturity Index, 2017	Acatech	Academics, Germany	Manufacturing industry	N/A, N/A	Available	N/A	-
5	Industry 4.0 Readiness Assessment Tool, 2017	The University of Warwick in association with Crimson&Co	Academics, UK	Manufacturing industry	Likert scale, scoring formula available (mean)	N/A	Available	-

No	Model, Published Year	Author	Origin, Country	Target	Assessment Method, Scoring Formula	Roadmap or Recommendation	Questionnaire Accessibility	Origin of Model
6	Industrie 4.0 by Munchen und Oberbayern, 2015	IHK (Chamber of Industry and Commerce) for Munich, Germany	Government, Munich, Germany	Manufacturing industry	Likert scale, N/A	N/A	Available	-
7	Digital Maturity Model 4.0, 2016	Forrester	Research industry, USA	Manufacturing and services	Likert scale, N/A	Available	Available	Digital Business Transformation Playbook
8	Digitalisierungs Index, 2018	Deutsche Telkom	Consultant, Germany	Manufacturing and services	Likert scale, N/A	N/A	Available	-
9	Digital Acceleration Index, 2019	BCG	Consultant, Boston, USA	Manufacturing and services	N/A, N/A	N/A	N/A	-
10	Industry 4.0 Self-assessment, 2015	PwC	Consultant, London	Manufacturing and services	Likert scale, N/A	Available	Available	-
11	System Integration Maturity Model Industry 4.0 (SIMMI 4.0), 2017	Leyh et al.	Academics, Germany	Company's IT system landscape	In-depth interviews, N/A	N/A	N/A	CMMI and SOAMM
12	Industry 4.0 Maturity Test, 2019	Connected Production	Practitioner, Germany	Manufacturing industry	6-tiered Likert scale, N/A	Available	Available	-
13	Industry 4.0 Maturity Model, 2018	Andreas Schumacher, Tanja Nemeth, and Wilfried Sihn	Academics, Austria	Manufacturing industry in Austria, Germany, Slovakia, Hungary, China, and India	Likert scale, scoring formula available (mean)	Available	N/A	-
14	Digital Quotient, 2015	McKinsey	Consultant, USA	All industry sectors	N/A, N/A	Available	N/A	-
15	Industry 4.0 Maturity Model, 2016	Andreas Schumacher, Selim Erol, and Wilfried Sihn	Academics, Austria	Austrian manufacturing industry	N/A, scoring formula available (mean average)	N/A	N/A	-
16	Digital Readiness Assessment Maturity Model (DREAMY), 2017	*Anna De Carolis, Marco Macchi, Elisa Negri, and Sergio Terzi*	Academics, Italy	Manufacturing industry	Questions with normative answers, N/A	N/A	N/A	CMMI (Capability Maturity Model Integration)

No	Model, Published Year	Author	Origin, Country	Target	Assessment Method, Scoring Formula	Roadmap or Recommendation	Questionnaire Accessibility	Origin of Model
17	360 Digital Maturity Assessment (DMA) Problem Based Learning (PBL), 2018	U. Berger, C. Moller, B. Vejrum Waehrens, M. Bockholt	Academics, Denmark	Manufacturing industry	PBL, expert model-external helper model	Available	N/A	Acatech
18	Digitalization Maturity Model, 2018	Luca Canetta, Andrea Barni, Elias Montini	Academics, Switzerland	Manufacturing industry	Likert scale, scoring formula available (mean average)	N/A	N/A	VDI (Association of German Engineers) & ASME
19	Delivery Process Maturity Model 4.0 (DPMM), 2018	Björn Asdecker and Vanessa Felch	Academics, Germany	Delivery process of manufacturing industry with MTS or MTO	4-tiered Likert scale, scoring formula available (mean average)	Available	N/A	De Bruin et al. (2005)
20	IoT Technological Maturity Assessment Scorecard, 2017	Bjørn Jæger and Lise Lillebrygfjeld Halse	Academics, Norway	Norwegian manufacturing companies	Case study with in-depth interview, N/A	N/A	N/A	De Bruin et al. (2005)
21	Maturity Levels for Logistics 4.0, 2018	Marjan Sternad, Tone Lerher, and Brigita Gajšek	Academics, Slovenia	Logistics of manucacturing industry	N/A, N/A	N/A	N/A	Kompetenzzentrum Mittelstand NRW's Industry 4.0 Maturity model
22	Simulation and Optimization (SMO) Maturity Model, 2017	A. Goienetxea Uriarte, A. H.C. Ng, M. Urenda Moris, M. Jägstam	Academics, Sweden	Manufacturing, healthcare, or construction industry	N/A, N/A	N/A	N/A	-
23	Industry 4.0-MM, 2017	Ebru Gökalp, Umut Şener, and P. Erhan Eren	Academics, Turkey	Not mentioned	N/A, N/A	N/A	N/A	-
24	Digital Readiness Assessment, 2019	EY	Consultant, Sweeney	All industry sectors	N/A, N/A	Available	Not accessible to individual	-
25	Big Data & Analytics Maturity Model, 2014	IBM	Consultant, UK	All industry sectors	N/A, N/A	Available	Not accessible to individual	-

No	Model, Published Year	Author	Origin, Country	Target	Assessment Method, Scoring Formula	Roadmap or Recommendation	Questionnaire Accessibility	Origin of Model
26	Blockchain Maturity Model, 2017	KPMG	Consultant, Netherlands	All industry sectors	Self-assessment based on block chain risk areas	Available	Not accessible to individual	CMMI by ISACA
27	Data Maturity Model, 2018	Accenture	Consultant, Ireland	All industry sectors	N/A, N/A	Available	Not accessible to individual	-
28	Evaluatioin of Digital Maturity of the Company, 2019	Firma4.cz	Practitioner, Czech Republic	All industry sectors	5-tiered Likert scale, N/A	N/A	Available	-
29	Capability Maturity Model Integration (CMMI) Version 2, 2018	CMMI Institute and Software Engineering Institute (SEI)	Practitioner, Czech Republic	All organizations and industry sectors	N/A, N/A	N/A	N/A	-
30	Three Stage 4.0 Maturity Model in SME's, 2016	Jaione Ganzarain, Nekane Errasti	Academics, Spain	SMEs	N/A, N/A	Available	N/A	-
31	Transforming and Digitizing Maturity Quest, 2017	Accenture	Consultant, Ireland	All industry sectors	Likert Scale, Scoring by percentage	N/A	Available	-
32	This research	Immarita Dinar Fajriyani	Academics, Indonesia	Manufacturing industry in Indonesia	Likert scale, scoring formula available (mean)	Available (generic, gap analysis)	Available	Merge of preceding models

This research analyzed 31 preceding maturity models as part of the model development. This research tried to address the gap from three important points in a maturity model: structure, assessment, and support.

1. Model Structure

Model structure talks about the dimension, level, and focus/targeted respondent. Lately, the trend and growth of this research topic increased rapidly. It can be seen easily by the publication year. The above 31 models were not older than 2014. Within the years lately, researchers (academics/research institute), consulting companies and practitioners are trying to cope with a more detailed and specific process to assess (under the maturity model). There were some models addressed specific to limited process or focus of technology, such as:

1. Data Maturity Model by Accenture (focused on how mature a company in managing big data)
2. Blockchain Maturity Model by KPMG (focused on one example of Cybersecurity)
3. Big Data & Analytics Maturity Model by IBM (almost the same as Accenture)
4. SMO Maturity Model by Goienetxea et al. (focused on Simulation)
5. Maturity Levels for Logistics by Sternad et al. (focused on one candidate of sub-dimension for the proposed model)
6. DPMM by Asdecker et al. (focused on delivery process or distribution and logistics)

Thus, the Author closed the gap by constructing a thorough model based on the above detail for the respective dimensions and/or technologies. For example, a potential sub-dimension such as Horizontal and Vertical Integration would consider the Maturity Levels for Logistics by Sternad et al. and DPMM by Asdecker et al. Potential sub-dimension such as technology would consider Blockchain Maturity Model, Big Data & Analytics Maturity Model, SMO Maturity Model, etc.

Additionally, the Ministry of Industry of Indonesia had progressively grown in 2019. What lacked was what this country put aside from its big

roadmap towards Indonesia 2030. This model targeted all sectors of manufacturing industry operating in Indonesia. Thus, it included sectors outside the priority sectors in Making Indonesia 4.0: the model is generic. Moreover, there was no or very few academic paper related to maturity model development taking case/survey in Indonesia.

2. Model Assessment

In terms of model assessment, the Author may also benefit the proposed model by merging some of the possible assessment method. The Author took one of 360 DMA Maturity Model's processes that was Validation from expert and external helper. Thus, it would close the gap for those research to which be launched without validation from relevant stakeholders. The proposed model also incorporated the most common scoring formula (adopting the principle of mean) for each sub-dimensions such as the maturity model by The University of Warwick and Crimson&Co. The Author also took deeper analysis about the maturity model performance/quality test such as through relevancy, reliability, and other measures which were mentioned in Asdecker and Felch (2018).

3. Model Support

Lastly, the model support was reflected on the accessibility and interface (the ease in assessment and the comprehensiveness of report). The Author considered to have a detail and complete explanation (but not confusing) for each questions. It has a complete explanation for each dimension but easy-to-chew report. It also took into account the metrics of target (not only as-is or current condition) to process the gap analysis.

CHAPTER 3
RESEARCH METHODOLOGY

This chapter explained about the methodology used in this research. The design principles used follow the Scope, Design, Populate, and Test methodology from Asdecker and Felch, (2018). The model's scope was designed as mentioned previously for manufacturing companies, which was distinguished based on their production strategy. The Design process is subchapter 3.1 until 3.3 (In Chapter 4, it is from subchapter 4.1 to 4.3). The Populate and Test processes are the same with the validation and data processing (subchapter 3.4, 3.5, Chapter 4 subchapter 4.4 and Chapter 5).

The explanations are structured as follow. The flowchart of methodology is presented at the end of this chapter.

3.1 Analysis of Extensive Literature Review on Maturity Models

The research methodology was started with the result of literature review. The list of preceding maturity models and the emerging technologies applications were already defined in literature review. As the initial step, in this subchapter, the preceding models were analyzed one by one based on three components: model structure (author, origin, dimension, level, and target), assessment (assessment method and scoring), and support (questionnaire accessibility, root/origin of model, roadmap/recommendation, and acuity of result) and additional information such as model performance. The analysis pointed out what can be taken into account from the preceding model for the maturity model development. The output of analysis (conceptual model) became the input for the next step (maturity model development). Some of the preceding models became the root/origin of the proposed model. It could also be specific: one preceding model was addressed for certain dimension in the proposed model.

3.2 Proposed Model Development: Dimension and Level Formulation

The preceding maturity models analysis became the input for this step. The framework used as the mind map or big picture for model development was the conceptual model. Thus, conceptual model was also regarded as an input to this step. By considering both the result of analysis (root of models) and the conceptual model, the proposed framework was built. It consisted of dimension and level formulation. It was expected to have a detailed definition of the dimension and level on each sub-dimension.

3.3 Assessment Instrument Making

After the model development was done defined, the remaining steps would sound more technical. In this subchapter, there were three things to accomplish: building questionnaire framework, formulating calculation, and designing the report scheme. Each of them resulted in different outputs as described below.

1. Questionnaire Framework

   The questionnaire used Likert scale scoring. Likert scale is an ordered scale from which respondent choose one option that best align their view. The number of scale used was the same with the number of levels proposed, which were defined in the next chapter. The method to convert the framework (previous output) to questionnaire was by detailing the sub-dimension (the sub-dimension may still have bullet points as the sub or it is a stand-alone). Each point had minimum one representative question in the assessment instrument.

2. Calculation Formulation

   There were three aspects to calculate: maturity levels, model performance test, and gap analysis. The remaining task would be to do descriptive statistics regarding the result of pilot survey.

   a. The maturity level was scored using the formula shown by Schumacher, Erol and Sihn (2016). In the equation, “M” corresponds to “Maturity”, “D” corresponds to “Dimension”, “I” corresponds to “Item”, “g” corresponds to “Weighting Factor” and “n” corresponds to “Number of Maturity Item”.

$$M_D = \frac{\sum_{i=1}^{n} M_{DIi} * g_{DIi}}{g_{DIi}} \quad \text{Eq. 3.3}$$

b. Model performance test. There were some models incorporating model performance test in order to see how good and how representative is the model from the respondent's perspective. The metrics that was taken into account is maturity model performance criteria. This test composed of several metrics shown by Asdecker and Felch (2018). He suggested principles for good model development and presented criteria to characterize the quality of a maturity model. The criteria taken into account were comprehensiveness, relevance, consistency, systematic structure, detailedness, conceptual reliability and applicability. This test was subjected into the validation stage.

c. Gap analysis: The gap analysis focused on assessing the deviation within company: from current condition relative to its target. The object of the analysis is the top performer. However, there were also deviation between companies, specifically, seen from the score of each dimensions.

3. Reporting-scheme design

Since this was a web-based assessment, it considered the algorithm for any possible arrangements of answers. Thus, the model support was the highlight in this reporting scheme. The assessment result (Maturity Profile) was sent to email to the respondent after they finished filling up the questionnaire.

3.4 Validation

1. Expert Assessment (Validation I)

The first validation was done by experts in this topic. The model and questionnaire were analyzed and assessed together with the model performance test, thus it gave key considerations for model revision.

2. Pilot Survey (Validation II)

The output of validation I (after-revised questionnaire) became the input for validation II. Pilot survey was an obligatory conduct to validate the ease of use and the relevance to real world industries. This was the second validation before the

model is launched. This model was tested to some manufacturing companies operating in Indonesia.

3.5 Model Revision

Model revision was a step done to check the availability and relevancy of data to the real world, the logic, and synchronization of calculation. This step was also used to check whether the questionnaire framework is logic towards the dimension and level proposed, also to check the comprehensiveness and robustness of model seen from the dimension and the defined level. After the model was revised, the output was reached, the model had been double validated, the model was, then, feasible to launch.

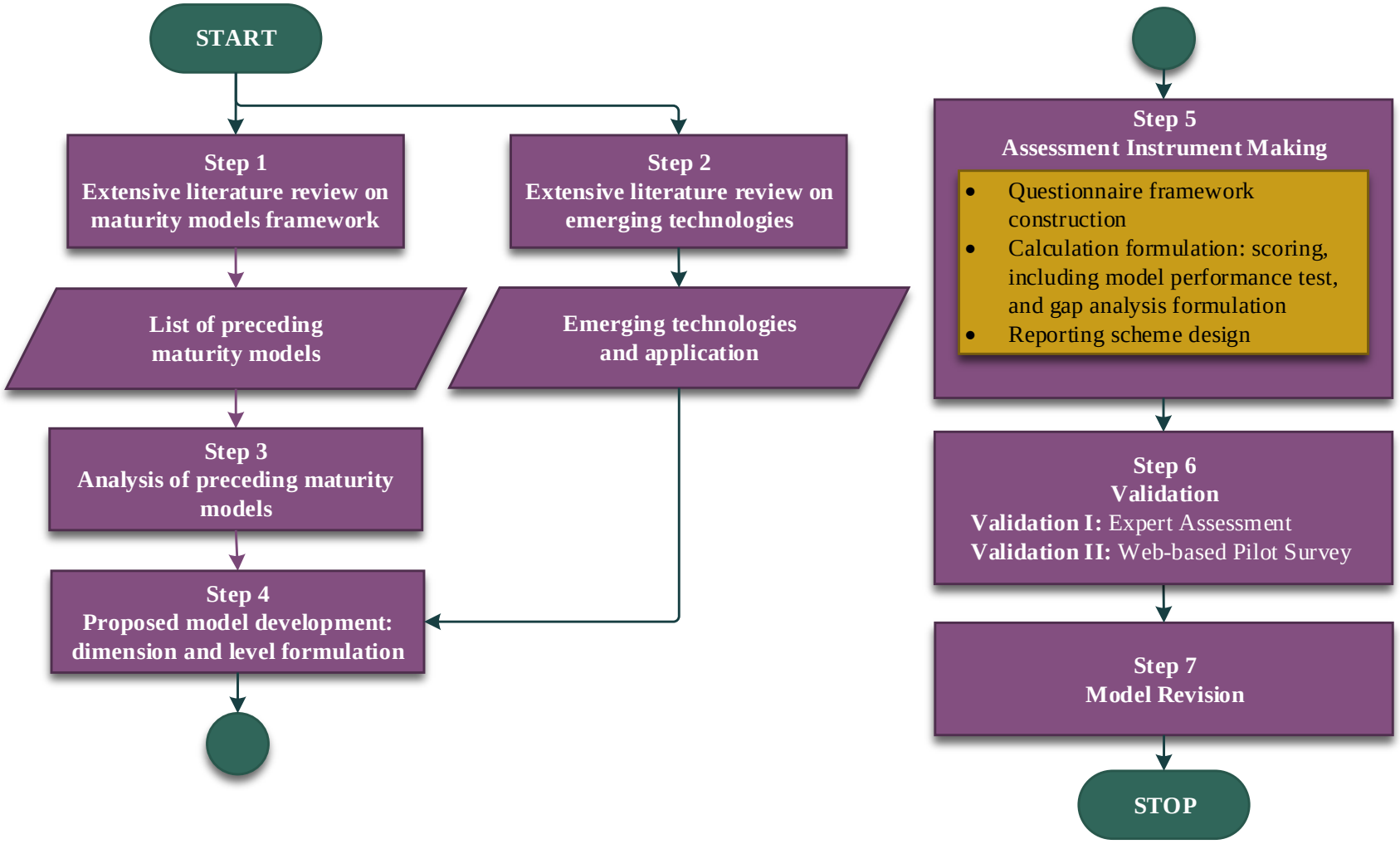


Figure 3.1 Research Methodology for the Proposed Maturity Model

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CHAPTER 4
MODEL DEVELOPMENT

This chapter explained the core process and has two outputs: the model and assessment instrument. The logic followed the flowchart in Chapter 3 starting from Step 3 (Analysis of preceding models) until Step 5 (Assessment instrument making).

4.1 Analysis of Extensive Literature Review on Maturity Models

This subchapter exhibited the result of the literature review as the input and conceptual model as the output, basis to move on to the next subchapter. The analysis was based on three components: model structure (author, origin, dimension, level, and target), assessment (assessment method and scoring), and support (questionnaire accessibility, root/origin of model, roadmap/recommendation, and acuity of result) and additional information such as model performance, strengths and weaknesses. The following subchapters observed deeper each of the preceding maturity models based on the model components.

4.1.1 Model Structure

The model structure was comprised of the Author, origin, country, dimension, level, and target/focus. The following are the pie charts in Figure 4.1 and Table 4.1 showing the Author/occupation of the 31 preceding maturity models. Numbering [xx] in Table 4.1 is linked to the number of maturity models listed in the first column of Table 2.2 Preceding Maturity Models.

Seen from the country origin of the Author, most of them were from Europe. 24/31 were European, 3/31 were Asian (Indonesia and Turkey), and the remaining 4/31 were American. This research added an academic contributing to Industry 4.0 maturity model relevant topics.

Not only seen from the Author, but also the dimension, level, and focus/target. The data shown on Table 4.2 were the list of dimensions in common, which were categorized based on the respective similar areas. It was divided into 5

dimensions in common and left a small amount of the rest (uncategorized dimensions: legal, tax, compliance, and other specific-to-target dimension such as characteristic of Latin America to business transformation, multi-perspective map regarding vision and roadmap, etc.).

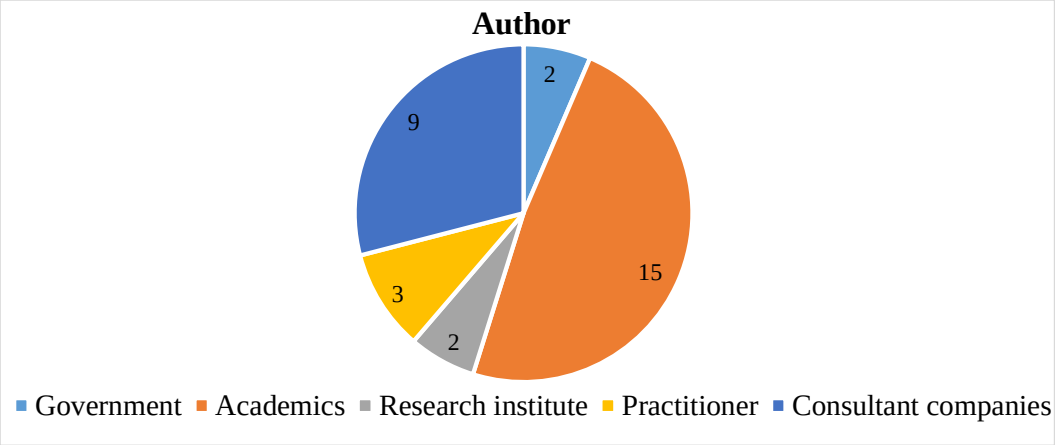

Figure 4.1 Author/Occupation of the 31 Preceding Maturity Models

The following dimensions, which always existed in almost every preceding models, were business strategy and organization. Business strategy drives the vision and mission, while the organization resembles how healthy the people and culture including the structure and the internal business. Customer service is also everywhere. Thus, the concluding first three dimensions were Business Strategy, People and Culture (representing the most-used dimension: organization), and Products and Service offerings (representing the customer service). Based on Table 4.2, here is the respective dimensions concluded:

a. Dimensions in Common 1 = Business Strategy
b. Dimensions in Common 2 = People and Culture
c. Dimensions in Common 3 = Products and Services

Meanwhile, the remaining 2 dimensions in common was discussed deeper in the following.

Within the year-range of the literature review, there was little references assessing the whole supply chain. Researchers focused on production process (it is shown in Common Dimensions 3 in Table 4.2). In addition, researchers tried to

cope with a more detailed and specific process to assess (under the maturity model). There were some models addressed specific to a limited process or focus on technology, such as:

1. Maturity Levels for Logistics by Sternad et al.: Focused on inbound and outbound logistics (warehousing and manufacturing are excluded). It adopted the NRW's model. This model incorporated purchase logistics, internal logistics, distribution logistics and after sales logistics.
2. DPMM by Asdecker et al.: Focused on delivery process or distribution and logistics. This model accommodated SCOR model and helped provide the digitization efforts in delivery process. However, it only focused on outbound logistics.
3. Industry 4.0 Maturity Test by Connected Production: Focused on production and services, warehouse and distribution.
4. Industry 4 readiness assessment tool by Crimson&Co (2017): one of its dimension is supply chain. In this case, there was one sub-dimension that could be used: the Inventory Control. However, the dimension name was supply chain but the sub-dimension talking specific about supply chain process was only the inventory control. The rest was supply chain visibility and integration in general.
5. Data Maturity Model by Accenture: Focused on how mature a company in managing big data.
6. Blockchain Maturity Model by KPMG: Focused on one example of Cybersecurity.
7. Big Data & Analytics Maturity Model by IBM: Focused to measure the data management.
8. SMO Maturity Model by Goienetxea et al.: Focused on Simulation.
9. IoT Technological Maturity Assessment Scorecard by Bjørn Jæger and Lise Lillebrygfjeld Halse: Focused on 4.0-enabled-object with keyword connectivity.

Point 1 to 4, from 4 preceding models, talked about logistics and supply chain. Since the highlight of contributions in this research was in the exploration of maturity of emerging technology adoption in supply chain, it would be

accommodated. Supply chain automatically concerned on value creation throughout the stream. Thus, Dimensions in Common 4 was closely related and was the subset of supply chain, including the manufacturing/factory operation as one of its processes. The success of supply chain surely improved the competitive advantage and was significant under 4.0 adoption. Thus, Dimensions in Common 4 was concluded as the Supply Chain.

Point 5 to 9 from 5 preceding models talked about a specific pillar in Industry 4.0. These technologies would surely be assessed in the proposed model. The content of these five models would be taken into account to design the assessment instrument in subsection technology. The Dimensions in Common 5 was then concluded as Information System and Technology. Thus, this research closed the gap by constructing a thorough model based on the sub-dimensions that were developed in the following subchapter.

The sub-dimension for Supply Chain considered the Maturity Levels for Logistics by Sternad et al. and DPMM by Asdecker et al. Sub-dimension of technology (regarding its pillars) considered each Data Maturity Model, Big Data & Analytics Maturity Model, SMO Maturity Model, etc.

Table 4.1 Preceding Maturity Models' Authors

Government	Academics	Research Institutes	Practitioner	Consultant Companies
1. **Indonesia**: Ministry of Industry of Indonesia [1] 2. **Germany**: IHK (Chamber of Industry and Commerce) for Munich [2]	1. **Turkey**: Kartal Yagiz Akdil, Alp Ustundag and Emre Cevikcan [8] 2. **Germany**: Acatech [9] 3. UK: The University of Warwick with Crimson&Co [10] 4. **Germany**: Leyh et al. [11] 5. **Austria**: Andreas Schumacher, Tanja Nemeth, and Wilfried Sihn [12] 6. **Austria**: Andreas Schumacher, Selim Erol, and Wilfried Sihn [13] 7. **Italy**: Anna De Carolis, Marco Macchi, Elisa Negri, and Sergio Terzi [14] 8. **Denmark**: U. Berger, C. Moller, B. Vejrum Waehrens, M. Bockholt [15] 9. **Switzerland**: Luca Canetta, Andrea Barni, Elias Montini [16] 10. **Germany**: Björn Asdecker and Vanessa Felch [17] 11. **Norway**: Bjørn Jæger and Lise Lillebrygfjeld Halse [18] 12. **Slovenia**: Marjan Sternad, Tone Lerher, and Brigita Gajšek [19] 13. **Sweden**: A. Goienetxea Uriarte, A. H.C. Ng, M. Urenda Moris, M. Jägstam [20] 14. **Turkey**: Ebru Gökalp, Umut Şener, and P. Erhan Eren [21] 15. **Spain**: Jaione Ganzarain, Nekane Errasti [22]	1. **Germany**: IW Consult (subsidiary of Cologne Institute for Economic Research) and Institute for Industrial Management at RWTH Aachen University. Advised and commissioned by IMPULS Foundation of German Engineering Federation (VDMA) [3] 2. **USA**: Forrester [4]	1. **Germany**: Connected Production [5] 2. **Czech Republic**: Firma4.cz [6] 3. **Czech Republic**: CMMI Institute with a group of industry, government, and Software Engineering Institute (SEI) [7]	1. **UK**: EY [23] 2. **UK**: IBM [24] 3. **Netherlands**: KPMG [25] 4. **Ireland**: Accenture [26] 5. **Ireland**: Accenture [27] 6. **Germany**: Deutsche Telkom [28] 7. **USA**: McKinsey [29] 8. **USA**: BCG [30] 9. **London, UK**: PwC [31]

Table 4.2 Dimensions in Common from Preceding Maturity Models

Model	Dimensions in Common 1	Model	Dimensions in Common 2	Model	Dimensions in Common 3	Model	Dimensions in Common 4	Model	Dimensions in Common 5
[1]	Management and organization	[1]	People and culture	[1]	Products and services	[1]	Factory operation	[1]	Technology
[2]	Smart organization	[3]	Employees	[2]	Smart products	[2]	Smart manufacturing	[2]	Smart technology
[3]	Strategy and organizations	[4]	Insight	[3]	Smart products	[3]	Smart operations	[3]	Smart factory
[4]	Organization		Culture	[5]	Customer service	[5]	Production		Datadriven services
[5]	Administration	[6]	Leadership, human potential, openness of corporate culture to digitalization		Research and Development		Logistics and warehouse management	[4]	Technology
[8]	Strategy and organization	[9]	Resources	[6]	Business model, customer orientation and digital product		Distribution	[6]	Technology
[9]	Organizational structure		Culture	[8]	Smart products and services	[6]	Operating model, digital value creation environment and digital control		Working with data and data culture
[10]	Strategy and organization	[12]	Employees	[10]	Products and services	[8]	Smart business processes	[9]	Information system
	Business model		Corporate standards	[11]	Digital product development	[10]	Manufacturing and operations	[12]	Technology
[12]	Strategy and leadership	[13]	Leadership	[12]	Products		Supply chain		Data & information
[13]	Strategy		Culture		Customer and partners	[11]	Vertical integration	[11]	Cross sectional technology criteria
	Governance		People	[13]	Customers		Horizontal integration	[13]	Technology
[14]	Technology and organization	[15]	Competence		Products	[12]	Value creation process	[15]	Technology
[15]	Governance	[16]	People	[16]	Products & services	[13]	Operations		Connectivity

Model	Dimensions in Common 1	Model	Dimensions in Common 2	Model	Dimensions in Common 3	Model	Dimensions in Common 4	Model	Dimensions in Common 5
[16]	Strategy	[23]	People & organization	[23]	Customer experience	[14]	Process	[16]	Technologies
[21]	Organizational alignment areas	[24]	Culture and execution	[28]	Relationship with customers		Monitoring and control	[18]	Either or not companies have three characteristics of 4.0-enabled-object: Embedded PLC-element, associated global unique identifier, and global connectivity
[23]	Strategy, innovation & growth	[28]	Productivity in the enterprise	[30]	Digitizing the core: Customer offer & go-to-market, operations, support function	[15]	Value creation	[20]	Either or not companies are aware, apply, and optimize the use of simulation
[24]	Business strategy	[29]	Culture	[31]	Digitization of products and service offerings	[16]	Processes	[23]	Technology, risk & cyber security
	Governance		Organization			[17]	Order processing, Shipping, Warehousing. With 15 SCOR process elements in total	[24]	Information
[26]	Strategy and governance	[30]	Enablers: Changing ways of working, leveraging the power of data & technology, integrating ecosystem			[19]	Purchase logistics		Analytics
[28]	Digital offers and business models	[31]	Organization, employee, and digital culture				Internal logistics		Architecture
[29]	Strategy						Distribution logistics	[25]	Access and user management

Model	Dimensions in Common 1	Model	Dimensions in Common 2	Model	Dimensions in Common 3	Model	Dimensions in Common 4	Model	Dimensions in Common 5
[30]	Business strategy driven by digital						After sales logistics		Authorization and provisioning management
						[21]	Process transformation		Data management
						[23]	Supply chain & Operations		Interoperability
						[31]	Digitization and integration of vertical and horizontal value chain		Scalability and performance
									Change management
									Privacy, Security
								[26]	Architecture
									Development
									Regulation and ethics
									User support
								[28]	IT and information security and data protection
								[29]	Capabilities
								[30]	New digital growth
								[31]	Data and analytics as core capability
									Agile IT architecture

4.1.2 Model Assessment

Author may also benefit the proposed model by merging some of the possible assessment method. The Author took one of 360 DMA Maturity Model's processes that was Validation from expert and external helper. Thus, it closed the gap for those researches to which were launched without validation from relevant stakeholders. The proposed model also incorporated the most common scoring formula (adopting the principle of mean) for each sub-dimensions such as the maturity model by The University of Warwick and Crimson&Co. The Author also took into deeper analysis about the maturity model performance/quality test such as through reliability, relevancy, and other measures which were originated from some of the above preceding models.

4.1.3 Model Support

Lastly, the model support was reflected on the accessibility and interface (the ease in assessment and the comprehensiveness of report). The Author considered to have a detail and complete explanation (but not confusing) for each questions. It also has a complete explanation for each dimension but easy-to-chew report. It also took into account the metrics of target (not only as-is or current condition) to process the gap analysis.

Based on the previous analysis, conceptual model was built (Figure 4.2). In this conceptual model, dimensions formulated based on the previous analysis are shown. This conceptual model acts as a big picture and basis of thinking in the model development. The dimensions were people and culture, products/services, business strategy, supply chain, and information system and technology.

It all started and driven strategically by the resources: people and culture. Organization determined how great the business strategy would be—in this case, how much Industry 4.0 would be incorporated in their vision and mission. These two dimensions drove the internal business (products, service offerings, and IT) and the supply chain. The supply chain was broken down to SCOR processes: Plan, Source, Make and Deliver. The IT system remarks how well the information flow, the interconnection, information feasibility, and also the adoption of Industry 4.0

technologies were implemented which in turn would influence the competitive advantage.

Based on the above principles, the proposed maturity model would ensure:

1. The awareness level regarding the exposure of Industry 4.0 technologies and current needs
2. The adoption level of Industry 4.0 technologies in each phase of SCOR model and strategic level (business and organization)
3. How far the current state was toward the company's goals on increasing productivity and competitiveness level

The resources would do the planning stage in strategic level: which was planning the supply chain. It included defining product characteristics to define the supply chain strategy, the network (inbound outbound) of the supply chain, and other important decisions. The following steps adopted the SCOR model, in which each phase had its detailed processes in operation level (Plan, Source, Make and Deliver). The ideal framework would have Industry 4.0 technologies implemented in the SCOR phases in accordance with the scale and urgencies/needs of the company. Industry 4.0 technologies might also be implemented in the strategic level: business and organization.

The red boxes in Figure 4.2 determined the initial dimensions in the model development. Those are:

1. Business strategy
2. People and culture
3. Products and service offerings
4. Information system and technology
5. Supply chain

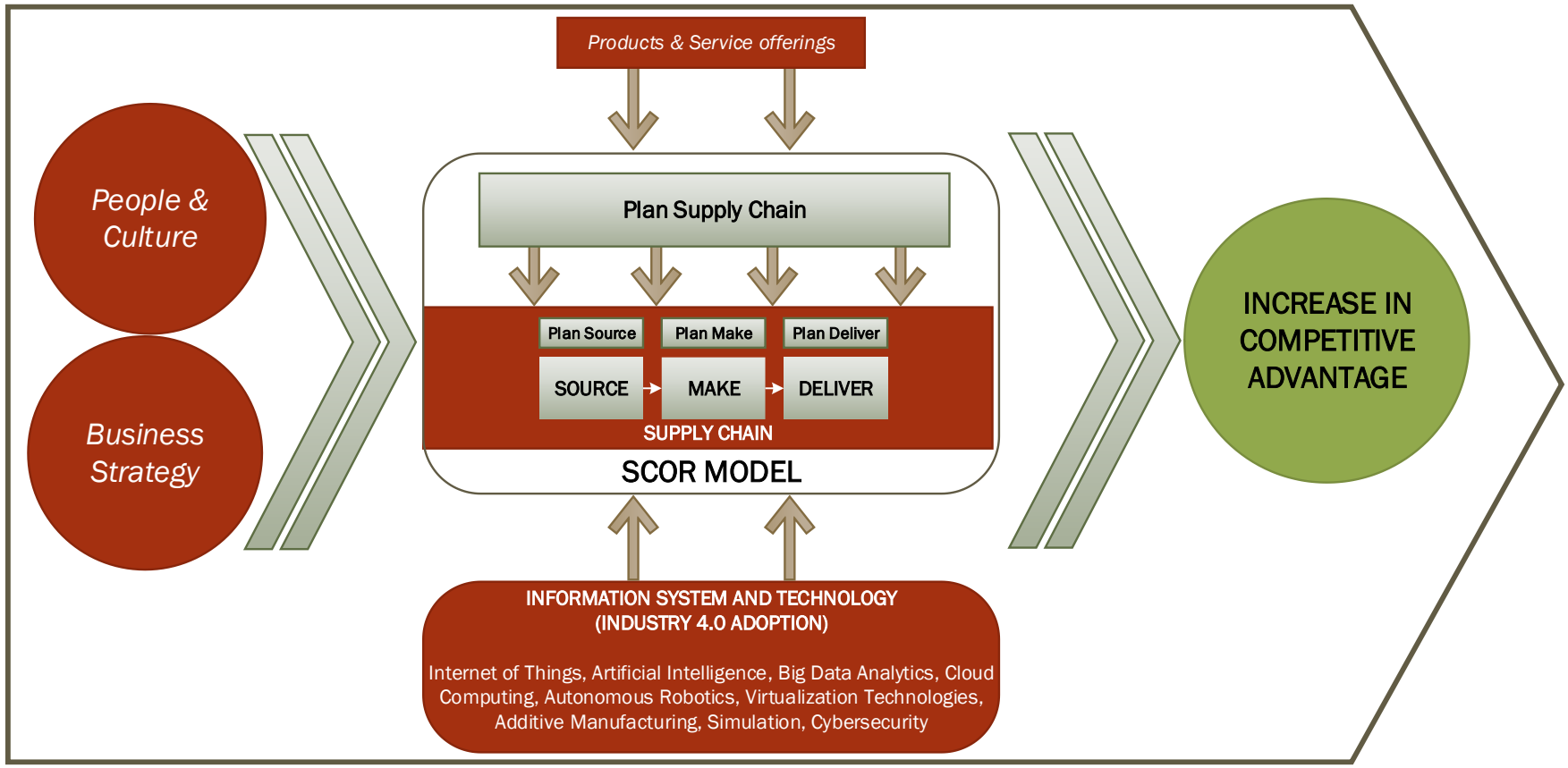

Figure 4.2 Conceptual Model

4.2 Proposed Model Development (Sub-dimension and Level Formulation)

In this subchapter, five dimensions were broken down to its respective sub-dimensions and levels. The output of this subchapter is sub-dimension vs level matrix. The content of the matrix is obtained by analyzing and developing the preceding models. For example, what are the assessment criteria to score the Business Strategy? What are the composing criteria and the contributing success to the IT System or to the Supply Chain? Those key points are the sub-dimensions. The details of sub-dimensions was discussed in the following subchapter.

After the dimensions were proposed, came the level definition. The formulation was based on the developing countries condition, in which, the preceding maturity models might attribute to the early implementation stage. It was signed by the fast and trending research topics incur only in the developed countries. Additionally, based on the aforementioned background, Indonesia had not much improved in any competitiveness indexes even after launching the framework and roadmap. The result of INDI 4.0 showed that 5 manufacturing sectors in Indonesia was in moderate level of maturity (scored 2.14 in average over 4).

Thus, justification was needed in order to make it more representative and corresponds to the real life. The preceding models were all in average have 4 up to 6 levels, from absence to say: completely mature. Meanwhile, Indonesia generally had the awareness widespread but the implementation scattered. Table 4.3 showed the initial proposed maturity model—full description of each level. The Table 4.3 Survival and Maturity level are for company with integration-ready, meanwhile most companies in Indonesia still grapple with initial implementation, in the phase of changes from awareness to real application. Thus, this work focused only to map out to levels with Existence divided into 3—break the bones the middle/moderate level into smaller detailed levels, shown in Table 4.4. Other than that was extreme down and up (Absence and Beyond Existence). Thus, if any companies scored above the three Existence level, they would be labelled as Beyond Existence: to show their condition was already in either Survival or Maturity level. Table 4.3 – 4.9 below are the initial version of the model before the validation. ***Not yet validated.***

Table 4.3 Initial Proposed Maturity Model (Dimension and Level)

Dimension/Level	Absence	Existence	Survival	Maturity
Business strategy	No awareness of implementing Industry 4.0 or recognized at departmental level only. No vision or direct statement regarding Industry 4.0 in business strategy.	Industry 4.0 is in the business strategy, but implementation is unclear. Alternatively, Industry 4.0 is not in the strategy but somehow with sparse implementation.	Industry 4.0 strategy has the hype and communicated, understood and implemented.	Industry 4.0 strategy has been implemented across the business
People and culture	Functionally dedicated. No digital culture at all.	Cross-function cooperation exist, but not structured and continuous. Cooperation starts to spark initiatives with/without digital culture.	Wider and frequent cross-function cooperation with digital culture.	Collaboration and digital are both a culture.
Customer, products, and service offerings	Online channel is separated from the offline, product focus instead of customer focus. No Industry 4.0 implementation in service offerings.	Integrated use of online and offline channels, initiatives or little implementation of Industry 4.0 in service offerings.	Proactive customer focus with Industry 4.0 service offerings.	Customer focus capturing empathy integrated with Industry 4.0 service offerings and breakthroughs.
Information System and Technology	Separated IT architecture, paper/paperless work with less use of internet and/or Industry 4.0.	Homogeneous IT architecture in-house. Connection between departments is developing. Paperless work increased. Works are around internet, not yet Industry 4.0 or little usage.	Homogenous IT structure in the partner network, linked data, Paperwork decreased and optimized, speedy and information transparent, Industry 4.0 technology implemented but not yet integrated.	Data lake is created, data flows real-time, transparent and integrated, capable and flexible organization. CPS applied thoroughly as needed.
Supply Chain	Digitized and automated sub processes. No supply chain 4.0 technology, no integration between partners.	Vertical digitization and integration of process and data flows within the company. Supply chain 4.0 technology implemented functional and only some.	Horizontal integration of processes and data flows with customers and external partners, intensive data use	Fully integrated ecosystem with self-optimized, virtualized processes decentralized autonomy.

Table 4.4 Proposed Maturity Model (Dimension and Level Formulation)

Dimension/Level	Absence	Existence I	Existence II	Existence III	Beyond Existence
Business strategy	- No industry 4.0 strategy exists - No measurable Industry 4.0 investment yet - No partnerships for Industry 4.0 projects	- Early awareness, pilot initiatives launched - No ongoing review of cost/benefit analysis for Industry 4.0 investment yet - Planning to have partnerships for Industry 4.0 projects	- Knowledge acquisition, understanding, knowledge used to develop strategy - No ongoing review of cost/benefit analysis of Industry 4.0 investment - Have partnership going on with academics/researcher/technology provider/other tier	- Early implementation, technology acquisition and strategy is formulated - Investment exists. Annual cost/benefit analysis of Industry 4.0 investment - Have partnership with more than one of the mentioned options	- Beyond existence, strategy is in implementation - Thoughtful investment, shorter-period or proactively conduct cost/benefit analysis of Industry 4.0 investment - Have mature and sustained partnership as long term project
People and culture	Work is fully dedicated. Employees with no digital capabilities. No digital culture	- Cross-functional cooperation - Cooperation is not structured and continuous - Digital skills and capability are none to low - No digital culture	- Cross-functional cooperation - Cooperation is not structured and continuous - Digital skills and capability are low - No digital culture	- Wider cross-functional cooperation - Cooperation is not structured and continuous - Digital skills and capability exist - Digital culture initiatives	- Wider cross-functional cooperation. Cooperation is structured and continuous. All across the business, cutting edge digital and analytical skills are prevalent. Digital culture Routine to be reviewed, colleagues are engaged proactively
Customer, products, and service offerings	No digital enablement of sales forces and use of gadgets/online channel, no	Planning to have digital enabler: use of gadgets/online channel, no to little customer data/insight analysis.	Use of gadgets/mobile devices, access to all relevant system anywhere and anytime, acquire customer data without further insight analysis	Use of gadgets/mobile devices, access to all relevant system anywhere and anytime, acquire customer data without further insight	Mature digital features, channel (i.e. online channel), and smart product (i.e. RFID tag). Personalized offers to customer based on

Dimension/Level	Absence	Existence I	Existence II	Existence III	Beyond Existence
	customer data/insight analysis. No collaboration			analysis. Producing/still planning the smart product.	customer insights: preference, situation, location, etc.
Information System and 4.0 Technology	No awareness and no implementation	Early awareness/pilot initiatives are launched. Pilot project are run but partially. IT architecture, paperless work, degree of information feasibility, connectivity, and significance of implementation are assessed.	Early implementation stage. IT architecture, paperless work, degree of information feasibility, connectivity, and significance of implementation are assessed.	Implementation stage with the starting stage of adaptation. IT architecture, paperless work, degree of information feasibility, connectivity, and significance of implementation are assessed.	Maturity stage with survival. IT architecture, paperless work, degree of information feasibility, connectivity, and significance of implementation are assessed.
Supply chain	No use of 4.0 technology, manual plan, source, make, and deliver stages.	Starting to adopt digital platform across the chain. Technology in plan, source, make, and deliver stages are assessed.	Starting to adopt a more automated digital platform (usually already invest in cloud) across the chain. Technology in plan, source, make, and deliver stages are assessed.	Starting to adopt a more advanced cloud platform with learning capability but still in adaptation stage across the chain.	Starting to adopt combinations of 4.0 technology across the chain. Technology in plan, source, make, and deliver stages are assessed.

Below is the explanation of each of the proposed dimensions. Each dimension has its sub-dimensions.

4.2.1 Business Strategy

Business strategy is the key driver to any success in the business. In this case, company would be regarded as digitally mature if it accommodated the implementation of 4.0 technology as one of the goals and had mature and sustained partnership as long-term project with another tier in the supply chain or any stakeholder (technology provider, academics, researcher, etc.). Not only those, but was also able to survive any costs—reflected in different levels described in Table 4.5. The sub-dimension of business strategy are the degree of industry 4.0 strategy implementation, investment and collaboration. These sub-dimensions were the results of analysing the preceding models that have business strategy dimension.

4.2.2 People and Culture

People and culture is the dimension that, together with product and service offerings dimension, supports the business strategy internally. It dealt with how the resources work including their digital skillsets and how the environment behaves inside the industry. Having a digital culture, which by definition is having a working environment closer to gadgets, wearable technologies, smart projector, clouds, indicates a close reach to digital maturity. For example, to print a document would not need an offline data transfer such as flash disk but by cloud such as emails/any social media. Signing presence list was outdated and replaced by fingerprint, face recognition, etc. Paperwork had been reduced and cloud is in intense use. Thus, the resources are capable and handy to operate such technologies. Other than that, the organization implemented an effective cross-function cooperation under the use of gadgets and/or 4.0 technology. Thus, the sub-dimension of people and culture are cross-functional cooperation, resources on digital capability, and digital culture, depicted in Table 4.6.

4.2.3 Product and Service Offerings

Product and service offerings is another dimension that would affect the success of strategy internally. It dealt with how products and services were delivered—in this case, how much technology was implemented and relied upon. The maturity indicated a reliability to technology to any operations in products and service offerings and an intense collaboration with other tier in the supply chain in the product development stage. Thus, the sub-dimensions of product and service offerings are digital enabler and digital features of products and services, and product development collaboration. The levelling is shown in Table 4.7.

4.2.4 Supply Chain

Supply chain is the most important dimension acts as a core in this model, which also remarks the research position. This dimension would assess how much technology had been involved and successfully relied upon the stream. It followed the SCOR framework in which the operational processes were assessed. However, Return phase was excluded due to limitation of research work and complexity. Maturity indicated a company that has grasped an advanced 4.0 technology throughout the stream based on SCOR framework—from Plan, Source, Make, and Deliver stages. Thus, the sub-dimensions are Plan, Source, Make, and Deliver. The levelling is shown in Table 4.8.

4.2.5 Information System and Technology

The last dimension aims to conclude the precision of technology implementation. It would assess the awareness of 4.0 technologies through paperless work percentage and the implementation of 4.0 technologies. Other than that, degree of transparency (information feasibility), connectivity (exchange of information) and the IT architecture were assessed. Those sub-dimensions were aimed to know how efficient the impact of implementation was. Thus, the sub-dimensions are IT architecture, percentage of paperless work, Degree of implementation of Industry 4.0, and degree of connectivity, transparency and exchange of information. Details are in Table 4.9.

Table 4.5 Business Strategy Dimension (Sub-dimension and Level Definition)

Business Strategy	Absence	Existence I	Existence II	Existence III	Beyond Existence
Degree of Industry 4.0 Strategy Implementation	No industry 4.0 strategy exists	Early awareness, pilot initiatives launched	Knowledge acquisition, understanding, knowledge used to develop strategy	Early implementation, technology acquisition and strategy is formulated	Beyond existence, strategy is in implementation
Finance and Investment	No measurable Industry 4.0 investment yet	No ongoing review of cost/benefit analysis for Industry 4.0 investment yet	No ongoing review of cost/benefit analysis of Industry 4.0 investment	Investment exists. Annual cost/benefit analysis of Industry 4.0 investment	Thoughtful investment, shorter-period or proactively conduct cost/benefit analysis of Industry 4.0 investment
Collaboration	No partnerships for Industry 4.0 projects	Planning to have partnerships for Industry 4.0 projects	Have partnership going on with academics/ researcher/ consultant/ technology provider/ other tier	Have partnership with more than one of the mentioned options	Have mature and sustained partnership as long term project

Table 4.6 People and Culture Dimension (Sub-dimension and Level Definition)

People and Culture	Absence	Existence I	Existence II	Existence III	Beyond Existence
Cross-functional cooperation	Work is fully dedicated.	Cross-functional cooperation. Cooperation is not structured and continuous	Cross-functional cooperation. Cooperation is not structured and continuous	Wider cross-functional cooperation. Cooperation is structured and continuous.	Wider cross-functional cooperation. Cooperation is structured and continuous.
Resources on Digital Capability	Employees have no experience with digital/emerging technologies	Employees have little experience with digital/emerging technologies	Technology focused areas of the business have employees with some digital skills	Most areas of the business have well developed digital and data analysis capability	All across the business, cutting edge digital and analytical skills are prevalent
Digital Culture	No digital culture	Digital culture exists in board and strategic level. Seldom implemented and controlled, no	Digital culture exists also in lower/ managerial level. Implemented partially with little	Digital culture exists also in operational level. Implemented partially with moderate engagement/enthusiasm (already becoming culture with	Digital culture exists well implemented in corporate level (requiring all workers' awareness). Routine to be reviewed,

People and Culture	Absence	Existence I	Existence II	Existence III	Beyond Existence
		engagement in colleagues	engagement/ enthusiasm	little proactiveness from colleagues)	colleagues are engaged proactively

Table 4.7 Products and Service Dimension (Sub-dimension and Level Definition)

Product and Service Offerings	Absence	Existence I	Existence II	Existence III	Beyond Existence
Digital enabler and digital features of products and services	No digital enablement of sales forces and use of gadgets/online channel, no customer data/insight analysis.	Planning to have digital enabler: use of gadgets/online channel, no to little customer data/insight analysis.	Use of gadgets/mobile devices, access to all relevant system anywhere and anytime, acquire customer data without further insight analysis	Use of gadgets/mobile devices, access to all relevant system anywhere and anytime, acquire customer data without further insight analysis. Producing/still planning the smart product.	Mature digital features, channel (i.e. online channel), and smart product (i.e. RFID tag). Personalized offers to customer based on customer insights: preference, situation, location, etc.
Product development collaboration	No collaboration	Early awareness of needs to collaborate, pilot initiatives launched.	Collaboration exists, understanding the possible scope to collaborate and to which external tier.	Collaboration gets more intense and developed.	Wide (involving multi stakeholder/players) and intense collaboration.

Table 4.8 Supply Chain Dimension (Sub-dimension and Level Definition)

Supply Chain	Absence	Existence I	Existence II	Existence III	Beyond Existence
Sub-dimension Plan	Supply chain plan (resources and requirements) is made without digital document and not well communicated, supply	Supply chain plan (resources and requirements) is documented in computer database but not well communicated, supply	Supply chain plan (resources and requirements) is documented in computer database and well communicated, supply	Supply chain plan (resources and requirements) is documented in cloud and well communicated, supply chain strategy	Supply chain plan (resources and requirements) is made in cloud and well communicated, supply chain strategy formulation

Supply Chain	Absence	Existence I	Existence II	Existence III	Beyond Existence
	chain strategy formulation is set manually (research, benchmark, etc.), supply network planning is conducted manually through software with algorithm, reactive communication with suppliers and customers, no integration between tiers (horizontal visibility), required-response to any market changes is slow (not proactive)	chain strategy formulation is set manually (research, benchmark, etc.), supply network planning is conducted manually through software with algorithm, basic communication and data sharing exist with suppliers and customers, no integration between tiers (horizontal visibility), required-response to any market changes is slow (not proactive)	chain strategy formulation is set manually (research, benchmark, etc.), supply network planning is conducted manually through software with algorithm, basic communication and data sharing exist with suppliers and customers, site location, capacity, inventory and operations are visible between first tier suppliers and customer (horizontal visibility), required-response to any market changes is moderate (quite proactive)	formulation (research, benchmark, etc.) is set with learning capability, supply network planning is conducted with advanced algorithm and visible real-time, data transfer exist between key strategic suppliers/ customers (e.g. customer inventory levels), site location, capacity, inventory and operations are visible throughout supply chain (horizontal visibility), required-response to any market changes is moderate (quite proactive)	(research, benchmark, etc.) is set with learning capability, supply network planning is conducted with advanced algorithm and visible real-time, fully integrated systems with suppliers/customers for appropriate processes (e.g. real-time integrated planning), site location, capacity, inventory and operations are visible real-time throughout supply chain and used for monitoring and optimisation (horizontal visibility), required-response to any market changes is good/proactive
Sub-dimension Source	Sourcing is done manually (offline or through calls), processes (sourcing, scheduling, receive, verify, and authorize supplier payment) are done segmented/individually, inventory control policy is set and understood, no data exchange with supplier	Use combined offline and online (e-sourcing and e-procurement), some processes (sourcing, scheduling, receive, verify, and authorize supplier payment) are done in series automatically/digitalized, inventory level is in computer database (manually update the inventory levels), exchange of specific data is exist	Use e-sourcing and e-procurement, processes (sourcing, scheduling, receive, verify, and authorize supplier payment) are automatic, inventory level is in computer database (manually update the inventory levels), exchange of additional data is exist	Use e-sourcing and e-procurement, processes (sourcing, scheduling, receive, verify, and authorize supplier payment) are automatic and smarter (system is able to fix problems real-time), inventory level is in computer database with smart devices updating inventory levels, data exchange is automatic	Use e-sourcing and e-procurement with adaptive switching (learning capability) due to changes, smart process (sourcing, scheduling, receive, verify, and authorize supplier payment), inventory level is in real-time database which is updated by smart device, data exchange is automatic

Supply Chain	Absence	Existence I	Existence II	Existence III	Beyond Existence
Sub-dimension Make	Process starting from scheduling production activities, issuing material, producing, until releasing product to deliver is done manually without any 4.0 technology	Process starting from scheduling production activities, issuing material, producing, until releasing product to deliver is not integrated, documented in a cloud-based information system	Process starting from scheduling production activities, issuing material, producing, until releasing product to deliver is integrated with the help of industrial robot, error checking system, use of cloud, etc.	Process starting from scheduling production activities, issuing material, producing, until releasing product to deliver is integrated with the help of AI robot, automatic error checking system, real-time data processing in centralized data center, etc.	Process starting from scheduling production activities, issuing material, producing, until releasing product to deliver is integrated with the help of AI robot, cyber physical system, automatic error checking system, real-time data processing in centralized data center, etc.
Sub-dimension Deliver	Process starting from inquiry, quote, validate order, route shipment, pick, pack, load, ship, and invoice are not digitized, long materials lead time resulting in high inventory levels.	Some processes from inquiry, quote, validate order, route shipment, pick, pack, load, ship, and invoice are digitized, improvements have been identified to reduce lead times for some materials	Process starting from inquiry, quote, validate order, route shipment, pick, pack, load, ship, and invoice are automated, real-time, and integrated. Improvements have been identified to reduce lead times for some materials	Process starting from inquiry, quote, validate order, route shipment, pick, pack, load, ship, and invoice are automated, real-time, and planned to have learning capability (Neural Networks for route shipment, etc.). Some improvements have been implemented to reduce lead times on key materials	Process starting from inquiry, quote, validate order, route shipment, pick, pack, load, ship, and invoice are transparent in real-time, automated, and widely implement 4.0 technologies where suitable (robotics, IoT, AI, etc.). Have differentiated stocking policies and lead times to fulfill order efficiently, use of driverless trucks, drone, etc.

Table 4.9 Information System and Technology Dimension (Sub-dimension and Level Definition)

Information and Technology System	Absence	Existence I	Existence II	Existence III	Beyond Existence
IT architecture	No homogenous IT architecture between functional silos/departments.	Homogenous in some departments.	Almost all IT architecture departments are homogenous. Use ERP.	Homogenous throughout the company. Use ERP.	Mature architecture. Homogenous throughout the holding and operating companies. Use ERP.
Percentage of Paperless Work	Paperwork 100%.	Paperwork 80%, computerized/cloud 20%.	Paperwork 60%, computerized/cloud 40%.	Paperwork 40%, computerized/cloud 60%.	Paperwork 20%, computerized/cloud 80%.
Degree of implementation of Industry 4.0	No information feasibility	Explicitly needed data is feasible, others are not processed.	Explicitly needed data is feasible, peripherals are limitedly processed. Aware of Big Data/Cloud/AI usage for data mining.	Explicitly needed data is feasible, peripherals are mined and processed through learning (AI/machine learning).	Explicitly needed data is feasible, peripherals are well and proactively processed through learning (machine learning/deep learning).
Degree of connectivity, transparency and exchange of information	No/little connectivity, exchange of information, no custom configuration (SOP) that may enable other department requesting internal documents.	Data transferred/obtained by crossfunction by needs/request with layers of approval.	Data transferred through hard devices (harddisk, flash, etc.) eye to eye.	Data transferred through cloud/online media such as email, telegram, etc. (approval done in distant).	Data can be downloaded/be traced for whom it is concerned through an integrated cloud system.

4.3 Assessment Instrument Making

The questionnaire is divided into 7 sections (introductory questions, 5 dimensions, and questionnaire rating). The questions were made dedicated to answer at what level was each sub-dimension of each dimensions. One question answered one sub-dimension, even though there were some sub-dimensions that have more than one question.

The questions were developed from the preceding models that open the assessment instrument. Other than that, questions were developed from the dimension matrix (sub-dimension levelling). The initial questionnaire is exhibited at the end part: Attachment 2.

4.4 Model Validation

After having the initial developed maturity model and assessment instrument, time to populate and test. The following subchapter explained about the validation stage, which consists of Validation I—Expert Assessment and Validation II—Pilot Survey.

4.4.1 Validation I: Expert Assessment

The first validation was by Face Validity without the Likert scale, but expert opinion. Four professors had done the expert assessment from Norway, Denmark, Austria and Australia. The systematic went through offline discussion (with Professor from Denmark) and by email (with Professor from Norway, Austria, and Australia). The point of assessment was giving corrections on both the conceptual model and assessment instrument. Here are some major comments from the experts:

1. The conceptual model is comprehensive. The dimension is quite holistic, and recognizes the interplay between technology, organization, and humans. The Business Strategy, Product, Services, and People dimensions are supporting points in the assessment, but indeed necessary. However, it needs to focus on the supply chain and consider literature that exactly dig the supply chain 4.0 maturity. Either way, it can be called as Supply Chain 4.0.

2. Better wording would be more descriptive. Based on the descriptions, "Recognition" may be used rather than “Survival”.
3. It is uncertain if a company with industry 4.0 offerings have to be customer-focused company and have online channels. Having online channel is not really Industry 4.0, 3.0 instead. Reformulate the matrix so that the definition is closer to "value-added digital product services".
4. Revisit the reason to break down the levelling from Absence, Existence, Survival, and Maturity to Absence, Existence I, Existence II, Existence III, and Beyond Existence. Write the argument with clarity that both of the levelling are different.
5. Consider to have not only manufacturing companies as the target respondents but also start-up companies and service providers such as retail, logistic company, etc.
6. The questionnaire is heavy. It needs to be revised so that it is easier to get responses. It needs to merge and delete some questions to have leaner questionnaire.

Meanwhile, some minor comments were:

1. Summarized comments for model: difference between levels and difference between options should be clear. In detail, those are:
    a. Differ the Mature and Survive level of People and Culture dimension. Difference in description is not clear.
    b. Differ the Mature and Survive level of Customer, Products and Service Offerings dimension. Difference in description is not clear.
    c. It is very few companies, which are at the horizontal integration stage, and in a very limited level. “Digitized and automated sub-processes” must not be in Absence level of Supply Chain dimension.
2. Summarized comments for the questionnaire:
    a. Good introductory questions. However, it can be difficult for service providers (e.g. IT, maintenance, laboratory, R&D, consultancy, etc.) to fill in this questionnaire. Since the service providers are critical

component of industry 4.0 success and there are also start-ups appearing with the opportunities given by industry 4.0, consider them.

b. "Should a company communicate its Industry 4.0 strategy to all workers?" in Degree of Implementation sub-dimension of Business Strategy dimension.
c. Consider deleting the cost/benefit analysis question in Investment sub-dimension of Business Strategy dimension if it is without further assessment. It will not be feasible to conclude anything. Focus more on the key point of the dimension: either the company incorporate Industry 4.0 strategy or not.
d. Cross-function cooperation in a company will always happen. The problem is how efficient the cooperation is. Consider another Likert scale for Cross-functional Cooperation sub-dimension in People and Culture dimension.
e. Terms that are not very well known must be written with definition, such as Digital Culture sub-dimension in People and Culture dimension and the abbreviated VRP in Deliver sub-dimension of Supply Chain dimension.
f. "How is the data you collect used in production?" and "How is the data you collect used in logistics and procurement?" are both a straightforward questions without a clear advancement levelling of options. Consider merging questions with another Likert-scale.
g. Paperwork percentage question in IT System dimension is too rigid that the respondent would have difficulties to measure. Consider merging/deleting the question.

3. Consider merging questions in IT System dimension to reduce heaviness/complexity.
4. Other comments: Dictions and complex sentence structure, unclear sentence structure, grammatical error, etc. For example, consider to shorten the question about how the data is performed and interpreted, in IT System dimension. Another example is to use automated compared to smart, regarding the options descriptions.

The above comments had been accommodated and discussed that the model were done revisited. The modification happened based on expert opinions are:

1. Survival level would not be changed to Recognition. Since Recognition is closer to adaptation-like level, thus it has closer representation towards Existence, rather than Survival.
2. Wording of online channel and customer-focus in the model matrix were shifted to highlight that Customer. Product and Service Offerings dimension more focused on how proactive the digital enablement of sales forces, use of gadgets and cloud and customer data/insight analysis.
3. The dimension would still be broken down to Absence, Existence I, Existence II, Existence III, and Beyond Existence. The justification was the Indonesia's background as stated in Chapter 1.
4. Broadening the target respondents from only manufacturing to service providers meaning to have drastic change on models since the literature review was not enough to build such a generic but comprehensive model. The target respondent was still limited to manufacturing company.

Minor changes were summarized as follows.

1. Wording and levelling descriptions modification.
    a. Initially in Customer, Product, and Service Offerings dimension, Survival and Maturity level description were unclear. It has been modified to "Reactive customer focus with Industry 4.0 service offerings" for Survival level and "Proactive customer focus capturing empathy integrated with Industry 4.0 service offerings and breakthroughs" for Maturity level.
    b. In People and Culture dimension, the Survival and Maturity level description were unclear. It was revised so that digital culture, resources' digital skillsets, and cross-function collaboration are different. Digital culture in Maturity level was very common and prevalent—embody proactive mindset, not only a habit likewise in Survival level.
2. Deleting inconsistencies and unnecessary descriptions:

a. In Supply Chain dimension, Absence level: “Digitized and automated sub-processes” was deleted because it did not represent an absence of 4.0 implementation.
b. Cost/benefit analysis question in Investment sub-dimension of Business Strategy dimension was deleted.
c. Yes or No questions (question 1 and 2) in Degree of Implementation sub-dimension of Business Strategy dimension were deleted.
d. Paperwork percentage question in IT System dimension was deleted. Paperless work was written as one example of digital culture implementation in its definition.

3. Merging questions:
   a. Questions 1 and 2 (yes or no question) of Cross-functional Cooperation sub-dimension in People and Culture dimension were merged to new Likert question.

      Question 1: Is there any cross-functional cooperation in your company for any work assignments or projects?

      Question 2: Is it structured and continued?

      Merged: Is the cross-function cooperation for work assignments/projects already structured, continued, and efficient with the use of technology (gadgets, cloud, etc.)?
   b. Questions in Make and Delivery sub-dimensions of Supply Chain were merged to Plan sub-dimension regarding data analytics.

      Question 1: How is the data you collect used in production?

      Question 2: How is the data you collect used in logistics and procurement?

      Merged: How is the supply chain’s big data analysed so far?
   c. All of the nine technologies’ questions in IT System dimension were deleted and merged into 3 questions: awareness of 4.0 technologies in general, list of implementation, and degree of implementation.

4. Defining terms:
   a. Digital Culture term was defined in the questionnaire.
   b. Vehicle Routing Problem was written in full, not abbreviated.

4.4.2 Revised Version: Maturity Model and Assessment Instrument

The completion of Expert Assessment revision remarked that the revised version was then ready to launch for the second Validation: Pilot Survey. In order to distinguish with the initial proposed model in subchapter 4.2 and 4.3, this subchapter exhibited the revised version of the proposed maturity model and assessment instrument is attached at the very end (Attachment 3). Before proceeding to Table 4.11 – 4.17, here is a short recap.

There are five dimensions and its sub-dimensions in the model:

1. Business Strategy: 1) Degree of Industry 4.0 Strategy Implementation, 2) Collaboration.
2. People and Culture: 1) Cross-functional Cooperation, 2) Resources on Digital Capability, and 3) Digital Culture.
3. Customer, Product, and Service Offerings: 1) Digital Enabler and Digital Features of Products and Services, and 2) Product Development Collaboration.
4. Supply Chain: 1) Plan, 2) Source, 3) Make and 4) Deliver.
5. IT System: 1) Awareness to Industry 4.0 Technologies, 2) Degree of Implementation of Industry 4.0 Technologies, 3) IT Architecture, and 4) Degree of Connectivity, Transparency/Info Feasibility and Exchange of Information.

The levels are Absence, Existence I, Existence II, Existence III and Beyond Existence. Absence is no implementation of Industry 4.0. Existence I represents a company having little awareness on Industry 4.0, already leaving paperwork but struggling on digital tech/gadgets, has good IT architecture or ERP but inefficient use (often switch to manual work). Existence II represents a company start to have its 4.0 technology acquisition at least one, awareness and 4.0 strategy are spread up, using cloud, start to have descriptive big data analytics. Existence III start to have combination of 4.0 technology implementation such as RFID, cloud, and predictive data analytics, and help of industrial robot. Beyond Existence is a state to try an advanced development of 4.0 and an integrated system: AI, CPS, IoT, etc.

Table 4.10 Initial Proposed Maturity Model (Dimension and Level)

Dimension/Level	Absence	Existence	Survival	Maturity
Business strategy	No awareness of implementing Industry 4.0 or recognized at departmental level only. No vision or direct statement regarding Industry 4.0 in business strategy.	Industry 4.0 is in the business strategy, but implementation is unclear. Alternatively, Industry 4.0 is not in the strategy but somehow with sparse implementation.	Industry 4.0 strategy has the hype and communicated, understood and implemented.	Industry 4.0 strategy has been widely implemented across the business
People and culture	People are functionally dedicated to their own work. No digital culture at all.	Cross-function cooperation exist, but not structured and continuous. Cooperation starts to spark initiatives with/without digital culture.	Wider and frequent cross-function cooperation with digital culture.	Collaboration and digital are both a mature culture.
Customer, products, and service offerings	No Industry 4.0 implementation in service offerings.	Little implementation of digital technology Industry 4.0 in service offerings.	Reactive customer focus with Industry 4.0 service offerings.	Proactive customer focus capturing empathy integrated with Industry 4.0 service offerings and breakthroughs.
Supply Chain	No supply chain 4.0 technology, no integration between partners.	Vertical digitization and integration of process and data flows within the company. Supply chain 4.0 technology implemented functional and only some.	Horizontal integration of processes and data flows with customers and external partners, intensive data use	Fully integrated ecosystem with self-optimized, virtualized processes decentralized autonomy.
Information System and Technology	Separated IT architecture, paper/paperless work with less use of internet and Industry 4.0.	Homogeneous IT architecture in-house. Connection between departments is developing. Paperless work increased. Works are around internet, not yet Industry 4.0 or little usage.	Homogenous IT structure in the partner network, linked data, Paperwork decreased and optimized, speedy and information transparent, Industry 4.0 technology implemented but not yet integrated.	Data lake is created, data flows real-time, transparent and integrated, capable and flexible organization. CPS applied thoroughly as needed.

Table 4.11 Proposed Maturity Model (Dimension and Level Formulation)

Dimension/Level	Absence	Existence I	Existence II	Existence III	Beyond Existence
Business strategy	- No industry 4.0 strategy exists - No partnerships for Industry 4.0 projects	- Early awareness, pilot initiatives launched - Planning to have partnerships for Industry 4.0 projects	- Knowledge acquisition, understanding, knowledge used to develop strategy - Have partnership going on with academics/researcher/technology provider/other tier	- Early implementation, technology acquisition and strategy is formulated - Have partnership with more than one of the mentioned options	- Beyond existence, strategy is in implementation - Have mature and sustained partnership as long term project
People and culture	Work is fully dedicated. Employees with no digital capabilities. No digital culture	- Cross-functional cooperation - Cooperation is not structured and continuous - Digital skills and capability are none to low - Digital culture direction/strategic level	- Cross-functional cooperation using cloud - Cooperation is not structured and continuous - Digital skills and capability are limited to only IT workers - Digital culture at manager level	- Wider cross-functional cooperation using some 4.0 tech (cloud, big data analytics, etc.) - Cooperation is not structured and continuous - Digital skills and capability exist in all - Digital culture until operational level	- Wider cross-functional cooperation with integrated 4.0 tech. - Cooperation is structured and continuous. All across the business, cutting-edge digital and analytical skills are prevalent. Digital culture Routine to be reviewed, colleagues are engaged proactively
Customer, products, and service offerings	No digital enablement of sales forces and use of gadgets/online channel, no customer data/insight analysis. No collaboration	Planning to have digital enabler: use of gadgets/online channel, only critical customer data/insight analysis.	Use of gadgets/mobile devices, access to all relevant system anywhere and anytime, acquire customer data with descriptive insight analysis	Use of gadgets/mobile devices, access to all relevant system anywhere and anytime, acquire customer data with predictive insight analysis. Producing/still planning the smart product.	Mature digital features, channel (i.e. online channel), and smart product (i.e. RFID tag). Personalized offers to customer based on prescriptive customer insights: preference, situation, location, etc.

Dimension/Level	Absence	Existence I	Existence II	Existence III	Beyond Existence
Supply chain	No use of 4.0 technology, manual plan, source, make, and deliver stages.	Starting to adopt digital platform across the chain. Technology in plan, source, make, and deliver stages are assessed.	Starting to adopt a more automated digital platform (usually already invest in cloud) across the chain. Technology in plan, source, make, and deliver stages are assessed.	Starting to adopt a more advanced cloud platform with predictive learning capability but still in adaptation stage across the chain.	Starting to adopt combinations of 4.0 technology across the chain with prescriptive capability. Technology in plan, source, make, and deliver stages are assessed.
Information System and 4.0 Technology	No awareness and no implementation	Early awareness/pilot initiatives are launched. Pilot project are run but partially. IT architecture, paperless work, degree of information feasibility, and connectivity are assessed.	Early implementation stage. IT architecture, paperless work, degree of information feasibility, and connectivity are assessed.	Implementation stage with the starting stage of adaptation. IT architecture, paperless work, degree of information feasibility, and connectivity are assessed.	Maturity stage with survival. IT architecture, paperless work, degree of information feasibility, and connectivity are assessed.

Table 4.12 Business Strategy Dimension (Sub-dimension and Level Definition)

Business Strategy	Absence	Existence I	Existence II	Existence III	Beyond Existence
Degree of Industry 4.0 Strategy Implementation	No industry 4.0 strategy exists	Early awareness, pilot initiatives launched	Knowledge acquisition, understanding, knowledge used to develop strategy	Early implementation, technology acquisition and strategy is formulated	Beyond existence, strategy is in implementation
Collaboration	No partnerships for Industry 4.0 projects	Planning to have partnerships for Industry 4.0 projects	Have partnership going on with academics/ researcher/ consultant/ technology provider/ other tier	Have partnership with more than one of the mentioned options	Have mature and sustained partnership as long term project

Table 4.13 People and Culture Dimension (Sub-dimension and Level Definition)

People and Culture	Absence	Existence I	Existence II	Existence III	Beyond Existence
Cross-functional cooperation	Work is fully dedicated.	Cross-functional cooperation. Cooperation is not structured and continuous	Cross-functional cooperation. Cooperation is structured and continuous using cloud.	Wider cross-functional cooperation. Cooperation is structured and continuous using some of 4.0 technologies (cloud, big data analytics, etc.)	Wider cross-functional cooperation. Cooperation is structured and continuous with integrated 4.0 technologies (cloud, AI, VR, RFID, big data analytics, etc.)
Resources on Digital Capability	Employees have no experience with digital technologies	Employees have little experience with digital/emerging technologies	Technology focused areas of the business have employees with some digital skills	Most areas of the business have well developed digital and data analysis capability	All across the business, cutting edge digital and analytical skills are prevalent
Digital Culture	No digital culture	Digital culture exists in board and strategic level. Seldom implemented and controlled, no engagement in colleagues	Digital culture exists also in lower/ managerial level. Implemented partially with little engagement/ enthusiasm	Digital culture exists also in operational level. Implemented partially with moderate engagement/enthusiasm (already becoming culture with little proactiveness from colleagues)	Digital culture exists well implemented in corporate level (requiring all workers' awareness). Routine to be reviewed, colleagues are engaged proactively

Table 4.14 Products and Service Dimension (Sub-dimension and Level Definition)

Product and Service Offerings	Absence	Existence I	Existence II	Existence III	Beyond Existence
Digital enabler and digital features of products and services	No digital enablement of sales forces and use of gadgets/online channel, no customer data/insight analysis.	Planning to have digital enabler: use of gadgets/online channel, only critical customer data/insight analysis.	Use of gadgets/mobile devices, access to all relevant system anywhere and anytime, acquire customer data with descriptive insight analysis	Use of gadgets/mobile devices, access to all relevant system anywhere and anytime, acquire customer data with predictive insight analysis. Producing/still	Mature digital features, channel (i.e. online channel), and smart product (i.e. RFID tag). Personalized offers to customer based on insights: preference,

Product and Service Offerings	Absence	Existence I	Existence II	Existence III	Beyond Existence
				planning the smart product.	situation, location, etc with prescriptive analysis.
Product development collaboration	No collaboration	Early awareness of needs to collaborate, pilot initiatives launched.	Collaboration exists, understanding the possible scope to collaborate and to which external tier.	Collaboration gets more intense and developed.	Wide (involving multi stakeholder/players) and intense collaboration.

Table 4.15 Supply Chain Dimension (Sub-dimension and Level Definition)

Supply Chain	Absence	Existence I	Existence II	Existence III	Beyond Existence
Plan	Supply chain plan (resources and requirements) is made without digital document and not well communicated, supply chain strategy formulation is set manually (research, benchmark, etc.), supply network planning is conducted manually through software with algorithm, reactive communication with suppliers and customers, no integration between tiers (horizontal visibility), required-response to any market changes is slow (not proactive)	Supply chain plan (resources and requirements) is documented in computer database but not well communicated, supply chain strategy formulation is set manually (research, benchmark, etc.), supply network planning is conducted manually through software with algorithm, basic communication and data sharing exist with suppliers and customers, no integration between tiers (horizontal visibility), required-response to any market changes is slow (not proactive)	Supply chain plan (resources and requirements) is documented in computer database and well communicated, supply chain strategy formulation is set manually (research, benchmark, etc.), supply network planning is conducted manually through software with algorithm, basic communication and data sharing exist with suppliers and customers, site location, capacity, inventory and operations are visible between first tier suppliers and customer (horizontal visibility), required-response to any market	Supply chain plan (resources and requirements) is documented in cloud and well communicated, supply chain strategy formulation (research, benchmark, etc.) is set with learning capability, supply network planning is conducted with advanced algorithm and visible real-time, data transfer exist between key strategic suppliers/ customers (e.g. customer inventory levels), site location, capacity, inventory and operations are visible throughout supply chain (horizontal visibility), required-response to any	Supply chain plan (resources and requirements) is made in cloud and well communicated, supply chain strategy formulation (research, benchmark, etc.) is set with learning capability, supply network planning is conducted with advanced algorithm and visible real-time, fully integrated systems with suppliers/customers for appropriate processes (e.g. real-time integrated planning), site location, capacity, inventory and operations are visible real-time throughout supply chain and used for monitoring and optimisation (horizontal visibility), required-response to

Supply Chain	Absence	Existence I	Existence II	Existence III	Beyond Existence
			changes is moderate (quite proactive)	market changes is moderate (quite proactive)	any market changes is good/proactive
Source	Sourcing is done manually (offline or through calls), processes (sourcing, scheduling, receive, verify, and authorize supplier payment) are done segmented/individually, inventory control policy is set and understood, no data exchange with supplier	Use combined offline and online (e-sourcing and e-procurement), some processes (sourcing, scheduling, receive, verify, and authorize supplier payment) are done in series automatically/digitalized, inventory level is in computer database (manually update the inventory levels), exchange of specific data is exist	Use e-sourcing and e-procurement, processes (sourcing, scheduling, receive, verify, and authorize supplier payment) are automatic, inventory level is in computer database (manually update the inventory levels), exchange of additional data is exist	Use e-sourcing and e-procurement, processes (sourcing, scheduling, receive, verify, and authorize supplier payment) are automatic and smarter (system is able to fix problems real-time), inventory level is in computer database with smart devices updating inventory levels, data exchange is automatic	Use e-sourcing and e-procurement with adaptive switching (learning capability) due to changes, smart process (sourcing, scheduling, receive, verify, and authorize supplier payment), inventory level is in real-time database which is updated by smart device, data exchange is automatic
Make	Process starting from scheduling production activities, issuing material, producing, until releasing product to deliver is done manually without any 4.0 technology	Process starting from scheduling production activities, issuing material, producing, until releasing product to deliver is not integrated, documented in a cloud-based information system	Process starting from scheduling production activities, issuing material, producing, until releasing product to deliver is integrated with the help of industrial robot, error checking system, use of cloud, etc.	Process starting from scheduling production activities, issuing material, producing, until releasing product to deliver is integrated with the help of AI robot, automatic error checking system, real-time data processing in centralized data center, etc.	Process starting from scheduling production activities, issuing material, producing, until releasing product to deliver is integrated with the help of AI robot, cyber physical system, automatic error checking system, real-time data processing in centralized data center, etc.
Deliver	Process starting from inquiry, quote, validate order, route shipment, pick, pack, load, ship, and invoice are not digitized, long materials lead time resulting in high inventory levels.	Some processes from inquiry, quote, validate order, route shipment, pick, pack, load, ship, and invoice are digitized, improvements have been identified to reduce lead times for some materials	Process starting from inquiry, quote, validate order, route shipment, pick, pack, load, ship, and invoice are automated, real-time, and integrated. Improvements have been identified to reduce lead times for some materials	Process starting from inquiry, quote, validate order, route shipment, pick, pack, load, ship, and invoice are automated, real-time, and planned to have learning capability (Neural Networks for route shipment, etc.). Some improvements have been implemented to reduce lead times on key materials	Process starting from inquiry, quote, validate order, route shipment, pick, pack, load, ship, and invoice are transparent in real-time, automated, and widely implement 4.0 technologies where suitable (robotics, IoT, AI, etc.). Have differentiated stocking policies and lead times to fulfill order

Supply Chain	Absence	Existence I	Existence II	Existence III	Beyond Existence
					efficiently, use of driverless trucks, drone, etc.

Table 4.16 Information System and Technology Dimension (Sub-dimension and Level Definition)

Information and Technology System	Absence	Existence I	Existence II	Existence III	Beyond Existence
Awareness to Industry 4.0 technologies	No awareness. Unfamiliar with Industry 4.0.	Familiar, already plan, and little implementation.	Knowledge and early technology acquisition without further advanced use such as analysis feature.	Technology acquisition with analysis feature and reactive development (such as the needs to do predictive/intelligent data analysis).	Beyond existence, technology is prescriptive and act as solution provider/architect.
Degree of Implementation of Industry 4.0 technologies	No implementation. All works are manual.	Hybrid of manual and installing stage. Use of internet is more common than paperwork.	Implementing at least one of 4.0 technologies: cloud/big data analytics.	Implementing at least one of 4.0 technologies with learning capability/adaptation or more than one.	Have integrated implementation of 4.0 technologies, smart product, smart warehouse, smart plant, etc.
IT architecture	No homogenous IT architecture between functional silos/departments.	Homogenous in some departments.	Almost all IT architecture departments are homogenous. Use ERP.	Homogenous throughout the company. Use ERP.	Mature architecture. Homogenous throughout the holding and operating companies. Use ERP.
Degree of connectivity, transparency/info feasibility and exchange of information	No/little connectivity, exchange of information, no custom configuration (SOP) that may enable other department requesting internal documents.	Data transferred/obtained by crossfunction by needs/request with layers of approval.	Data transferred through mix use of cloud and hard devices (harddisk, flash, etc.) eye to eye. Aware of AI usage for data mining, etc.	Data transferred through cloud/online media such as email, telegram, etc. (approval done in distant). Try to analyse with learning capability.	Data can be downloaded/be traced for whom it is concerned through an integrated cloud system. Mature big data analytics.

The questionnaire had 7 sections (introductory questions, 5 dimensions, and questionnaire rating). The questions were made dedicated to answer at what level was each sub-dimension of each dimensions. One question answered one sub-dimension, even though there were some sub-dimensions that have more than one question.

These questions were developed from the dimension matrix (sub-dimension levelling). It has 29 core questions, 6 performance rating questions and some introductory questions. The revised questionnaire is attached in **Attachment 3**.

4.4.3 Validation II: Pilot Survey

The web-based Pilot Survey was done from December 2019 until early January 2020 with responses from 24 manufacturing companies operating in Indonesia. Those are different in manufacturing sectors ranging from FMCG, pulp and paper manufacturer, pharmaceutical, health products, fertilizer, auto parts, lightweight bricks manufacturers, etc. Below, Table 4.17, is the detailed results of the Pilot Survey. The complete result of each respondent is listed at the very end part of the document: Attachment 1—Maturity Profile.

Table 4.17 Identity of Respondent and Manufacturing Companies

Company	Product - Sector	Number of workers estimate	Latest annual revenue estimate (IDR)	Respondent position	Age	Starting working year
Company 1	Lightweight bricks and floor panels – Construction Material	100-249	>1 billion – 500 billion	PPIC Admin	24	2018
Company 2	Beverage – FMCG	>500	>1 trillion	SCM Director	43	2018
Company 3	Radiator, spark plug – Automotive	>500	>1 billion – 500 billion	Production Engineering Staff	24	2018
Company 4	Pulp – Chemical	<100	>1 trillion	Country Supply Chain Manager	37	2019
Company 5	Fertilizer – Chemical	>500	>1 trillion	Head Section of Internal Warehouse	30	2012
Company 6	Beverage cans – FMCG	100-249	>1 billion – 500 billion	Warehouse and Logistic Coordinator	23	2018
Company 7	Pharmaceutical – FMCG	>500	>1 trillion	PPIC Officer	23	2018
Company 8	Spices and food – FMCG	>500	>1 trillion	Food Technology Staff	24	2017
Company 9	Sugar – FMCG	>500	>1 billion – 500 billion	SCM Specialist	33	2015
Company 10	Cosmetics – FMCG	>500	>1 trillion	IT Business Partner for Manufacturing	23	2018
Company 11	Ceramics – Construction material	<100	500 million – 1 billion	Marketing	35	2015
Company 12	Fashion industry – FMCG	>500	>1 trillion	Senior Manager	43	2010
Company 13	Wheel rim – Automotive	100-249	>500 billion – 1 trillion	PPIC Supervisor	27	2017
Company 14	Creamer – FMCG	250-499	>1 billion – 500 billion	Logistic Manager	40	2012
Company 15	Wheel – Automotive	>500	>1 billion – 500 billion	Purchasing Supervisor	26	2016
Company 16	Food – FMCG	>500	>1 billion – 500 billion	PPIC Area Manager	29	2017

Company	Product - Sector	Number of workers estimate	Latest annual revenue estimate (IDR)	Respondent position	Age	Starting working year
Company 17	Glass – Construction	>500	>1 billion – 500 billion	Production Expert Staff	44	2007
Company 18	Household products – FMCG	>500	>1 trillion	Area Team Leader	24	2018
Company 19	Cement – Construction material	>500	>500 million – 1 billion	General Manager SCM	38	2018
Company 20	Beverage – FMCG	>500	>1 billion – 500 billion	Inventory Control Team Leader	21	2018
Company 21	Paper – Chemical	>500	>1 trillion	Section Head Production Converting 1B Pad Line	37	2008
Company 22	Cement – Chemical	>500	>1 trillion	Manager Dept. Design & Engineering	29	2014
Company 23	Velg – Automotive	>500	>1 billion – 500 billion	Section Head PPIC	26	2016
Company 24	Pharmaceutical – FMCG	>500	>1 trillion	Supply Chain Leader	44	2000

Based on the identity above, here is the categorization summarized in pie charts.

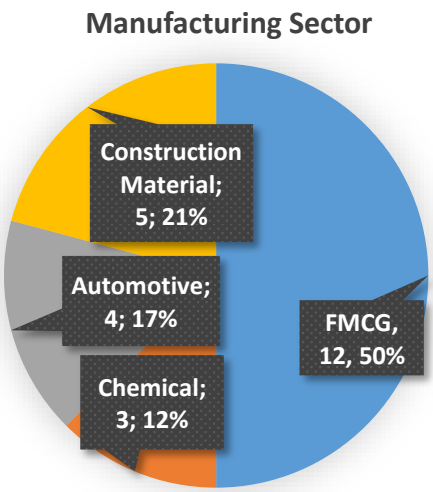

Figure 4.3 Respondent based on Manufacturing Sector

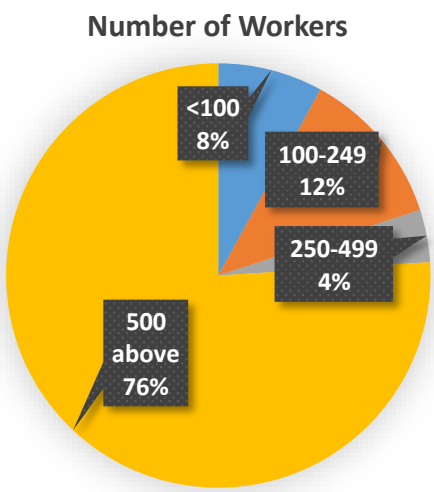

Figure 4.4 Respondent based on Number of Workers

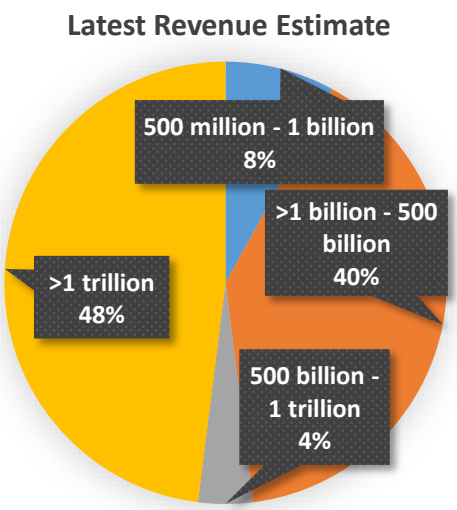

Figure 4.5 Respondent based on Latest Revenue Estimate

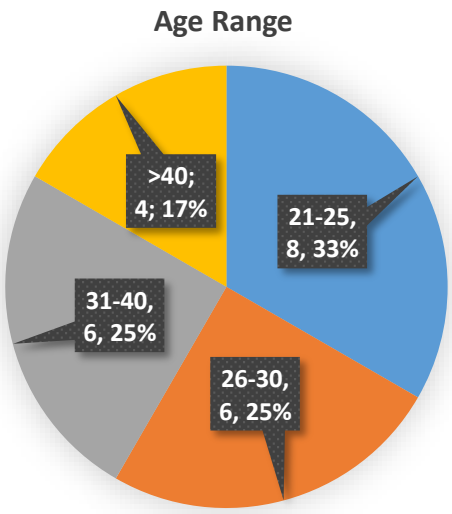

Figure 4.6 Respondent based on the Age Range

Respondent had filled in 29 core questions representing both current condition and target of the company. The maturity profile for each respondent is available in the Attachment 1. Based on the questionnaire result, here are the processed data.

Table 4.18 Maturity Level Summary

No	Respondent	Sector	Business Strategy	People and Culture	Product and Service Offerings	Supply Chain	Information System and Technology	Overall Score	Level
1	Company 1	Construction Material	3.5	4	4.3	3.292	3	3.618	Existence II
2	Company 2	FMCG	1.167	2.5	1	1.521	2	1.638	Absence
3	Company 3	Automotive	4.5	3	3.333	3.079	4.25	3.632	Existence II
4	Company 4	Chemical	3.5	3.333	3	3.208	3.75	3.358	Existence II
5	Company 5	Chemical	4	4	3.5	2.563	2.75	3.363	Existence II
6	Company 6	FMCG	2.333	2.333	2.3	1.313	2	2.056	Existence I
7	Company 7	FMCG	2.333	3.667	3.75	2.354	3.333	3.087	Existence II
8	Company 8	FMCG	1.333	2.167	2	2.063	1.75	1.863	Absence
9	Company 9	FMCG	1.667	2.667	3.750	2.583	2.5	2.633	Existence I
10	Company 10	FMCG	3	4	3.75	3.208	4	3.592	Existence II
11	Company 11	Construction Material	4	4	4	3.708	3	3.692	Existence II
12	Company 12	FMCG	3.5	4.3	4	3.625	4	3.842	Existence II
13	Company 13	Automotive	2.167	3.833	3	2.375	2.75	2.825	Existence I
14	Company 14	FMCG	2.333	2.333	2.5	2.25	2.75	2.433	Existence I
15	Company 15	Automotive	3	3.833	4.5	4.083	4.25	3.933	Existence II
16	Company 16	FMCG	1.833	2.667	2	1.875	1.5	1.975	Absence

No	Respondent	Sector	Business Strategy	People and Culture	Product and Service Offerings	Supply Chain	Information System and Technology	Overall Score	Level
17	Company 17	Construction Material	1	3	1.5	1.792	1	1.658	Absence
18	Company 18	FMCG	3	2.167	2.5	1.896	2.25	2.363	Existence I
19	Company 19	Construction Material	2.5	1	1.0	1.688	2	1.704	Absence
20	Company 20	FMCG	1.667	3.0	4	2.313	2	2.496	Existence I
21	Company 21	Chemical	4.5	4	4.000	3.354	3.50	3.904	Existence II
22	Company 22	Construction Material	3.5	4.167	5	4.146	4.00	4.063	Existence III
23	Company 23	Automotive	1	3	1.0	1.854	2.25	1.854	Absence
24	Company 24	FMCG	2.500	3.667	3.0	2.833	3	3.050	Existence II
Mean			2.674	3.188	2.99	2.624	2.826	2.860	
Standard Deviation			1.049	0.804	1	0.819	0.92	0.833	
Variance			1.054	0.619	1.197	0.642	0.8	0.665	

The overall score was ranging from Level 1 (Absence) to Level 4 (Existence III). The level composition is shown in a pie chart Figure 4.7. There were 6 companies in Absence level, those were Company 2 (1.638), Company 8 (1.863), Company 16 (1.975), Company 17 (1.658), Company 19 (1.704), and Company 23 (1.854). There were 6 companies in Existence I, those were the Company 6 (2.056), Company 9 (2.633), Company 13 Indonesia (2.825), Company 14 (2.433), Company 18 (2.363), and Company 20 (2.496). There were 11 companies in Existence II, those were Company 1, Company 3, Company 4, Company 5, Company 7, Company 10, Company 11, Company 12, Company 15, Company 21, and Company 24. There was only 1 company lied within Existence III, which is Company 22 (4.063). No companies lied in Beyond Existence. The details regarding each sub-dimensions' levels were discussed in the following subchapters.

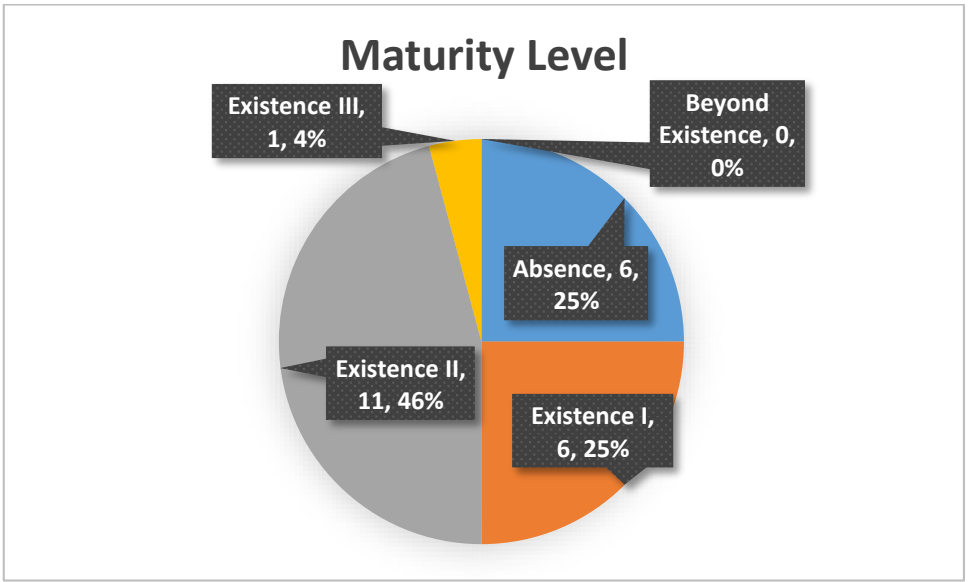

Figure 4.7 Maturity Level of 22 Manufacturing Companies

To have clearer insights, here is the summary of 4.0 (and non-4.0) technologies that the respondents use in its company. List of technologies obtained from the Pilot Survey is compiled in Table 4.24

Table 4.19 List of Respondents' Technologies

Respondent	Sector	Technology	Areas and Function
Company 1	Construction Material	-	-
Company 2	FMCG	1) RFID, 2) GPS	1) Factory. To track gallon circulation, goods position, 2) Distribution. Tracking truck position real-time.
Company 3	Automotive	RFID and QR Code	Production. To change the engine program when changing product models. QR Code in warehouse, production and delivery for product identification.
Company 4	Chemical	RFID, SAP, usage of cloud such as ProDoc and SharePoint	Customer service. For sales order and confirmation, PO automation and communication
Company 5	Chemical	WMS	Warehouse. Integrated with tracking the product location, production date (for FIFO) and space optimization
Company 6	FMCG	Database teamwork, sunsystem, excel	Management/office. Help accounting works.
Company 7	FMCG	Big data analytics using Tableau	Management/office. To ease workflow with information feasibility.
Company 8	FMCG	RFID, industrial robot palletizing	Plant and Warehouse. To help pick and stack boxes and products.
Company 9	FMCG	Barcode scan	Plant and Warehouse. For product identification.
Company 10	FMCG	1) AR, 2) RFID and fingerprint, 3) Machine Learning, 4) 3D Printing	1) Customer Service. To help gammification of product testing to user, 2) Office. For access control, 3) Plant. Machine vision to help QC, 4) Plant. Support production process.
Company 11	Construction Material	RFID	-
Company 12	FMCG	1) Big data analytics using SAP, 2) IoT, 3) Cloud and integrated system	*In a project with the headquarter to realize smart factory. Details are not mentioned.*
Company 13 Indonesia	Automotive	1) ERP, 2) Industrial Robot	1) Office and Warehouse. To help the accounting and inventory system, 2) Factory. Support production process.
Company 14	FMCG	1) Integrated ERP, 2) WMS, 3) Semi-automated vehicle.	-
Company 15	Automotive	1) QR Code, 2) Cloud (in development), 3) 3D Printing	1) Warehouse. Help identify quantities in shelf. 3) In trial for production process.
Company 16	FMCG	-	-
Company 17	Construction Material	Foxpro	Management. Support the database management system.
Company 18	FMCG	-	-
Company 19	Construction Material	Cloud: Evocon	Production. Support the production performance tracking.

Respondent	Sector	Technology	Areas and Function
Company 20	FMCG	1) e-SIC, 2) Quinsys, 3) SAP EWM, 4) IR2	1) Production. Support the reports of production, usage of material, defect quantity. 2) Production. Help to cope with production downtime and predictive maintenance. 3) Warehouse. Real-time warehousing data. 4) Delivery. To support delivery and real time settlement.
Company 21	Chemical	Fiori and Aspiro	Management. Support requests for leave, salary slip without hardcopy, quick action trouble shooting computer system.
Company 22	Chemical	1) Online tracking, 2) 3D Printing, 3) AR, 4) Cloud, 5) RFID tag	1) Delivery. Tracking truck real-time. 2) Production. (in development). 3) Marketing. To gamify the product for customer experience/test, 4) Management. Integrated internal server. 5) Asset Management. For production equipment identification.
Company 23	Automotive	-	-
Company 24	FMCG	WMS Markov E1	Warehouse. Support warehouse management and dispensing process.

Seen from the technology list, the most commonly used technology was software like ERP across the chain. Either it is WMS, SAP ERP for predictive maintenance, e-procurement, etc. Sensor for tracking goods in warehouse and delivery was also commonly used by some of the respondents, which were QR/Barcode and RFID. Real-time location tracking such as online GPS were also common. However, there was a few specific usage of 4.0 technology. Industrial robots were used in some and 3D Printing existed in Company 12, Company 10 and Company 22—the only one levelled in Existence III that had the highest score among all.

In order to be able to launch the model to public for a massive survey, the questionnaire result validity had to be tested. The respondents also did Likert scale performance rating. The result showed that the comprehensiveness level was 3.29, conceptual reliability and consistency was 3.29, relevance to company and applicability was 3.5, structure systematic ws 3.125 and level of detail in 3.29.

Aside from the moderate-rated questionnaire, another measure of construct was used. A measure of reliability: internal consistency called Cronbach's Alpha is used to test the current condition of respondents. The formula used was from Kappa and Becker (2000) as follows.

$$\alpha = \frac{N}{N-1}\left[1 - \frac{\sum \sigma^2(Y_i)}{\sigma_z^2}\right] \quad \text{Eq. 4.4.3}$$

N = number of indicants or items

$\sum \sigma^2(Y_i)$= Sum of indicants variances

σ_z^2= Variance of the total composites (scores)

Under 26 Likert questions and 24 respondents, the Cronbach's Alpha was 0.962, which signed a very high reliability in terms of internal consistency. Not only was about the current condition of the company, the questionnaire also assessed the target that the company has in strategy and goals. Further gap analysis from current condition towards the target would be discussed in Chapter 5. Measurement of Cronbach's Alpha was done also to the companies' targets. Under the same 26 Likert questions and 22 questions, the Cronbach's Alpha of the target condition was 0.974. Thus, the proposed model is valid to launch based on the double validation (face validity from expert opinion and pilot survey), performance rating and Cronbach's Alpha.

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CHAPTER 5
PILOT SURVEY ANALYSIS

This chapter explored and analysed the result of the Pilot Survey in form of gap analysis. It can be seen from the best performing companies, dimension analysis and company gap analysis.

5.1 Dimension Analysis

This subchapter analysed the result of each dimensions' level, best-worst performing dimension and sub-dimension from the Pilot Survey.

5.1.1 Supply Chain Level

This subchapter aimed to have further details on the questionnaire results. The Supply Chain dimension has 13 questions in total. The details were 4 questions in Plan sub-dimension, 3 questions in Make sub-dimension, 3 questions in Source sub-dimension, and 3 questions in Deliver sub-dimension. The questions contributing to each sub-dimension were averaged to get the level of the sub-dimension. It could be seen that the Supply Chain dimension had 2.67 in average score. Compared to other dimensions, Supply Chain had the least average. Most of them were in Absence (6 companies), Existence I (7 companies) and Existence II (7 companies). Here is the summary of results of Supply Chain Dimension.

Table 5.1 Supply Chain Dimension Maturity Level

No	Respondent	Plan	Source	Make	Deliver	Overall Score	Level
1	Company 1	3.500	3.667	3.000	3.000	3.292	Existence II
2	Company 2	1.750	1.000	2.000	1.333	1.521	Absence
3	Company 3	4.500	4.000	4.000	2.333	3.708	Existence II
4	Company 4	3.500	3.333	3.000	3.000	3.208	Existence II
5	Company 5	2.250	3.000	3.000	2.000	2.563	Existence I
6	Company 6	1.250	1.000	1.667	1.333	1.313	Absence
7	Company 7	2.750	2.667	2.000	2.000	2.354	Existence I

No	Respondent	Plan	Source	Make	Deliver	Overall Score	Level
8	Company 8	2.250	2.000	2.333	1.667	2.063	Existence I
9	Company 9	3.000	2.667	2.333	2.333	2.583	Existence I
10	Company 10	3.500	3.333	3.667	2.333	3.208	Existence II
11	Company 11	3.500	3.667	4.000	3.667	3.709	Existence II
12	Company 12	3.500	3.667	3.333	4.000	3.625	Existence II
13	Company 13	2.500	2.667	2.333	2.000	2.375	Existence I
14	Company 14	2.000	2.667	2.000	2.333	2.250	Existence I
15	Company 15	5.000	4.667	5.000	1.667	4.084	Existence III
16	Company 16	2.500	2.000	1.667	1.333	1.875	Absence
17	Company 17	1.500	2.333	1.667	1.667	1.792	Absence
18	Company 18	2.250	2.000	1.667	1.667	1.896	Absence
19	Company 19	2.750	1.333	1.667	1.000	1.688	Absence
20	Company 20	3.250	2.333	2.000	1.667	2.313	Existence I
21	Company 21	3.750	3.667	3.333	2.667	3.354	Existence II
22	Company 22	4.250	4.333	4.000	4.000	4.146	Existence III
23	Company 23	1.75	2.333	2	1.333	1.854	Absence
24	Company 24	3	2.667	3.000	2.667	2.834	Existence I
Mean		2.906	2.792	2.694	2.208	2.650	
Standard Deviation		0.961	0.982	0.947	0.845	0.844	
Variance		0.884	0.924	0.860	0.684	0.682	

Lots of 4.0 technology that are plant or office-based revolved around cloud and big data analytics. Those technologies can be applied throughout the stream, unexceptionally Plan, Source, and Make sub-dimensions which have the highest scored. Meanwhile, many 4.0 technologies used in distribution stage are AI-like. For example auto-pilot trucks, machine learning or deep learning for smart routing, advanced sensor for tracking, etc. However, globally, AI is still growing and has not been as prevalent as the use of cloud. In this case, it is seen that the least score in Supply Chain dimension lies in Deliver sub-dimension (2.208). It implied a good awareness but no to very little technology acquisition.

Based on the above summary, the percentage of maturity level is shown in pie chart in Figure 5.1 below. There are 32% companies lying in Existence II, 32% in Existence I, even 27% in Absence. There is only 9% in Existence III.

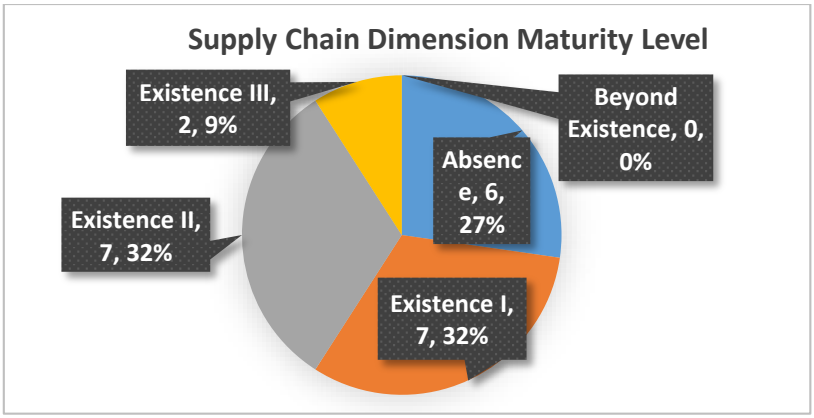

Figure 5.1 Supply Chain Dimension Maturity Level

5.1.2 Business Strategy Level

The Business Strategy dimension had few questions rooting to score the Degree of Industry 4.0 Strategy Implementation and Collaboration. It can be seen that the Business Strategy dimension has 2.7 in average score, slightly above Supply Chain (2.6). Here is the summary of results of Business Strategy dimension.

Table 5.2 Business Strategy Dimension Maturity Level

No	Respondent	Degree of 4.0 Strategy Implementation	Collaboration	Overall Score	Level
1	Company 1	3.000	4.000	3.500	Existence II
2	Company 2	1.333	1.000	1.167	Absence
3	Company 3	4.000	5.000	4.500	Existence III
4	Company 4	4.000	3.000	3.500	Existence II
5	Company 5	4.000	4.000	4.000	Existence III
6	Company 6	1.667	3.000	2.334	Existence I
7	Company 7	1.667	3.000	2.334	Existence I
8	Company 8	1.667	1.000	1.334	Absence
9	Company 9	3.500	4.000	3.750	Existence II
10	Company 10	3.000	3.000	3.000	Existence II
11	Company 11	4.000	4.000	4.000	Existence III
12	Company 12	3.000	4.000	3.500	Existence II
13	Company 13	2.333	2.000	2.167	Existence I
14	Company 14	1.667	3.000	2.334	Existence I
15	Company 15	3.000	3.000	3.000	Existence II
16	Company 16	1.667	2.000	1.834	Absence
17	Company 17	1.000	1.000	1.000	Absence

No	Respondent	Degree of 4.0 Strategy Implementation	Collaboration	Overall Score	Level
18	Company 18	3.000	3.000	3.000	Existence II
19	Company 19	2.000	3.000	2.500	Existence I
20	Company 20	2.333	1.000	1.667	Absence
21	Company 21	5.000	4.000	4.500	Existence III
22	Company 22	3.000	4.000	3.500	Existence II
23	Company 23	1.667	1.000	1.334	Absence
24	Company 24	2.000	3.000	2.500	Existence I
Mean		2.646	2.875	2.760	
Standard Deviation		1.054	1.191	1.048	
Variance		1.065	1.359	1.053	

The company must have implemented 4.0 technology only if the strategy is going there. Based on the above summary, it clearly showed the otherwise. Even if the standard deviation was above 1 (which showed some companies scored 3 and above), the means of both the sub-dimension and the overall score were around 2.7. The companies surely embedded the awareness, but not the real implementation. The percentage of maturity level is shown in pie chart in Figure 5.2 below. It spanned from Absence to Existence III. There are 17% companies in Existence III, 33% in Existence II, 25% in Existence I, and 25% in Absence. There is only 9% in Existence III.

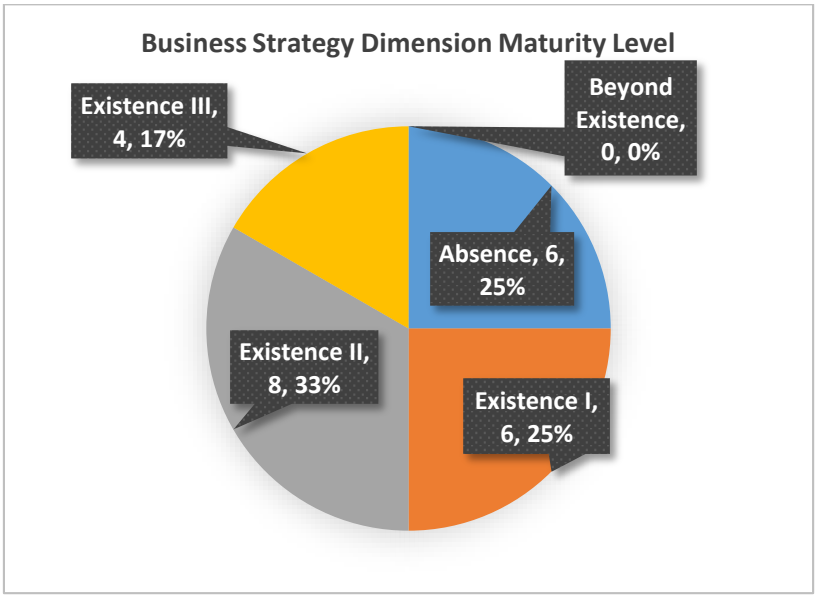

Figure 5.2 Business Strategy Dimension Maturity Level

5.1.3 People and Culture Level

People and Culture was the dimension with the highest average score (3.18). It is obtained from 4 questions and contributed by 3 sub-dimensions. The summary is in Table 5.3.

Table 5.3 People and Culture Dimension Maturity Level

No	Respondent	Cross-function Cooperation	Resources' Digital Capability	Digital Culture	Overall Score	Level
1	Company 1	4.000	5.000	3.000	4.000	Existence III
2	Company 2	2.000	3.000	2.500	2.500	Existence I
3	Company 3	3.000	3.000	3.000	3.000	Existence II
4	Company 4	3.000	3.000	4.000	3.333	Existence II
5	Company 5	4.000	4.000	4.000	4.000	Existence III
6	Company 6	2.000	2.000	3.000	2.333	Existence I
7	Company 7	4.000	3.000	4.000	3.667	Existence II
8	Company 8	1.000	1.000	4.500	2.167	Existence I
9	Company 9	3.000	2.000	3.000	2.667	Existence I
10	Company 10	4.000	4.000	4.000	4.000	Existence III
11	Company 11	4.000	3.000	3.500	3.500	Existence II
12	Company 12	5.000	4.000	4.000	4.333	Existence III
13	Company 13	4.000	4.000	3.500	3.833	Existence II
14	Company 14	2.000	2.000	3.000	2.333	Existence I
15	Company 15	5.000	3.000	3.500	3.833	Existence II
16	Company 16	2.000	2.000	4.000	2.667	Existence I
17	Company 17	3.000	2.000	4.000	3.000	Existence II
18	Company 18	2.000	2.000	2.500	2.167	Existence I
19	Company 19	2.000	1.000	1.000	1.333	Absence
20	Company 20	2.000	4.000	3.000	3.000	Existence II
21	Company 21	5.000	4.000	3.500	4.167	Existence III
22	Company 22	4.000	4.000	4.500	4.167	Existence III
23	Company 23	2.000	3.000	3.500	2.833	Existence I
24	Company 24	4.000	4.000	3.000	3.667	Existence II
Mean		3.167	3.000	3.396	3.188	
Standard Deviation		1.167	1.063	0.766	0.804	
Variance		1.306	1.083	0.562	0.619	

From Table 5.3, digital culture had the highest average score. Companies were quite confident in its people. Cross-function cooperation and resources' digital

skillsets were also not far from the highest average. It showed that workers were quite familiar with digital technology, cloud, gadgets, etc. However, the eagerness to use digital tool for knowledge management and skill enhancement was a concern to develop. Shown in Figure 5.3, Existence II held the highest (38%), followed by Existence I (33%), Existence III (25%) and Absence (4%). There was only 1 company in Absence level for People and Culture.

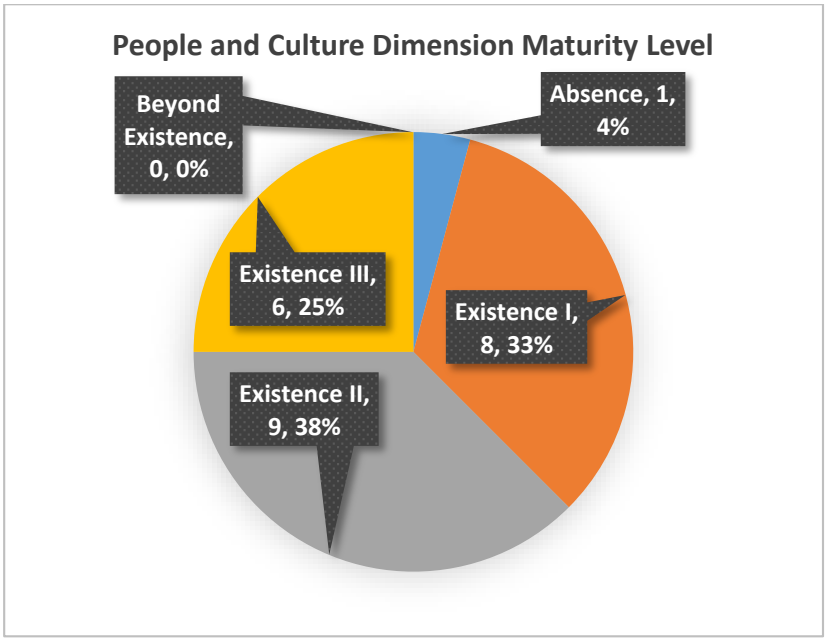

Figure 5.3 People and Culture Dimension Maturity Level

5.1.4 Customer, Product and Service Offerings Level

This dimension had 2 sub-dimensions with 3 questions in the assessment instrument. It was the second highest in dimension's average score, which was 2.979. The summary is in Table 5.4.

Table 5.4 Customer, Product and Service Offerings Dimension Maturity Level

No	Respondent	Digital enabler and digital features of product and service	Product development collaboration	Overall Score	Level
1	Company 1	3.500	5.000	4.250	Existence III
2	Company 2	1.000	1.000	1.000	Absence
3	Company 3	3.500	3.000	3.250	Existence II

No	Respondent	Digital enabler and digital features of product and service	Product development collaboration	Overall Score	Level
4	Company 4	3.000	3.000	3.000	Existence II
5	Company 5	3.000	4.000	3.500	Existence II
6	Company 6	1.500	3.000	2.250	Existence I
7	Company 7	3.500	4.000	3.750	Existence II
8	Company 8	3.000	1.000	2.000	Existence I
9	Company 9	3.500	4.000	3.750	Existence II
10	Company 10	4.500	3.000	3.750	Existence II
11	Company 11	4.000	4.000	4.000	Existence III
12	Company 12	4.000	4.000	4.000	Existence III
13	Company 13	3.000	3.000	3.000	Existence II
14	Company 14	2.000	3.000	2.500	Existence I
15	Company 15	4.000	5.000	4.500	Existence III
16	Company 16	2.000	2.000	2.000	Existence I
17	Company 17	1.000	2.000	1.500	Absence
18	Company 18	3.000	2.000	2.500	Existence I
19	Company 19	1.000	1.000	1.000	Absence
20	Company 20	4.000	3.000	3.500	Existence II
21	Company 21	4.000	4.000	4.000	Existence III
22	Company 22	5.000	4.000	4.500	Existence III
23	Company 23	1.000	1.000	1.000	Absence
24	Company 24	3.000	3.000	3.000	Existence II
Mean		2.958	3.000	2.979	
Standard Deviation		1.188	1.216	1.115	
Variance		1.352	1.417	1.192	

Based on Table 5.4 above, both of the sub-dimensions had almost the same average score. It implied that most of the companies had understood the possible scope to collaborate and to which external tier. The use of gadgets/mobile devices were prevalent with access to all relevant system anywhere and anytime. Figure 5.4 has the percentage which is heavy in Existence II (37%). Followed by Existence III (25%), Existence I (21%) and Absence (17%).

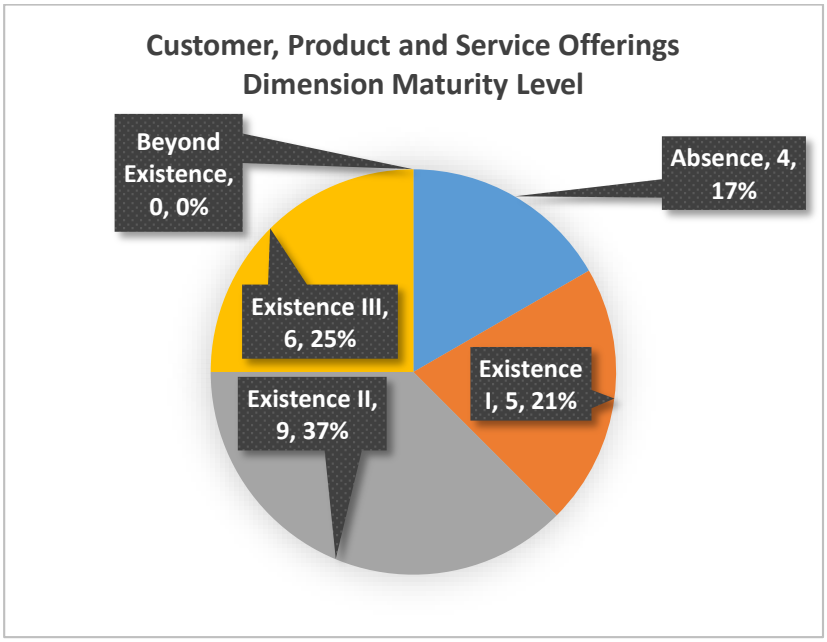

Figure 5.4 Customer, Product and Sevice Offerings Dimension Maturity Level

5.1.5 IT System Level

The IT System dimension had 5 questions rooting to score 4 sub-dimensions. It can be seen that this dimension had 2.8 in average score, the third highest in average score between dimensions. Here is the summary of results.

Table 5.5 IT System Dimension Maturity Level

No	Respondent	Awareness to Industry 4.0 technologies	Degree of Industry 4.0 Implementation	IT Architecture	Connectivity and transparency	Overall Score	Level
1	Company 1	3.000	3.000	3.000	3.000	3.000	Existence II
2	Company 2	1.000	3.000	2.000	2.000	2.000	Existence I
3	Company 3	4.000	4.000	4.000	5.000	4.250	Existence III
4	Company 4	3.000	4.000	4.000	4.000	3.750	Existence II
5	Company 5	3.000	3.000	3.000	2.000	2.750	Existence I
6	Company 6	2.000	2.000	2.000	2.000	2.000	Existence I
7	Company 7	2.000	1.000	3.000	5.000	2.750	Existence I
8	Company 8	2.000	1.000	2.000	2.000	1.750	Absence
9	Company 9	2.000	2.000	3.000	3.000	2.500	Existence I
10	Company 10	4.000	4.000	4.000	4.000	4.000	Existence III
11	Company 11	3.000	3.000	3.000	4.000	3.250	Existence II

No	Respondent	Awareness to Industry 4.0 technologies	Degree of Industry 4.0 Implementation	IT Architecture	Connectivity and transparency	Overall Score	Level
12	Company 12	3.000	4.000	4.000	4.000	3.750	Existence II
13	Company 13	2.000	1.000	4.000	4.000	2.750	Existence I
14	Company 14	3.000	2.000	3.000	3.000	2.750	Existence I
15	Company 15	4.000	4.000	5.000	4.000	4.250	Existence III
16	Company 16	1.000	2.000	1.000	2.000	1.500	Absence
17	Company 17	1.000	1.000	1.000	1.000	1.000	Absence
18	Company 18	2.000	1.000	2.000	4.000	2.250	Existence I
19	Company 19	2.000	2.000	2.000	2.000	2.000	Existence I
20	Company 20	2.000	2.000	2.000	2.000	2.000	Existence I
21	Company 21	3.000	4.000	4.000	3.000	3.500	Existence II
22	Company 22	4.000	4.000	4.000	4.000	4.000	Existence III
23	Company 23	2.000	3.000	2.000	2.000	2.250	Existence I
24	Company 24	4.000	3.000	3.000	3.000	3.250	Existence II
Mean		2.583	2.625	2.917	3.083	2.802	
Standard Deviation		0.974	1.135	1.060	1.100	0.912	
Variance		0.910	1.234	1.076	1.160	0.797	

Based on the table above, information feasibility (transparency) connectivity and exchange of information outperformed another sub-dimensions in average. It could be seen that there was no problem with exchange of data and information. However, the IT architecture, awareness and degree of Industry 4.0 implementation needed a highlight to level up. Figure 5.5 showed the span of level from Absence to Existence III, with the heavy 46% Existence I. Most of the companies had not yet implemented Industry 4.0, specifically an integrated system.

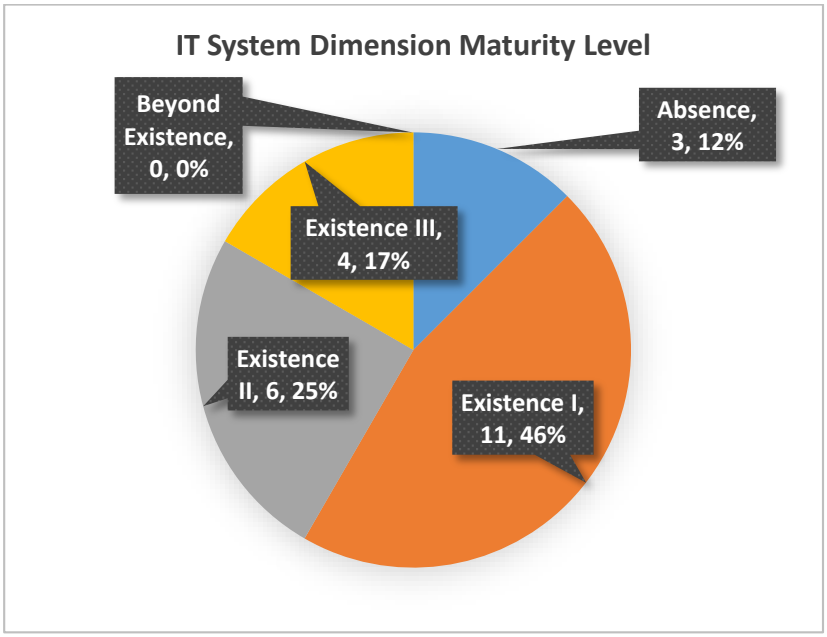

Figure 5.5 IT System Dimension Maturity Level

In summary, the best performing dimension based on the Pilot Survey was 1) People and Culture, scored 3.18, followed by 2) Customer, Product and Service Offerings which scored 2.979, 3) IT System, scored 2.8, 4) Business Strategy, scored 2.76, and lastly 5) Supply Chain, scored 2.65. The span of the dimensions' scores was between 2.65 (Existence I) to 3.18 (Existence II). It showed that most companies play on these two average levels. In fact, none of them scored 5 in any dimension.

It was also seen that most companies were confident with its people. The digital culture and cross-function cooperation was moderately good. Prevalence to digital tools/gadgets were common. In contrary, other dimensions needed improvement. In terms of Supply Chain, there were many areas to implement 4.0 technologies; however, it has the lowest score.

5.2 Gap Analysis

This subchapter aimed to discuss maturity level of some companies and do the gap analysis. This was critical for companies as a guideline to plan their roadmap. Gap analysis basically is comparing the present to the future/desired state, thus steps taken to scale up are determined.

The questionnaire accommodated respondents to state their current condition and target. From the result, it is known that Company 22 has the best score. Some of the top performers were Company 22 (scored 4.06, Existence III), Company 15 (3.933, Existence II), Company 12 (3.84, Existence II), and Company 21 (3.9, Existence II).

Company 22 had currently implemented many 4.0 technologies compared to other respondents. They implemented Online Tracking for truck transporting bulk/bags up until the sea transportation: the bulk carriers. Goods were real-time tracked under the Supply Chain Department. They also implemented Augmented Reality for marketing purposes. It dealt with product testing so that customer could gamify/try their needs. Not only that, the common implementation of ERP-like software or usage of cloud for most of the respondents were also applied in Company 22. They had internal server which architecture was integrated. Thus it eased exchange of information and a sign of transparency/information feasibility. They also had RFID tag, which was mentioned specifically applied in Asset Management Department. It kept an asset identity including assets like production equipment. Additionally, what made Company 22 outperform other companies was the ongoing project that remarked Industry 4.0 vision in their business strategy. They were on their trial with 3D Printing technology, which ink was a material from mortar/cement, to 3D print a simple wall for housing.

Those were the current condition of Company 22. Seen from the questionnaire result, Company 22 was now on their early implementation in implementing Industry 4.0 strategy/vision, with a technology acquisition and formulated strategy. The score for Business Strategy in average was 3.5. However, it implied a close call to 4 since they had an ongoing Industry 4.0 project (meaning a collaboration with technology provider). Their target score was 5 which meant they had to have a mature strategy implementation and a long term thoughtful collaboration with any external tier for 4.0 projects. This gap could be filled with meeting the current's goal (which was to finish the 3D Printing project) until it reached a real success, evaluated, improved and penetrated other 4.0 projects.

Its People and Culture scored 4.167, indicated: 1) a structured and continuous cross-function cooperation with the help of gadgets and cloud, 2) that almost all

business areas had an improving digital skillsets such as using digital tools for knowledge management and skill enhancement, and lastly 3) a proactive and routinely reviewed digital culture up until its operational level. Their target score was 5 which meant they had to have an outstanding resources with digital skillsets, digital culture getting common/prevalent and an advanced level of cross-function cooperation such as with the help of wearable technologies (HMD) for distant meeting, big data analytics, etc. This gap could be filled with making the digital culture obligatory: lean needs of paper, fingerprint/face recognition or using GPS for presence list, and enhance the resources' skills through training or projects.

Company 22's other three dimensions (Product and Service Offerings, Supply Chain and IT System) were all scored above 4 and scored a target of 5. In summary, their current condition for the sales force and service offerings was the same with People and Culture: good collaboration, good digital skillsets, good use of gadgets and digital technology for product development and marketing purposes. The Supply Chain's current condition was also one level away from Beyond Existence. They had predictive data analytics so the data processed could imply a prediction/forecast, which signed a software's learning capability, 24 hour automatic customer service bot, digital transaction, and many other things. The awareness of Industry 4.0 was also good, with a homogeny IT architecture and transparent information exchange. All Company 22 needed to fill the gap to maturity was adapting, evaluating and improving from the current state.

Meanwhile, another three top performers were in Existence II (3.8-3.93). The highlights of their current condition were 1) Company 15 had 3D Printing project, aside from the implementation of cloud and advanced tracking/sensor, 2) Company 12 had a project with its headquarters outside of Indonesia (it is a multinational company) to become a smart factory. The initialization was through the early implementation of IoT and big data analytics. Further details were not mentioned due to confidentiality. 3) Company 21 focused on system upgrade, machine and robot investment. Closest implementation was big data analytics. However, no further information can be provided.

Their target scores are 5 for Company 12 and 4 for Company 15 and PT Parbik Kertas Tjiwi Kimia. Company 12's needs to fill in gap (from the score of 3

to 5) was by: 1) finishing the current projects, 2) not only getting used to any cross-function cooperation but also consider the help of 4.0 technologies. 3) Have training for awareness and digital skill enhancement for the resources, 4) increase the enthusiasm for digital culture, 5) acknowledge the possible use of data analytics (the needs to scale up from descriptive to predictive data analytics), etc. The other two companies had the same formula with Company 22 to scale up one level: bear with adaptation, do evaluation and improve.

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CHAPTER 6
CONCLUSION

This chapter explained about the conclusion obtained based on the objectives of research and recommendation for future research and the research object.

6.1 Summary of Findings

This research had come into its concluding remarks. The summary of findings is explained in the following.

1. From the result of model development and reviewing preceding models, the proposed model has five dimensions: 1) Business Strategy, 2) People and Culture, 3) Customer, Product and Service Offerings, 4) Supply Chain and 5) IT System. The initial proposed levelling is Absence, Existence, Survival, and Maturity. However, for a fit use in Indonesia based on the information from research background (low indexes on technological advancement aspect even after the official big roadmap is launched and readiness index is assessed), the levelling is adjusted to Absence, Existence I, Existence II, Existence III and Beyond Existence.
2. The assessment instrument has introductory questions, 5 core sections with the total of 29 questions and performance rating. Both the model and the assessment instrument has been validated through double validation: Expert Assessment through face validity with expert opinion and a web-based Pilot Survey. Other than that, the reliability has been tested with Likert performance rating from the respondents (scored 3.3) and Cronbach's Alpha for internal consistency and resulted an excellence: 0.964.
3. There are 24 manufacturing companies participating in the Pilot Survey with the span of 4 classification of sectors: 1) FMCG (consist of F&B, pharmaceutical, fashion industry, and household products), 2) Chemical (pulp & paper, fertilizer company), 3) Construction material (cement, glass, ceramics, etc.) and 4) Automotive (wheel rim, wheel, radiator, spark plug, etc.). The top performers are Company 22 (scored 4.06, Existence III),

Company 15 (3.933, Existence II), Company 12 (3.84, Existence II), and Company 21 (3.9, Existence II). The average maturity level of all 24 companies is 2.86 (Existence I).

4. Gap analysis is done for the top performers such as Company 22, which has an ongoing 3D Printing project and some other 4.0 technology implementation: online tracking, RFID, Augmented Reality and cloud. Company 15 (with 3D Printing project), Company 21 (with integrated system upgrade and machine investment) and Company 12 (project with its headquarters outside of Indonesia to become a smart factory through the help of IoT and big data) are also analysed. To scale up to their target level, they are in short suggested to finish the current project, adapt, evaluate, improve and consistently explore and broaden the strategy.

6.2 Recommendation

The recommendation is made for future research and the research object. It is formulated as follows.

1. Consider service provider and start-up companies for wider applicability. Consider Return and Mitigation stage from SCOR framework and segregate questions based on the nature of the company (i.e. nature of production system). Different system would have different detail questions. Thus, Make-to-Stock companies would have different assessment instrument with those with Make-to-Order and Engineer-to-Order.
2. Use weighting in scoring the sub-dimensions with specific MCDM method. Deep research is required to determine which sub-dimension is critical and which are not. This model can also be used for case study which objective is roadmap planning (this research has not accommodate it).
3. Consider other dimensions to add comprehensiveness, so that the model is robust to judge. Such as legal aspect, factory operation (the detail of Make sub-dimension in the Supply Chain dimension).

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ATTACHMENT

Attachment 1. Maturity Profile

1. Company 1

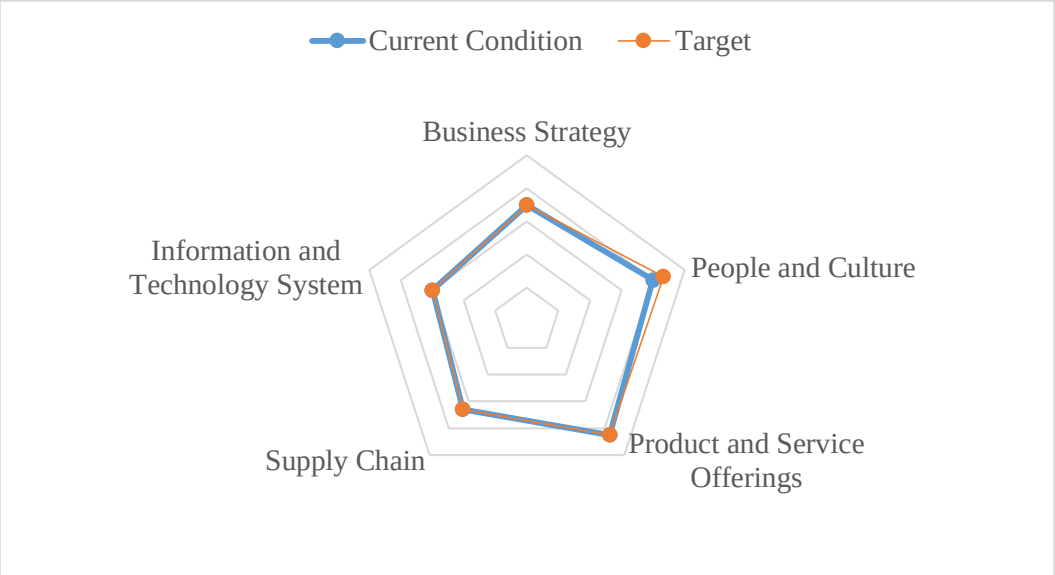

Figure A1. Maturity Level of Company 1

Company 1 is a lightweight bricks and floor panel manufacturer. It has 100-249 workers with > 1 billion to 500 billion rupiah latest revenue estimate. Its overall score is **3.61**. Its highest dimension level is Product and Service Offerings which is 4.3. Below is the detailed sub-dimensions' current and target level.

Table A1. Business Strategy of Company 1

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	3	3	3.5	3.5
Collaboration	4	4		

Table B1. People and Culture of Company 1

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	4	5	4	4.333333333

People and Culture	Current Condition	Target	Current Level	Target Level
Resources on Digital Capability	5	5		
Digital Culture	3	3		

Table C1. Product and Service Offerings of of Company 1

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	3.5	3.5	4.3	4.3
Product development collaboration	5	5		

Table D1. Supply Chain of Company 1

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	3.5	3.5	3.2916667	3.291666667
Source	3.66666667	3.66666667		
Make	3	3		
Deliver	3	3		

Table E1. Information and Technology System of of Company 1

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	3	3	3	3
IT architecture	3	3		
Degree of implementation of Industry 4.0	3	3		
Degree of connectivity, transparency and exchange of information	3	3		

2. Company 2

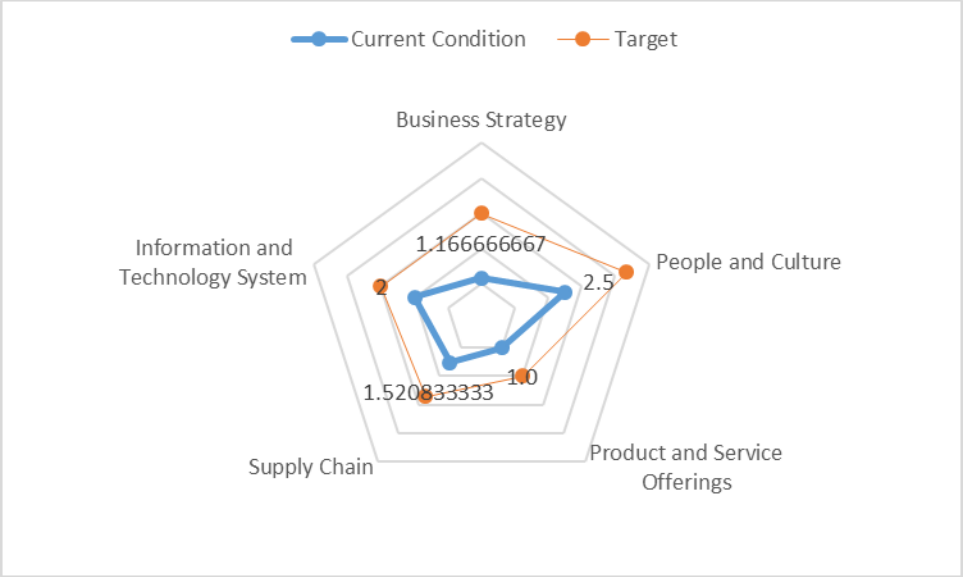

Figure A2. Maturity Level of Company 2

Company 2 is a **Mineral water manufacturer**. It has **more than 500** workers with **> 1 trillion rupiah** latest revenue estimate. Its overall score is **1.64**. Its highest dimension level is **People and Culture** which is **2.5**. Below is the detailed sub-dimensions' current and target level.

Table A2. Business Strategy of Company 2

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	1.333333333	4	1.166666667	3
Collaboration	1	2		

Table B2. People and Culture of Company 2

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	2	4	2.5	4.333333333
Resources on Digital Capability	3	4		
Digital Culture	2.5	5		

Table C2. Product and Service Offerings of Company 2

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	1.0	2	1.0	2.0
Product development collaboration	1	2		

Table D2. Supply Chain of Company 2

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	1.75	3.5	1.520833333	2.708333333
Source	1	2		
Make	2	3		
Deliver	1.333333333	2.333333333		

Table E2. Information and Technology System of Company 2

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	1	2	2	3
IT architecture	3	4		
Degree of implementation of Industry 4.0	2	3		
Degree of connectivity, transparency and exchange of information	2	3		

3. Company 3

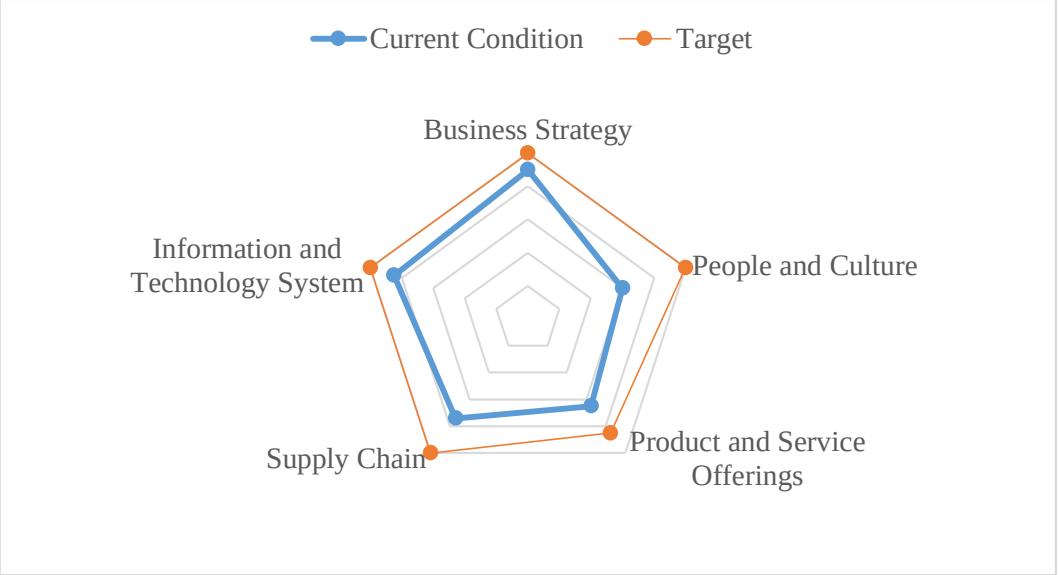

Figure A3. Maturity Level of Company 3

Company 3 is an automotive components manufacturer. It has 500 and above workers with > 1 billion to 500 billion rupiah latest revenue estimate. Its overall score is **3.74,** the highest of all companies surveyed. Its highest dimension level is the Business Strategy, which is 4.5. Below is the detailed sub-dimensions' current and target level.

Table A3. Business Strategy of Company 3

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	4	5	4.5	5
Collaboration	5	5		

Table B3. People and Culture of Company 3

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	3	5	3	5
Resources on Digital Capability	3	5		
Digital Culture	3	5		

Table C3. Product and Service Offerings of Company 3

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	3.5	4.5	3.3	4.3
Product development collaboration	3	4		

Table D3. Supply Chain of Company 3

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	4.5	5	3.708333333	5
Source	4	5		
Make	4	5		
Deliver	2.333333333	5		

Table E3. Information and Technology System of Company 3

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	4	5	4.25	5
IT architecture	4	5		
Degree of implementation of Industry 4.0	4	5		
Degree of connectivity, transparency and exchange of information	5	5		

4. Company 4

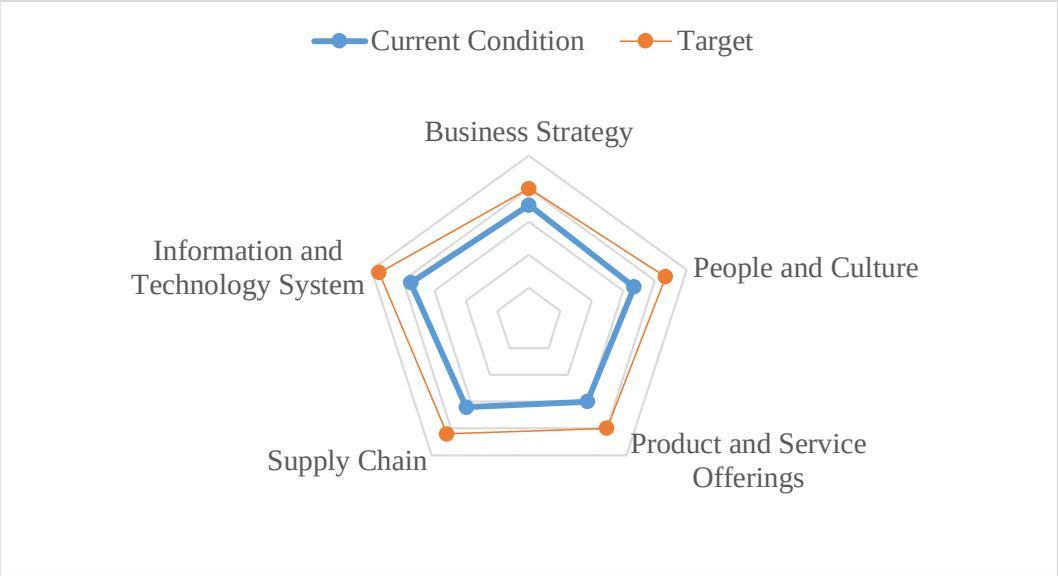

Figure A4. Company 4

Company 4 is a chemicals manufacturer. It has < 100 workers with > 1 trillion rupiah latest revenue estimate. Its overall score is **3.36**. Its highest dimension level is the Information and Technology System, which is 3.75. Below is the detailed sub-dimensions' current and target level.

Table A4. Business Strategy of Company 4

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	4	4	3.5	4
Collaboration	3	4		

Table B4. People and Culture of Company 4

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	3	4	3.333333	4.3333333
Resources on Digital Capability	3	4		
Digital Culture	4	5		

Table C4. Product and Service Offerings of Company 4

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	3.0	4.0	3.0	4.0
Product development collaboration	3	4		

Table D4. Supply Chain of Company 4

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	3.5	4.5	3.208333333	4.20833333
Source	3.333333333	4.333333333		
Make	3	4		
Deliver	3	4		

Table E4 Information and Technology System of Company 4

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	3	4	3.75	4.75
IT architecture	4	5		
Degree of implementation of Industry 4.0	4	5		
Degree of connectivity, transparency and exchange of information	4	5		

5. Company 5

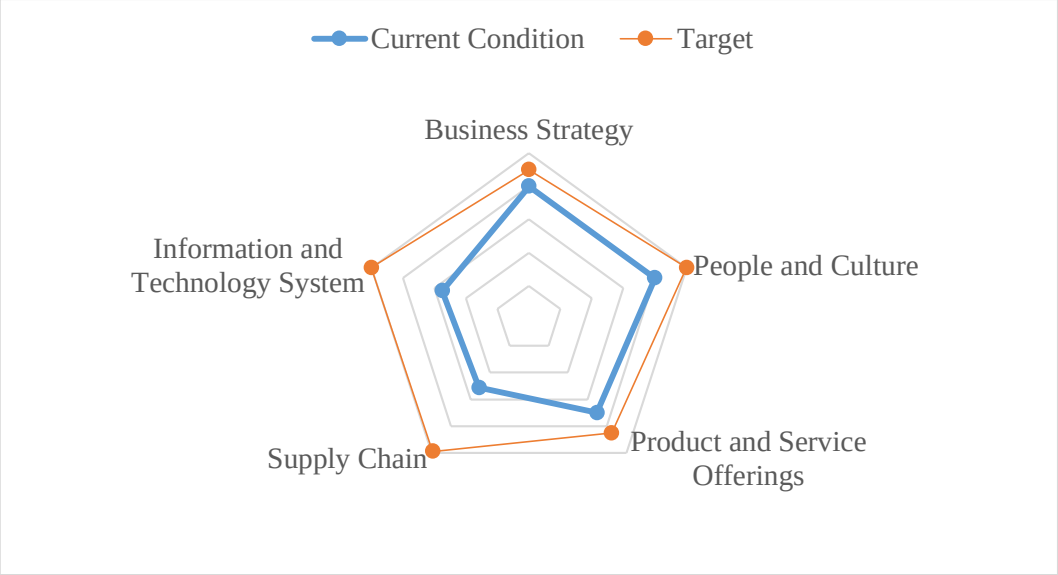

Figure A5. Maturity Level of Company 5

Company 5 is a fertilizer manufacturer. It has 500 and above workers with > 1 trillion rupiah latest revenue estimate. Its overall score is **3.36**. Its highest dimension level are both the Business Strategy and People and Culture, which is 4. Below is the detailed sub-dimensions' current and target level.

Table A5. Business Strategy of Company 5

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	4	5	4	4.5
Collaboration	4	4		

Table B5. People and Culture of Company 5

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	4	5	4	5
Resources on Digital Capability	4	5		
Digital Culture	4	5		

Table C5. Product and Service Offerings of Company 5

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	3.0	4.5	3.5	4.3
Product development collaboration	4	4		

Table D5. Supply Chain of Company 5

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	2.25	4.75	2.5625	4.9375
Source	3	5		
Make	3	5		
Deliver	2	5		

Table E5. Information and Technology System of Company 5

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	3	5	2.75	5
IT architecture	3	5		
Degree of implementation of Industry 4.0	3	5		
Degree of connectivity, transparency and exchange of information	2	5		

6. Company 6

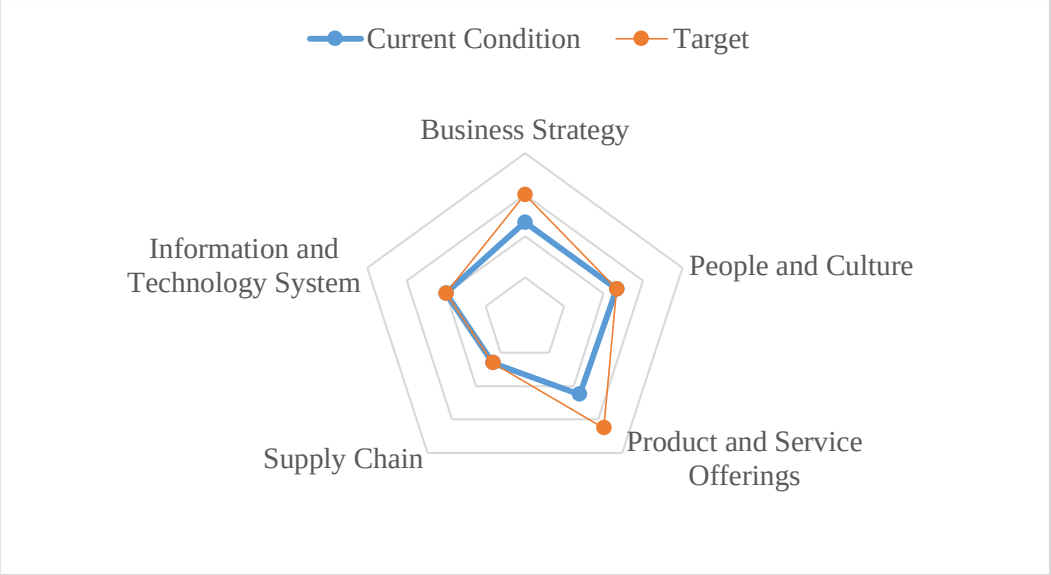

Figure A6. Maturity Level of Company 6

Company 6 is a multi-national company which name is protected producing beverage cans. It has 100-249 workers with > 1 billion to 500 billion rupiah latest revenue estimate. Its overall score is **2.05**. Its highest dimension level are both Business Strategy, and People and Culture, which is 2.33. Below is the detailed sub-dimensions' current and target level.

Table A6. Business Strategy of Company 6

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	1.6666667	3	2.3333333	3
Collaboration	3	3		

Table B6. People and Culture of Company 6

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	2	2	2.3333333	2.333333333
Resources on Digital Capability	2	2		
Digital Culture	3	3		

Table C6. Product and Service Offerings of Company 6

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	1.5	1.5	2.3	3.3
Product development collaboration	3	5		

Table D6. Supply Chain of Company 6

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	1.25	1.25	1.3125	1.3125
Source	1	1		
Make	1.66666667	1.66666667		
Deliver	1.33333333	1.33333333		

Table E6. Information and Technology System of Company 6

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	2	2	2	2
IT architecture	2	2		
Degree of implementation of Industry 4.0	2	2		
Degree of connectivity, transparency and exchange of information	2	2		

7. Company 7

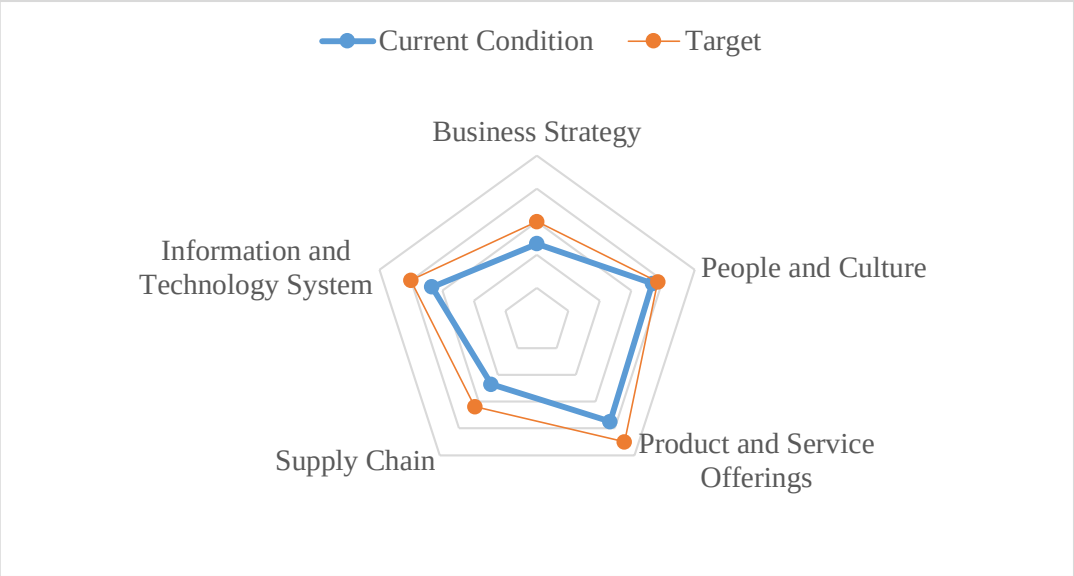

Figure A7. Maturity Level of Company 7

Company 7 is a pharmaceuticals and supplements manufacturer. It has 500 and above workers with > 1 trillion rupiah latest revenue estimate. Its overall score is **3.09**. Its highest dimension level is Product and Service Offerings, which is 3.8. Below is the detailed sub-dimensions' current and target level.

Table A7. Business Strategy of Company 7

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	1.6666667	3	2.3333333	3
Collaboration	3	3		

Table B7. People and Culture of Company 7

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	4	4	3.666667	3.8333333
Resources on Digital Capability	3	3		
Digital Culture	4	4.5		

Table C7. Product and Service Offerings of Company 7

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	3.5	4.0	3.8	4.5
Product development collaboration	4	5		

Table D7. Supply Chain of Company 7

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	2.75	3.25	2.35416667	3.1875
Source	2.66666667	3.33333333		
Make	2	3.66666667		
Deliver	2	2.5		

Table E7. Information and Technology System of Company 7

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	2	4	3.3333333	4
IT architecture	1	1		
Degree of implementation of Industry 4.0	3	3		
Degree of connectivity, transparency and exchange of information	5	5		

8. Company 8

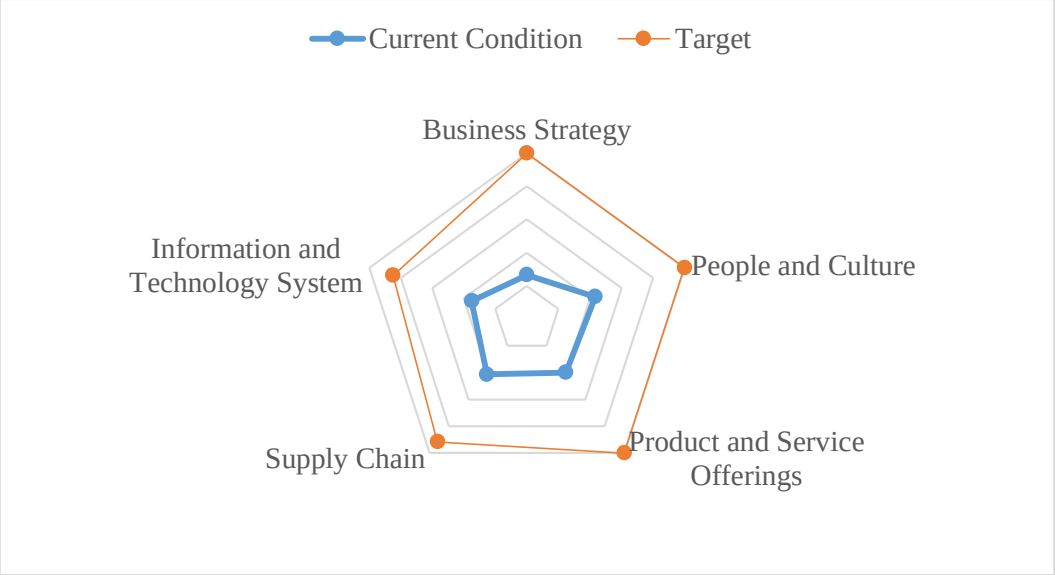

Figure A8. Maturity Level of Company 8

Company 8 is spices and food manufacturer. It has 500 and above workers with > 1 trillion rupiah latest revenue estimate. Its overall score is **1.86**. Its highest dimension level is People and Culture, which is 2.167. Below is the detailed sub-dimensions' current and target level.

Table A8. Business Strategy of Company 8

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	1.666666667	5	1.3333333	5
Collaboration	1	5		

Table B8. People and Culture of Company 8

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	1	5	2.166666667	5
Resources on Digital Capability	1	5		
Digital Culture	4.5	5		

Table C8. Product and Service Offerings of Company 8

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	3.0	5.0	2.0	5.0
Product development collaboration	1	5		

Table D8. Supply Chain of Company 8

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	2.25	5	2.0625	4.583333333
Source	2	5		
Make	2.333333333	4.3333333		
Deliver	1.666666667	4		

Table E8. Information and Technology System of Company 8

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	2	4	1.75	4.25
IT architecture	1	4		
Degree of implementation of Industry 4.0	2	5		
Degree of connectivity, transparency and exchange of information	2	4		

9. Company 9

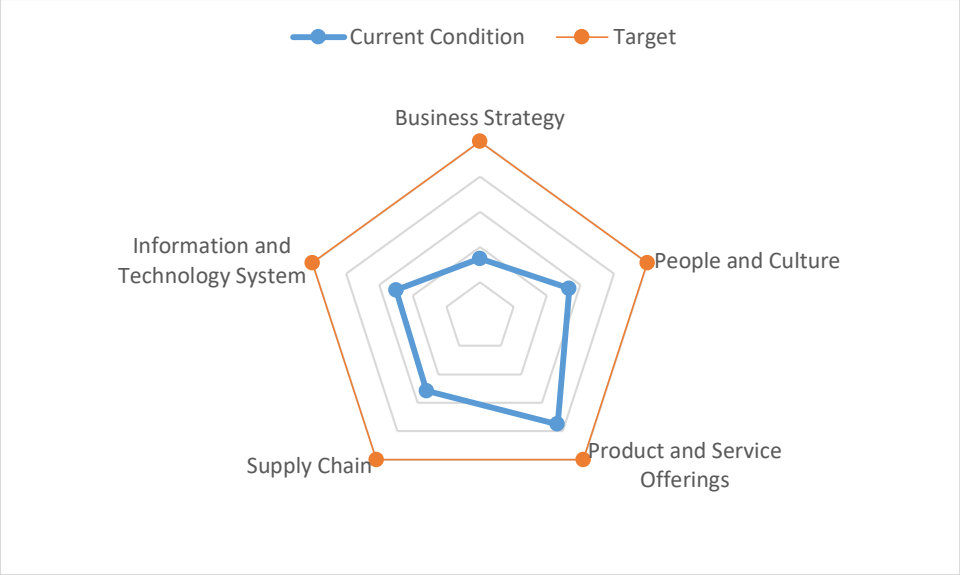

Figure A9. Maturity Level of Company 9

Company 9 is a sugar production company. It has **more than 500** workers with **> 1 billion to 500 billion rupiah** latest revenue estimate. Its overall score is **2.63**. It's highest dimension level is **Product and Service Offerings** which is **3.8**. Below is the detailed sub-dimensions' current and target level.

Table A9. Business Strategy of Company 9

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	1.333333333	5	1.666666667	5
Collaboration	2	5		

Table B9. People and Culture of Company 9

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	3	5	2.666666667	5
Resources on Digital Capability	2	5		
Digital Culture	3	5		

Table C9. Product and Service Offerings of Company 9

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	3.5	5	3.8	5.0
Product development collaboration	4	5		

Table D9. Supply Chain of Company 9

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	3	5	2.583333333	5
Source	2.666666667	5		
Make	2.333333333	5		
Deliver	2.333333333	5		

Table E9. Information and Technology System of Company 9

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	2	5	2.5	5
IT architecture	2	5		
Degree of implementation of Industry 4.0	3	5		
Degree of connectivity, transparency and exchange of information	3	5		

10. Company 10

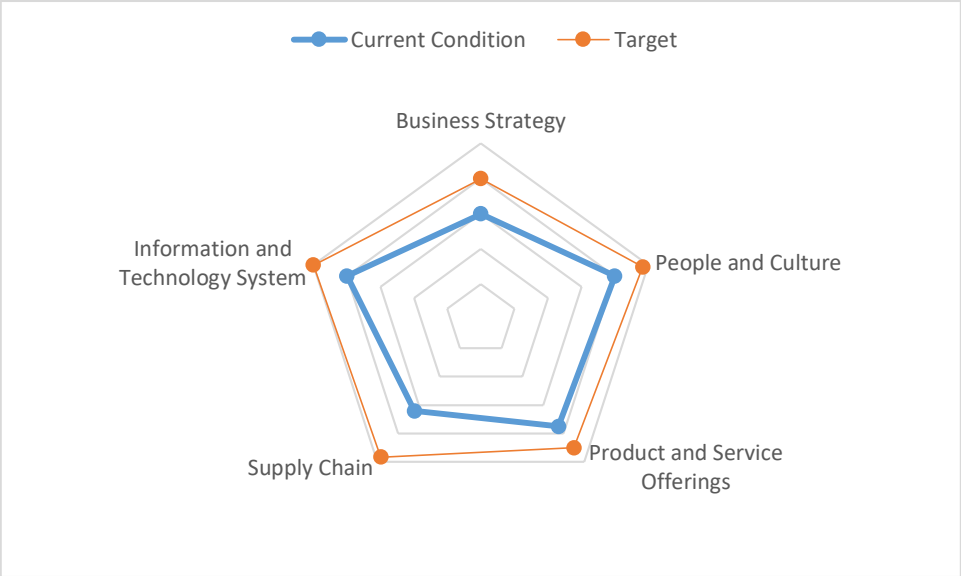

Figure A10. Maturity Level of Company 10

Company 10 is a Cosmetics manufacturer. It has **more than 500** workers with **> 1 trillion rupiah** latest revenue estimate. Its overall score is **3.59**. It's highest dimension level is **People and Culture and Information and Technology System** which is **4**. Below is the detailed sub-dimensions' current and target level.

Table A10. Business Strategy of Company 10

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	3	5	3	4
Collaboration	3	3		

Table B10. People and Culture of Company 10

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	4	5	4	4.833333333
Resources on Digital Capability	4	5		
Digital Culture	4	4.5		

Table C10. Product and Service Offerings of Company 10

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	4.5	5	3.8	4.5
Product development collaboration	3	4		

Table D10. Supply Chain of Company 10

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	3.5	5	3.208333333	4.833333333
Source	3.333333333	5		
Make	3.666666667	4.666666667		
Deliver	2.333333333	4.666666667		

Table E10. Information and Technology System of Company 10

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	4	5	4	5
IT architecture	4	5		
Degree of implementation of Industry 4.0	4	5		
Degree of connectivity, transparency and exchange of information	4	5		

11. Company 11

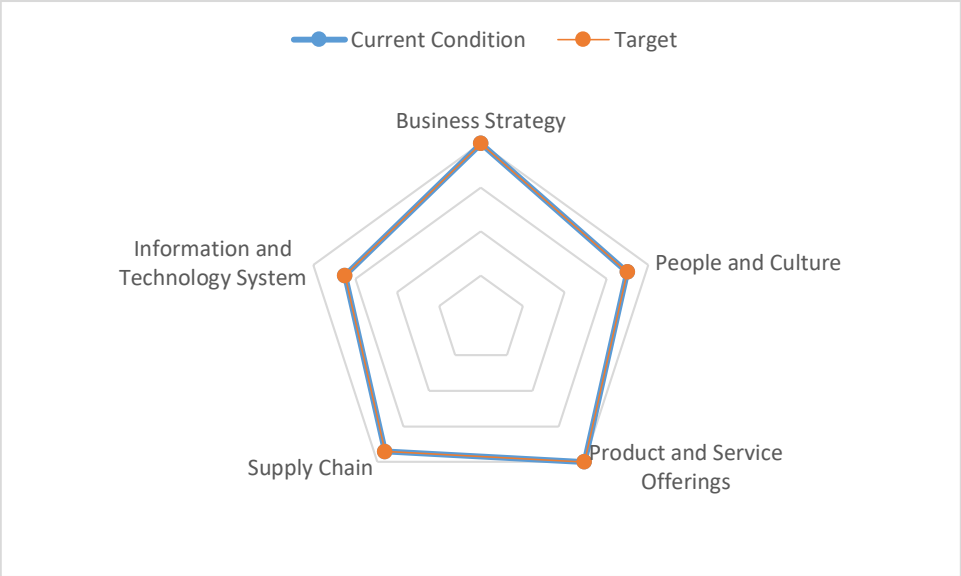

Figure A11. Maturity Level of Company 11

Company 11 is a Ceramics and modern warehouseing machine manufacturer. It has **less than 100** workers with **500 million to 1 billion rupiah** latest revenue estimate. Its overall score is **3.69**. It's highest dimension level is **Product and Service Offerings** which is 4. Below is the detailed sub-dimensions' current and target level.

Table A11. Business Strategy of Company 11

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	4	4	4	4
Collaboration	4	4		

Table B11. People and Culture of Company 11

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	4	4	3.5	3.5
Resources on Digital Capability	3	3		
Digital Culture	3.5	3.5		

Table C11. Product and Service Offerings of Company 11

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	4.0	4	4.0	4.0
Product development collaboration	4	4		

Table D11. Supply Chain of Company 11

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	3.5	3.5	3.708333333	3.708333333
Source	3.666666667	3.666666667		
Make	4	4		
Deliver	3.666666667	3.666666667		

Table E11. Information and Technology System of Company 11

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	3	3	3.25	3.25
IT architecture	3	3		
Degree of implementation of Industry 4.0	3	3		
Degree of connectivity, transparency and exchange of information	4	4		

12. Company 12

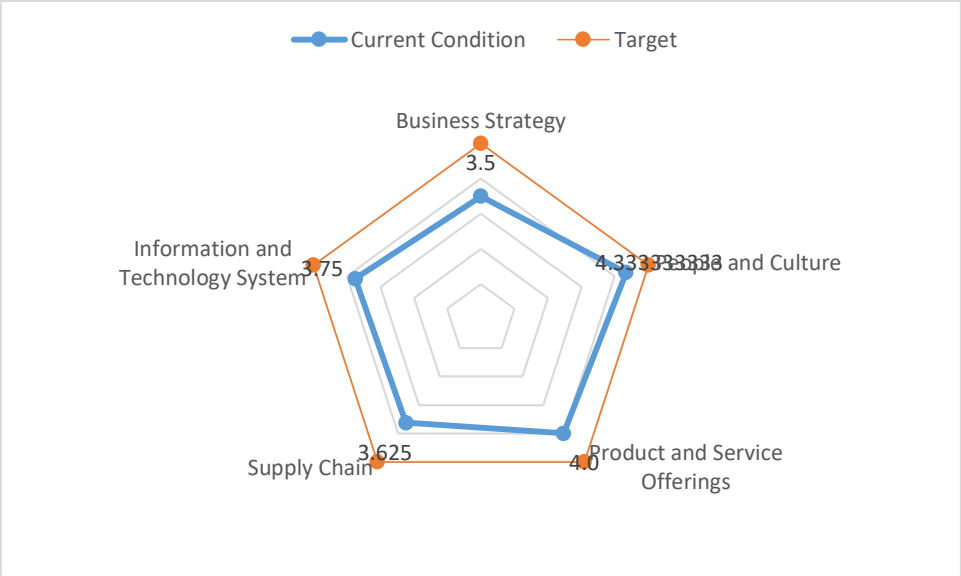

Figure A12. Maturity Level of Company 12

Company 12 is a Shoes manufacturer. It has **more than 500** workers with **> 1 trillion rupiah** latest revenue estimate. Its overall score is **3.84**. It's highest dimension level is **People and Culture** which is **4.33**. Below is the detailed sub-dimensions' current and target level.

Table A12. Business Strategy of Company 12

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	3	5	3.5	5
Collaboration	4	5		

Table B12. People and Culture of Company 12

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	5	5	4.333333333	5
Resources on Digital Capability	4	5		
Digital Culture	4	5		

Table C12. Product and Service Offerings of Company 12

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	4.0	5	4.0	5.0
Product development collaboration	4	5		

Table D12. Supply Chain of Company 12

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	3.5	5	3.625	5
Source	3.666666667	5		
Make	3.333333333	5		
Deliver	4	5		

Table E12. Information and Technology System of Company 12

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	3	5	3.75	5
IT architecture	4	5		
Degree of implementation of Industry 4.0	4	5		
Degree of connectivity, transparency and exchange of information	4	5		

13. Company 13

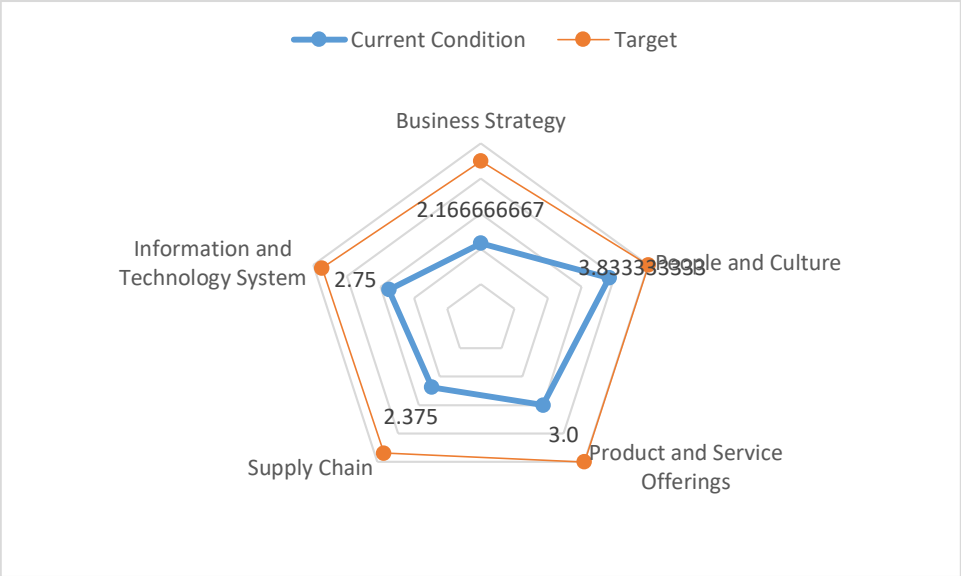

Figure A13. Maturity Level of Company 13

Company 13 is a multinational wheel rim (Auto parts) manufacturer. It has **around 100 - 249** workers with **500 million to 1 billion rupiah** latest revenue estimate. Its overall score is **2.83**. It's highest dimension level is **People and Culture** which is **3.83**. Below is the detailed sub-dimensions' current and target level.

Table A13. Business Strategy of Company 13

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	2.333333333	5	2.166666667	4.5
Collaboration	2	4		

Table B13. People and Culture of Company 13

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	4	5	3.833333333	5
Resources on Digital Capability	4	5		

Digital Culture	3.5	5		

Table C13. Product and Service Offerings of Company 13

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	3.0	5	3.0	5.0
Product development collaboration	3	5		

Table D13. Supply Chain of Company 13

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	2.5	4.75	2.375	4.6875
Source	2.666666667	5		
Make	2.333333333	4.666666667		
Deliver	2	4.333333333		

Table E13. Information and Technology System of Company 13

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	2	4	2.75	4.75
IT architecture	1	5		
Degree of implementation of Industry 4.0	4	5		
Degree of connectivity, transparency and exchange of information	4	5		

14. Company 14

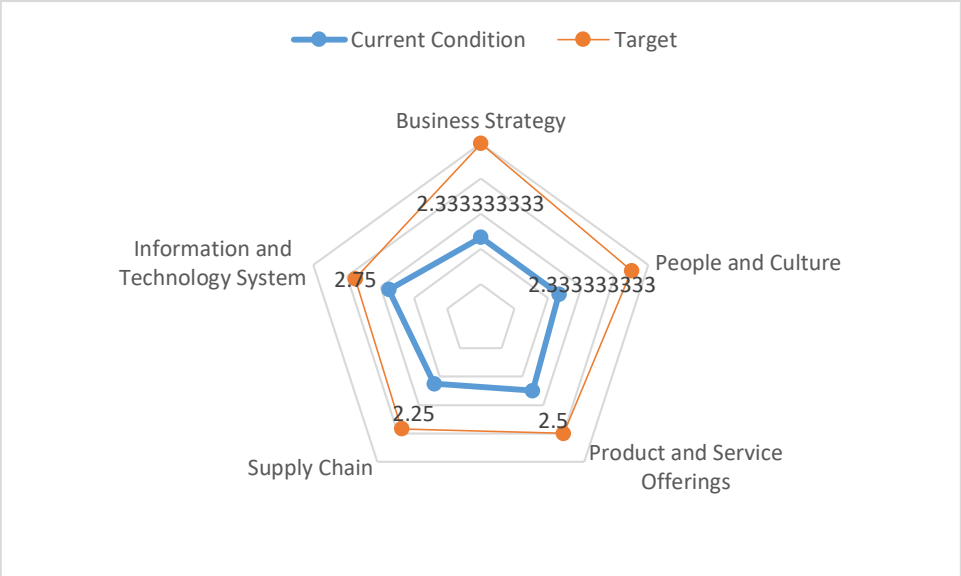

Figure A14. Maturity Level of Company 14

Company 14 is a creamer/food manufacturer. It has **aound than 250 to 499** workers with **> 1 billion – 500 billion rupiah** latest revenue estimate. Its overall score is **2.43**. It's highest dimension level is **Information and Technology System** which is **2.75**. Below is the detailed sub-dimensions' current and target level.

Table A14. Business Strategy of Company 14

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	1.666666667	5	2.333333333	5
Collaboration	3	5		

Table B14. People and Culture of Company 14

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	2	5	2.333333333	4.5
Resources on Digital Capability	2	4		
Digital Culture	3	4.5		

Table C14. Product and Service Offerings of Company 14

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	2.0	4	2.5	4.0
Product development collaboration	3	4		

Table D14. Supply Chain of Company 14

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	2	4	2.25	3.833333333
Source	2.666666667	4		
Make	2	2.666666667		
Deliver	2.333333333	4.666666667		

Table E14. Information and Technology System of Company 14

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	3	4	2.75	3.75
IT architecture	2	4		
Degree of implementation of Industry 4.0	3	4		
Degree of connectivity, transparency and exchange of information	3	3		

15. Company 15

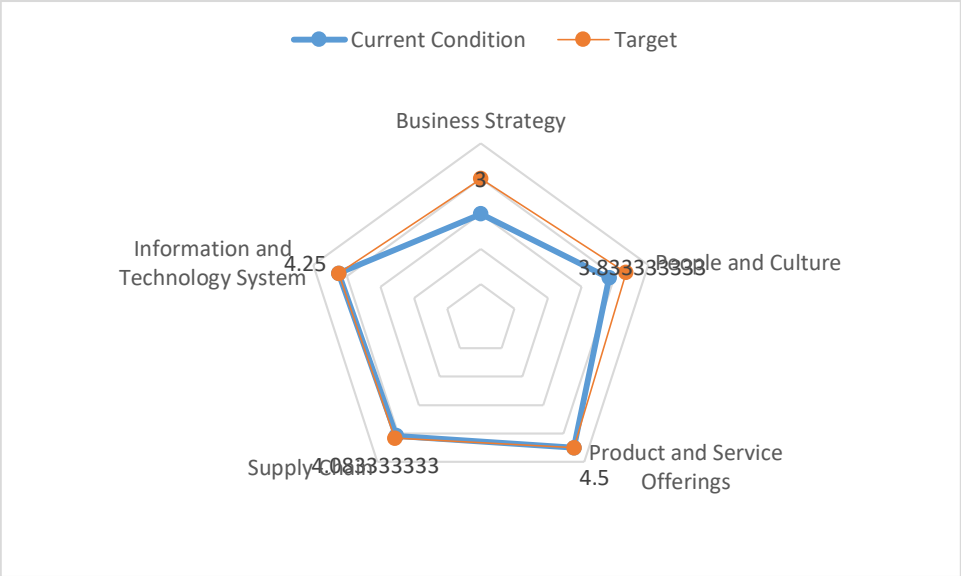

Figure A15. Maturity Level of Company 15

Company 15 is a wheel/auto parts manufacturer. It has **more than 500** workers with **> 1 billion – 500 billion rupiah** latest revenue estimate. Its overall score is **3.93**. It's highest dimension level is **Product and Service Offerings** which is **4.5**. Below is the detailed sub-dimensions' current and target level.

Table A15. Business Strategy of Company 15

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	3	4	3	4
Collaboration	3	4		

Table B15. People and Culture of Company 15

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	5	5	3.833333333	4.333333333
Resources on Digital Capability	3	4		
Digital Culture	3.5	4		

Table C15. Product and Service Offerings of Company 15

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	4.0	4	4.5	4.5
Product development collaboration	5	5		

Table D15. Supply Chain of Company 15

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	5	5	4.083333333	4.166666667
Source	4.666666667	5		
Make	5	5		
Deliver	1.666666667	1.666666667		

Table E15. Information and Technology System of Company 15

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	4	4	4.25	4.25
IT architecture	4	4		
Degree of implementation of Industry 4.0	5	5		
Degree of connectivity, transparency and exchange of information	4	4		

16. Company 16

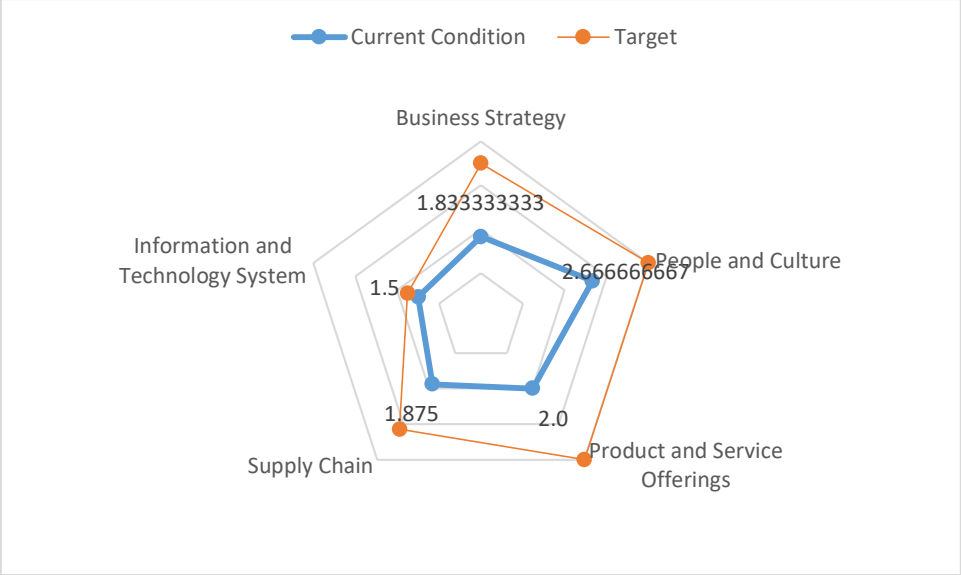

Figure A16. Maturity Level of Company 16

Company 16 is a food manufacturer. It has **more than 500** workers with **> > 1 billion – 500 billion rupiah** latest revenue estimate. Its overall score is **1.98**. It's highest dimension level is **People and Culture** which is **2.67**. Below is the detailed sub-dimensions' current and target level.

Table A16. Business Strategy of Company 16

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	1.666666667	4	1.833333333	3.5
Collaboration	2	3		

Table B16. People and Culture of Company 16

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	2	3	2.666666667	4
Resources on Digital Capability	2	4		
Digital Culture	4	5		

Table C16. Product and Service Offerings of Company 16

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	2.0	4	2.0	4.0
Product development collaboration	2	4		

Table D16. Supply Chain of Company 16

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	2.5	4.25	1.875	3.145833333
Source	2	3.333333333		
Make	1.666666667	3		
Deliver	1.333333333	2		

Table E16. Information and Technology System of Company 16

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	1	1	1.5	1.75
IT architecture	2	2		
Degree of implementation of Industry 4.0	1	2		
Degree of connectivity, transparency and exchange of information	2	2		

17. Company 17

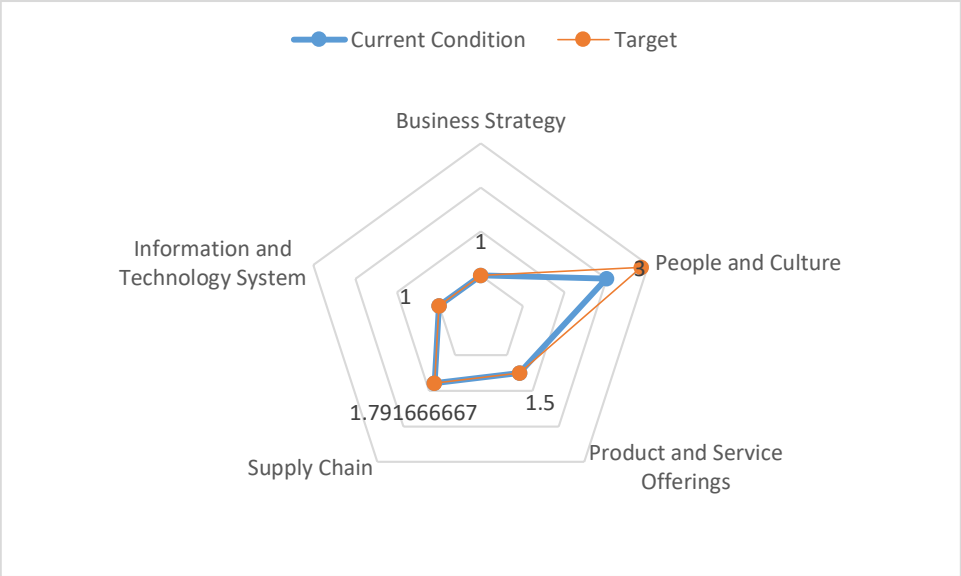

Figure A17. Maturity Level of Company 17

Company 17 is a glass manufacturer. It has **more than 500** workers with **> 1 billion – 500 billion rupiah** latest revenue estimate. Its overall score is **1.66**. It's highest dimension level is **People and Culture** which is **3**. Below is the detailed sub-dimensions' current and target level.

Table A17. Business Strategy of Company 17

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	1	1	1	1
Collaboration	1	1		

Table B17. People and Culture of Company 17

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	3	3	3	3.833333333
Resources on Digital Capability	2	4		
Digital Culture	4	4.5		

Table C17. Product and Service Offerings of Company 17

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	1.0	1	1.5	1.5
Product development collaboration	2	2		

Table D17. Supply Chain of Company 17

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	1.5	1.5	1.791666667	1.791666667
Source	2.333333333	2.333333333		
Make	1.666666667	1.666666667		
Deliver	1.666666667	1.666666667		

Table E17. Information and Technology System of Company 17

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	1	1	1	1
IT architecture	1	1		
Degree of implementation of Industry 4.0	1	1		
Degree of connectivity, transparency and exchange of information	1	1		

18. Company 18

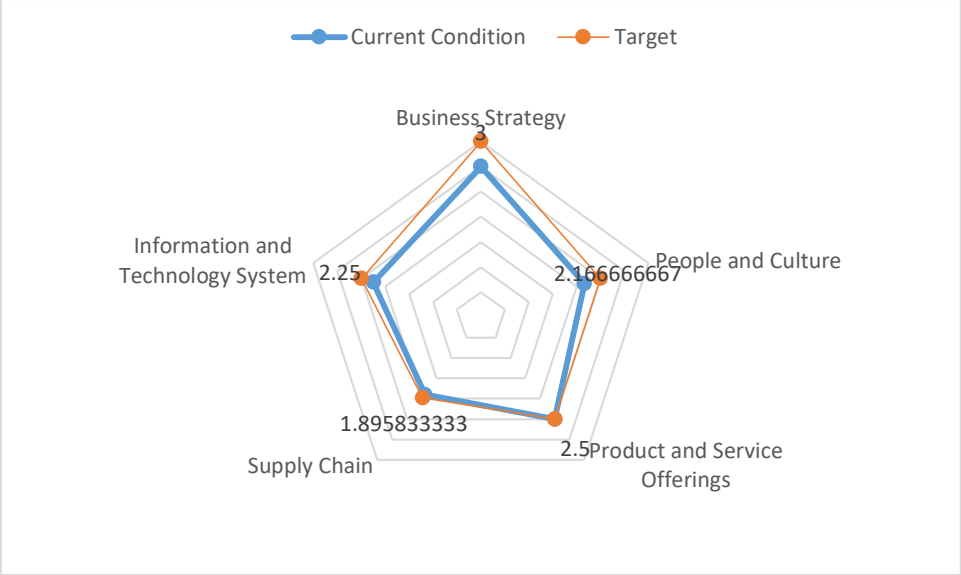

Figure A18. Maturity Level of Company 18

Company 18 is a health products, hygiene, and household products manufacturer. It has **more than 500** workers with **> 1 trillion rupiah** latest revenue estimate. Its overall score is **2.36**. It's highest dimension level is **Business Strategy** which is **3**. Below is the detailed sub-dimensions' current and target level.

Table A18. Business Strategy of Company 18

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	3	4	3	3.5
Collaboration	3	3		

Table B18. People and Culture of Company 18

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	2	3	2.166666667	2.5
Resources on Digital Capability	2	2		
Digital Culture	2.5	2.5		

Table C18. Product and Service Offerings of Company 18

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	3.0	3	2.5	2.5
Product development collaboration	2	2		

Table D18. Supply Chain of Company 18

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	2.25	2.25	1.895833333	1.979166667
Source	2	2		
Make	1.666666667	2		
Deliver	1.666666667	1.666666667		

Table E18. Information and Technology System of Company 18

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	2	2	2.25	2.5
IT architecture	1	2		
Degree of implementation of Industry 4.0	2	2		
Degree of connectivity, transparency and exchange of information	4	4		

19. Company 19

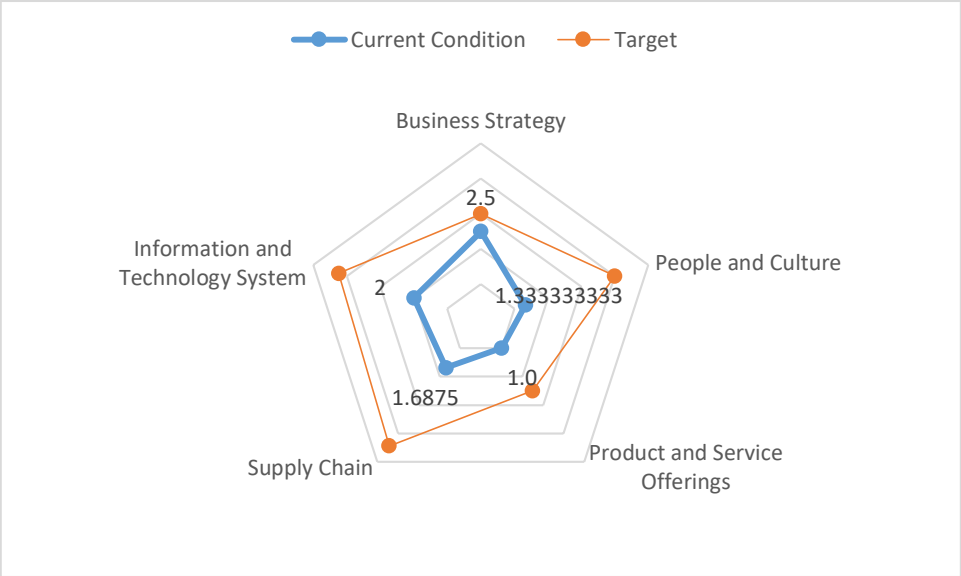

Figure A19. Maturity Level of Company 19

Company 19 is a construction materials (cement) manufacturer. It has **more than 500** workers with **500 million to 1 billion rupiah** latest revenue estimate. Its overall score is **1.70**. It's highest dimension level is **Business Strategy** which is **2.5**. Below is the detailed sub-dimensions' current and target level.

Table A19. Business Strategy of Company 19

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	2	3	2.5	3
Collaboration	3	3		

Table B19. People and Culture of Company 19

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	2	3	1.333333333	4
Resources on Digital Capability	1	4		
Digital Culture	1	5		

Table C19. Product and Service Offerings of Company 19

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	1.0	2	1.0	2.5
Product development collaboration	1	3		

Table D19. Supply Chain of Company 19

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	2.75	4.75	1.6875	4.4375
Source	1.333333333	4.666666667		
Make	1.666666667	4.666666667		
Deliver	1	3.666666667		

Table E19. Information and Technology System of Company 19

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	2	4	2	4.25
IT architecture	2	5		
Degree of implementation of Industry 4.0	2	3		
Degree of connectivity, transparency and exchange of information	2	5		

20. Company 20

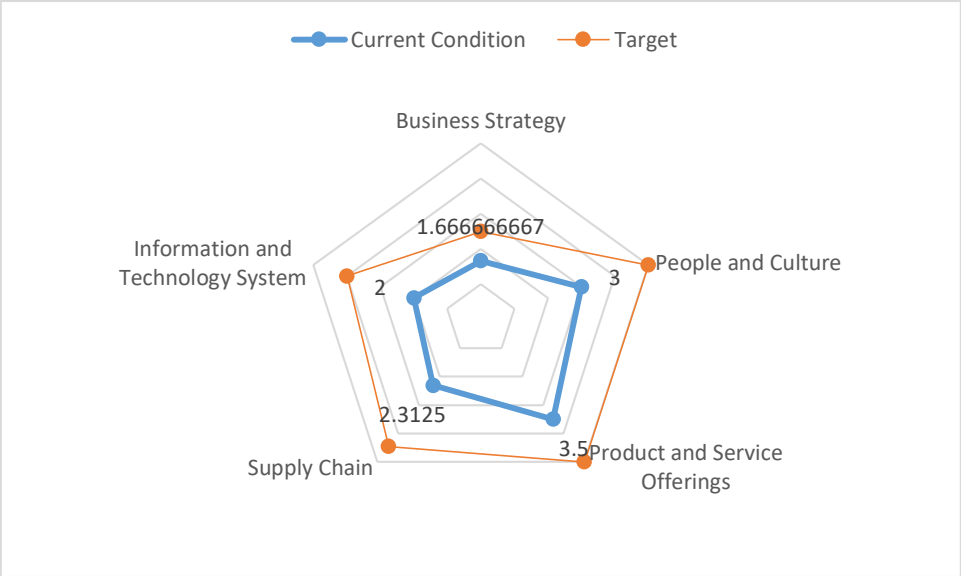

Figure A20. Maturity Level of Company 20

Company 20 is a **fast-moving consumer goods manufacturer**. It has **more than 500** workers with **> 1 billion – 500 billion rupiah** latest revenue estimate. Its overall score is **2.50**. It's highest dimension level is **Product and Service Offerings** which is **3.5**. Below is the detailed sub-dimensions' current and target level.

Table A20. Business Strategy of Company 20

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	2.333333333	4	1.666666667	2.5
Collaboration	1	1		

Table B20. People and Culture of Company 20

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	2	5	3	5
Resources on Digital Capability	4	5		
Digital Culture	3	5		

Table C20. Product and Service Offerings of Company 20

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	4.0	5	3.5	5.0
Product development collaboration	3	5		

Table D20. Supply Chain of Company 20

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	3.25	4.5	2.3125	4.458333333
Source	2.333333333	4.666666667		
Make	2	4.666666667		
Deliver	1.666666667	4		

Table E20. Information and Technology System of Company 20

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	2	4	2	4
IT architecture	2	4		
Degree of implementation of Industry 4.0	2	4		
Degree of connectivity, transparency and exchange of information	2	4		

21. Company 21

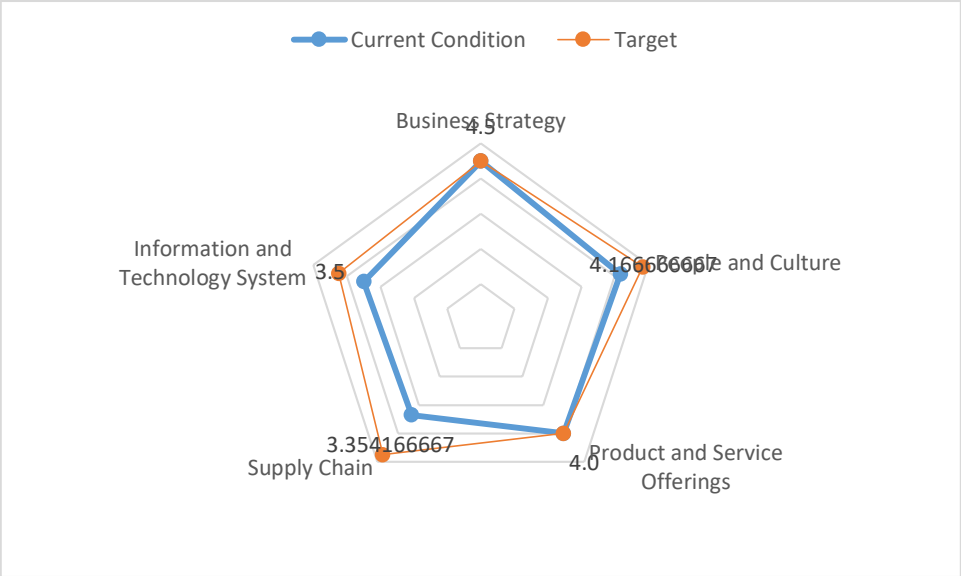

Figure A21. Maturity Level of Company 21

Company 21 is a **Paper manufacturer**. It has **more than 500** workers with **> 1 trillion rupiah** latest revenue estimate. Its overall score is **3.90**. It's highest dimension level is **Business Strategy** which is **4.5**. Below is the detailed sub-dimensions' current and target level.

Table A21. Business Strategy of Company 21

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	5	5	4.5	4.5
Collaboration	4	4		

Table B21. People and Culture of Company 21

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	5	5	4.166666667	4.833333333
Resources on Digital Capability	4	5		
Digital Culture	3.5	4.5		

Table C21. Product and Service Offerings of Company 21

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	4.0	4	4.0	4.0
Product development collaboration	4	4		

Table D21. Supply Chain of Company 21

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	3.75	5	3.354166667	4.75
Source	3.666666667	5		
Make	3.333333333	4.333333333		
Deliver	2.666666667	4.666666667		

Table E21. Information and Technology System of Company 21

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	3	4	3.5	4.25
IT architecture	4	4		
Degree of implementation of Industry 4.0	4	5		
Degree of connectivity, transparency and exchange of information	3	4		

22. Company 22

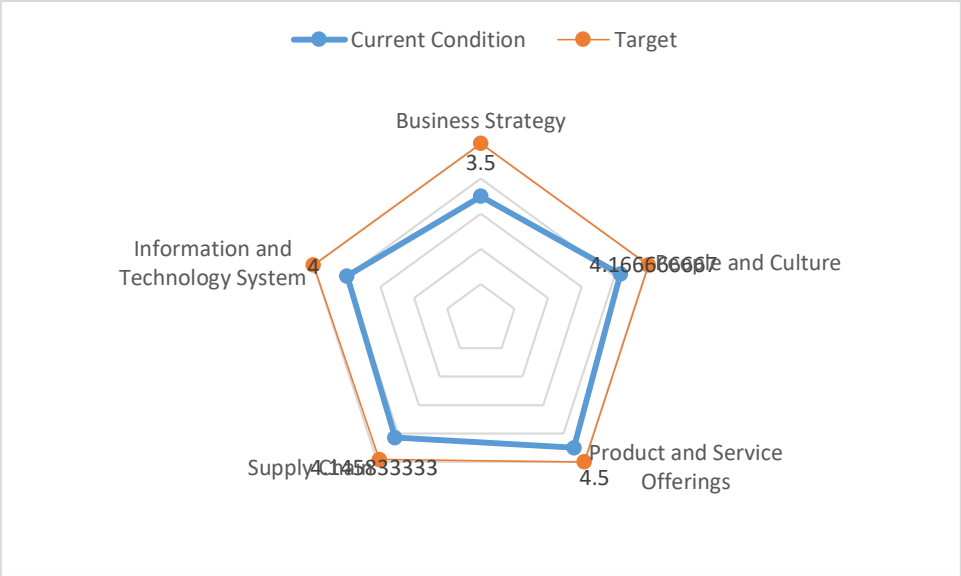

Figure A22. Maturity Level of Company 22

Company 22 is a cement manufacturer. It has **more than 500** workers with **> 1 trillion rupiah** latest revenue estimate. Its overall score is 4.06 . It's highest dimension level is **Product and Service Offerings** which is **4.5**. Below is the detailed sub-dimensions' current and target level.

Table A22. Business Strategy of Company 22

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	3	5	3.5	5
Collaboration	4	5		

Table B22. People and Culture of Company 22

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	4	5	4.166666667	5
Resources on Digital Capability	4	5		
Digital Culture	4.5	5		

Table C22. Product and Service Offerings of Company 22

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	5.0	5	4.5	5.0
Product development collaboration	4	5		

Table D22. Supply Chain of Company 22

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	4.25	5	4.145833333	4.916666667
Source	4.333333333	5		
Make	4	5		
Deliver	4	4.666666667		

Table E22. Information and Technology System of Company 22

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	4	5	4	5
IT architecture	4	5		
Degree of implementation of Industry 4.0	4	5		
Degree of connectivity, transparency and exchange of information	4	5		

23. Company 23

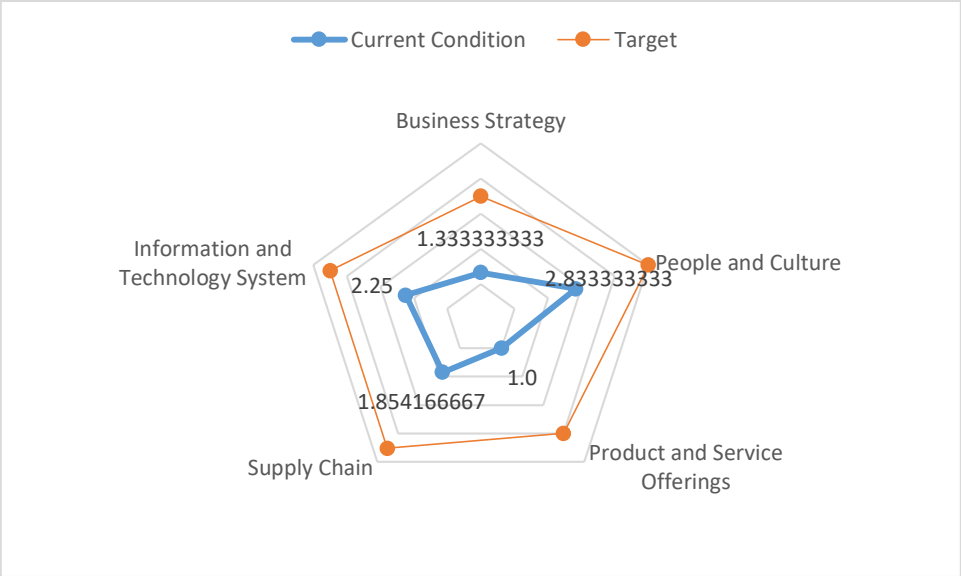

Figure A23. Maturity Level of Company 23

Company 23 is a **automotive manufacturer**. It has **more than 500** workers with **> 1 billion – 500 billion rupiah** latest revenue estimate. Its overall score is **1.85**. It's highest dimension level is **People and Culture** which is **2.83**. Below is the detailed sub-dimensions' current and target level.

Table A23. Business Strategy of Company 23

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	1.666666667	5	1.333333333	3.5
Collaboration	1	2		

Table B23. People and Culture of Company 23

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	2	5	2.833333333	5
Resources on Digital Capability	3	5		
Digital Culture	3.5	5		

Table C23. Product and Service Offerings of Company 23

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	1.0	4	1.0	4.0
Product development collaboration	1	4		

Table D23. Supply Chain of Company 23

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	1.75	4.75	1.854166667	4.520833333
Source	2.333333333	4.666666667		
Make	2	4		
Deliver	1.333333333	4.666666667		

Table E23. Information and Technology System of Company 23

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	2	4	2.25	4.5
IT architecture	3	5		
Degree of implementation of Industry 4.0	2	5		
Degree of connectivity, transparency and exchange of information	2	4		

24. Company 24

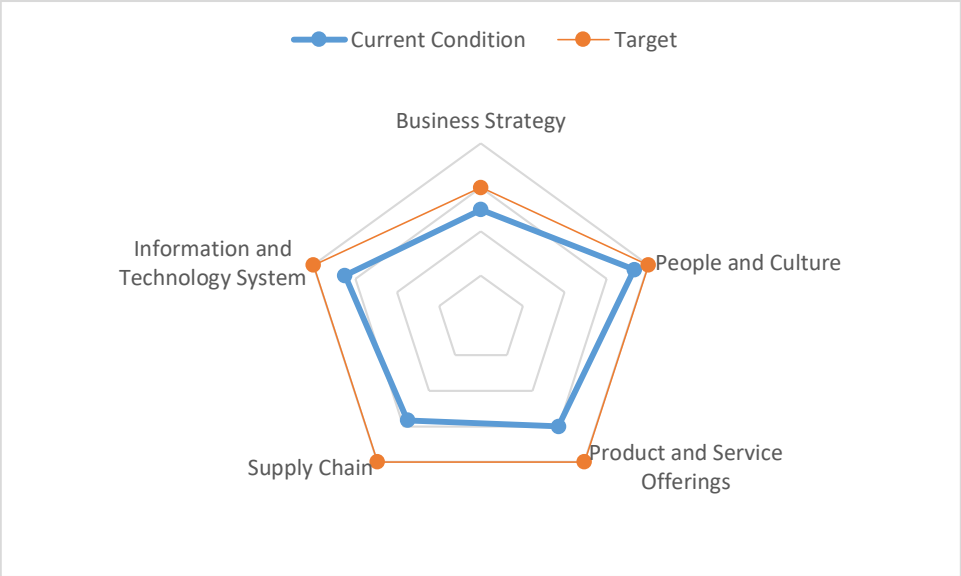

Figure A24. Maturity Level of Company 24

Company 24 is a pharmaceuticals and supplements manufacturer. It has **more than 500** workers with **> 1 trillion rupiah** latest revenue estimate. Its overall score is **3.05**. It's highest dimension level is **People and Culture** which is **3.67**. Below is the detailed sub-dimensions' current and target level.

Table A24. Business Strategy of Company 24

Business Strategy	Current Condition	Target	Current Level	Target Level
Degree of Industry 4.0 Strategy Implementation	2	3	2.5	3
Collaboration	3	3		

Table B24. People and Culture of Company 24

People and Culture	Current Condition	Target	Current Level	Target Level
Cross-functional cooperation	4	4	3.666666667	4
Resources on Digital Capability	4	4		
Digital Culture	3	4		

Table C24. Product and Service Offerings of Company 24

Product and Service Offerings	Current Condition	Target	Current Level	Target Level
Digital enabler and digital features of products and services	3.0	4	3.0	4.0
Product development collaboration	3	4		

Table D24. Supply Chain of Company 24

Supply Chain	Current Condition	Target	Current Level	Target Level
Plan	3	4	2.833333333	4
Source	2.666666667	4		
Make	3	4		
Deliver	2.666666667	4		

Table E24. Information and Technology System of Company 24

Information and Technology System	Current Condition	Target	Current Level	Target Level
Awareness to Industry 4.0 technologies	4	4	3.25	4
IT architecture	3	4		
Degree of implementation of Industry 4.0	3	4		
Degree of connectivity, transparency and exchange of information	3	4		

Attachment 2. Initial Questionnaire

(Not validated yet)

Section 1 – Introductory Questions

1. Respondent name: ……..…
   Age: ….. years old
   Email: ……..……...…….
2. Structural attribute at the company:…….……...
3. Starting working year at company: ……
4. Company Name: ……...…….
5. Number of employees:
   a. <100
   b. 100 – 249
   c. 250 – 499
   d. 500 and above
6. Latest annual revenue estimate:
   a. <100 million rupiah
   b. 100 million – 250 million rupiah
   c. 250 million – 500 million rupiah
   d. 500 million rupiah – 1 trillion rupiah
   e. >1 million rupiah

Section 2 – Business strategy

Subdimension Degree of Implementation

2. Does your business strategy have a vision in implementing Industry 4.0?

   ○ yes ○ no

3. Does your company directly states any about Industry 4.0 in your business strategy?

   ○ yes ○ no

4. If the answer to number 2 is yes, have you (your company) communicate to all workers and departments?

   ○ yes ○ no

5. If the answer to number 3 is yes, have the workers understood by the proof of any calculated metrics?

   ○ yes ○ no

6. How would you rate the implementation status of your Industry 4.0 strategy?

   Current Condition:

   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Absence, no strategy exists
2 = Early awareness, pilot initiatives launched
3 = Knowledge acquisition, understanding, knowledge used to develop strategy
4 = Early implementation, technology acquisition and strategy is formulated
5 = Beyond existence, strategy is in implementation

Subdimension Finance and Investment

7. How often do you conduct a cost/benefit analysis for Industry 4.0 investment?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Absence. No measurable Industry 4.0 investment yet
2 = Early awareness. No ongoing review of cost/benefit analysis for Industry 4.0 investment yet
3 = Knowledge acquisition/understanding. No ongoing review of cost/benefit analysis of Industry 4.0 investment
4 = early implementation, technology acquisition, Annual cost/benefit analysis of Industry 4.0 investment
5 = mature implementation, Shorter-period or proactively conduct cost/benefit analysis of Industry 4.0 investment

Subdimension Collaboration

8. Does your company have partnerships for Industry 4.0 projects?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1= No partnerships for Industry 4.0 projects
2= Planning to have partnerships for Industry 4.0 projects
3=Have partnership going on with academics/researcher/consultant/technology provider/other tier
4= Have partnership with more than one of the mentioned options
5= Have mature and sustained partnership as long term project

Section 3– People and Culture

Subdimension Cross-functional cooperation

1. Is there any cross-functional cooperation in your company for any work assignments or projects?

○ yes ○ no

2. Is it structured and continued?

○ yes ○ no

Subdimension Resources on Digital Capability

3. Is there a special team of digital experts that is deployed to drive digital adoption across the organization?

○ yes ○ no

4. Does digital tool used for knowledge management and skill enhancement in your company?

○ yes ○ no

5. To what extent are employees equipped with relevant skills for Industry 4.0?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Employees have no experience with digital/emerging technologies
2 = Employees have little experience with digital/emerging technologies
3 = Technology focused areas of the business have employees with some digital skills
4 = Most areas of the business have well developed digital and data analysis capability
5 = All across the business, cutting edge digital and analytical skills are prevalent

Subdimension Digital Culture

6. To what level does the digital culture be implemented in your company?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = No digital culture
2 = Digital culture exists in board and strategic level
3 = Digital culture exists also in lower/managerial level, partial
4 = Digital culture exists also in operational level
5 = Digital culture exists wholly in corporate level (requiring all workers' awareness)

7. How would you rate the digital culture in your company and the engagement of your colleagues?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = No digital culture
2 = Digital culture exists, but seldom implemented and controlled, no engagement in colleagues
3 = Digital culture exists, implemented partially with little engagement/enthusiasm
4 = Digital culture exists, implemented partially with moderate engagement/enthusiasm (already becoming culture with little proactiveness from colleagues)
5 = Digital culture is well implemented and routine to be reviewed, colleagues are engaged proactively

Section 4 – Customer, products, and service offerings

Subdimension Product Development Collaboration

1. How intense is your collaboration with partners, suppliers and clients for the development of your products and services?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Absence, no collaboration.
2 = Early awareness of needs to collaborate, pilot initiatives launched.

3 = Collaboration exists, understanding the possible scope to collaborate and to which external tier.
4 = Collaboration gets more intense and developed.
5 = Wide (involving multi stakeholder/players) and intense collaboration.

Subdimension Digital Enabler and Digital Features of Services

2. How advanced is the digital enablement of your sales force (mobile devices, access to all relevant system anywhere and anytime, full sales process possible at client site)?
   Current Condition:
   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant
   Target:
   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1= No digital enablement of sales forces and use of gadgets/online channel
2= Planning to have digital enabler: use of gadgets/online channel
3= Use of gadgets/mobile devices, access to all relevant system anywhere and anytime
4= Use of gadgets/mobile devices, access to all relevant system anywhere and anytime, but is more focused on producing/still planning the smart product.
5= Mature digital features, channel (i.e. online channel), and smart product (i.e. RFID tag)

3. To which extent do you analyze customer data to increase customer insight (e. g. personalized offers to customers based on their personal situation, preferences, location, credit score; consideration of usage data for design & engineering etc.)?
   Current Condition:
   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant
   Target:
   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=no customer data/insight analysis.
2=no to little customer data, no insight analysis
3=acquire customer data without further insight analysis
4= acquire customer data with early insight analysis (product recommendation according to personal preferences/amount of clicks, location, etc.)
5=Personalized offers to customer based on customer insights: preference, situation, location, etc.

Section 5 – Supply Chain

Plan Sub-dimension

1. Is your supply chain planning regarding resources and requirements (at the early establishment) already documented and communicated through advanced technologies?
   Current Condition:
   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant
   Target:
   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1= made without digital document and not communicated
2= documented in computer database but not thoroughly communicated

3= documented in computer database and well communicated
4= documented in cloud and well communicated
5= made in cloud collaboratively, real-time communicated

2. How do you use 4.0 technologies to plan your supply network (making facility decision: location, number, etc.)?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Conducted manually (paperwork)
2=Conducted manually through paperwork or algorithm in an offline software (such as heuristics, etc.)
3= Conducted more automated through software algorithm (such as metaheuristics in a software capable of to handle big data)
4=Conducted with advanced algorithm and visible real-time, higher computational intelligence
5=Conducted with the integrative help of emerging technologies such as AI technology (machine learning, deep learning, etc.) combined with simulation, cloud, and so forth.

1. How advanced the technologies you use to formulate your supply chain strategy?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Conducted manually/paperwork through group discussion (such as board brainstorming, FGD, etc.)
2=Conducted iteratively through real discussion and digital documentation
3=Conducted iterative and collaborative through real discussion documented in cloud
4=Conducted iterative and collaborative through real discussion put directly in a platform with a supporting learning capability (accommodating trigger and suggestion)
5=Conducted iterative and collaborative through real discussion in a platform with a supporting learning capability (accommodating evaluation and update)

2. How much do you rely on technology for your supply chain integration and visibility?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=communication between tiers (such as with supplier) are as needed/reactive due to not using digital platform
2=basic communication and data sharing exist with suppliers and customers (such as bot available for customer service, etc.)
3=basic communication and data sharing exist with suppliers and customers, bot for CS is more responsive and proactive

4= data transfer exist between key strategic suppliers/ customers (e.g. customer inventory levels), bot for CS already includes learning capability and automated (serving 24 hours straight)
5= fully integrated systems with suppliers/customers for appropriate processes (e.g. real-time integrated planning), bot includes AI such as with computer vision, neural network, NLP, etc.

Source Sub-dimension

3. How technology-advanced is your sourcing process?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Sourcing is done manually (offline or through calls)
2=Use combined offline and online (e-sourcing and e-procurement), or already installed an online platform but still use offline for majority of the process
3=Use combined offline and online (e-sourcing and e-procurement) effectively
4=Use an online/e-sourcing platform that is enough agile
5=Use e-sourcing and e-procurement with adaptive switches (learning capability) due to changes, able to accommodate big data for alternatives such as in supplier selection

4. How advanced-in-technology is your inventory policy (order review, replenishment schedule, etc.) made?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Adapting inventory policy suitable with the business strategy
2=Adapting an inventory policy from best practices from the result of benchmarking
3=Adapting a continuously updated inventory policy due to market changes
4=Adapting both judgment and insight analysis from the used platform (warehouse database)
5=Adapting inventory policy under the help of smart platform (includes learning capability)

3. How technology-advanced is your transaction with supplier gone so far?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Normal transaction under the allowed tenor (AP towards supplier)
2= Normal transaction under the allowed tenor (AP towards supplier), but already aware with the possible use of cyber-secure technology
3= Normal transaction under the allowed tenor (AP towards supplier), and planning to use a more automated platform/technology
4=Transaction is recorded automatically in the used platform
5=Secured using block chain or other 4.0 technology

Make Sub-dimension

4. How much you rely on technology to forecast your demand?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Conducted manually
2=Conducted manually or through algorithm in an offline software (use Microsoft-default software, etc.)
3=Conducted through algorithm in a cloud software and visible real-time for collaborative work
4= Conducted more automated through software algorithm (software capable of to handle big data) and higher computational intelligence, used by best practices with lower error/higher accuracy
5=Conducted with the integrative help of emerging technologies such as AI technology (machine learning, deep learning, etc.) combined with simulation, cloud, and so forth.

5. How much you rely on technology to plan your production schedule?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Conducted manually, separated from procurement department
2=Conducted manually or through algorithm in an offline software (use Microsoft default software, etc.), separated from procurement department
3=Conducted through algorithm in a cloud software and visible real-time for collaborative work, with data input from procurement department
4= Conducted more automated through software algorithm (software capable of to handle big data) and higher computational intelligence, used by best practices with lower error/higher accuracy, with an automated data input from procurement department
5=Conducted with the integrative help of emerging technologies such as AI technology (machine learning, deep learning, etc.) combined with simulation, cloud (for data sharing from procurement), and so forth.

6. How automated and internet-evolved is your production process?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Manual operation up to machine level
2=Reduced labor work/shifting work from operator to quality checker (dealing with data or changing data to be an information), aware and plan to invest in industrial robots
3=Use clouds in several basic plant process, paperless and more automated
4=Use industrial robots partially or other 3.0 technology
5=Use AI robots, machines are interconnected through internet (Data is automatically and real-time shared to data centre, etc.)

7. How is the data you collect used in production?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Predictive maintenance.
2 = Optimization of production processes.
3 = Creation of transparency across production process.
4 = Quality management.
5 = Automatic production control through use of real-time data

Deliver Sub-dimension

8. How smart is your warehouse (loading-unloading process, picking, packing, etc.)?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=No use of industrial robots (all are labours)
2=No use of industrial robots, but labours with the help of gadget
3=Use of industrial robots and labours collaboratively
4=Use of RFID, AI robot, VR, etc. and lean amount of labours

9. How much you rely on technology to make your transportation decision (mode, ownership, etc.)?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Adopt best practices from benchmark results with justification, with some exposed alternatives
2=Adopt wider solution alternatives (such as 3PL alternatives, transportation brand, etc.) from various channels with bigger data
3=Adopt the optimal solution suggested by the used optimization software (for cost minimization and responsiveness) such as through simulation
4=Adopt decision from both external recommendations and technology (such as simulation)
5=Adopt the optimum use of 4.0 technology: big data analysis, simulation, cloud computing, etc.

10. How much you rely on technology to route your shipment and how flexible it is towards disruption?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Manual, with reactive re-route
2=Manual, with the anticipated re-route

3=Use software for VRP, with the anticipated re-route
4=Use software for VRP, with the anticipated re-route, with continuous evaluation and updates for routing forecasts (to capture traffic and any seasonality on road)
5=Use RTLS and/or combined with autonomous trucks, etc.

11. How is the data you collect used in logistics and procurement?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Predictive supplier risk management (to detect supplier failures early on).
2 = Digital supplier scorecards, objectives and improvement tracking.
3 = Automated tracking of target achievement and bonus payments.
4 = Digital claim management system with integrated automatic warning system.
5 = Big data analytics to detect new suppliers globally.

Section 6 – Information System and Technology

1. In what area of application do you use these technologies in your company?

No	Technology/Investment Done	Application Areas	Functions	Note	Investment Planning (within 5 years ahead)
1	Example: Augmented Reality	Warehouse	Helps order picking, identify detailed information	Name and types of AR: Vision and GT123 by Google	
2	Advanced sensors: RFID, RTLS, etc.				
3	Internet of Things: smart factory, etc.				
4	Big data analytics				
5	Artificial intelligence				
6	Augmented reality				
7	Cloud				
8	Autonomous robots				
9	3D Printing				
10	Cybersecurity				
11	Simulation				

2. To what extent do you allocate sufficient budget to investments in Industry 4.0?
   Current Condition:
   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant
   Target:
   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = none, 2 = very low, 3 = low, 4 = medium, 5 = high.

3. How homogenous your company IT architecture?
   Current Condition:
   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant
   Target:
   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = no homogenous IT architecture between functional silos/departments.
2 = homogenous in some departments.
3 = almost all IT architecture departments are homogenous. Use ERP.
4 = homogenous throughout the company. Use ERP.
5 = mature architecture. Homogenous throughout the holding and operating companies. Use ERP.

4. How would you rate the paperwork percentage above all work assignments in your company?
   Current Condition:
   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant
   Target:
   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Paperwork 100%.
2 = Paperwork 80%, computerized/cloud 20%.
3 = Paperwork 60%, computerized/cloud 40%.
4 = Paperwork 40%, computerized/cloud 60%.
5 = Paperwork 20%, computerized/cloud 80%.

5. How would you rate the transparency and ease of exchange information across departments?
   Current Condition:
   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant
   Target:
   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = No/little exchange of information, no custom configuration (SOP) that may enable other department requesting internal documents.
2 = Data transferred/obtained by crossfunction by needs/request with layers of approval.
3 = Data transferred through hard devices (harddisk, flash, etc.) eye to eye.
4 = data transferred through cloud/online media such as email, telegram, etc. (approval done in distant).
5 = Data can be downloaded/be traced for whom it is concerned through an integrated cloud system.

6. How would you rate the degree of implementation of Industry 4.0 technologies in your company?
   Current Condition:
   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant
   Target:
   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = absence, no 4.0 technology exists
2 = early awareness, pilot initiatives launched
3 = knowledge acquisition, understanding the possible use of 4.0 technologies
4 = early implementation, technology acquisition
5 = beyond existence, 4.0 technology implementation is well developed/survived

- ***Big Data Analytics and Artificial Intelligence (AI)***

1. How is your company's awareness regarding big data analytics and artificial intelligence?

   Current Condition:

   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = absence.
2 = early awareness, pilot initiatives launched such as oblige some positions to join seminar/training program to raise awareness.
3 = knowledge acquisition, understanding the possible implementation of big data analytics to which areas in the company, making plans and arrangements with little technology acquisition.
4 = early implementation, technology acquisition/data analytics exists.
5 = beyond existence, big data analytics is getting advanced and developed.

2. In your company, how is important data* generally processed and up to what levels it can perform and interpret? Up to what level the data analysis can perform and benefit the business?
   *important data = data regarding sales, customer behavior, complaints, etc.

   Current Condition:

   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Data is only collected/stored, no big data analytics
2 = Descriptive—Capture products' condition, environment and operation. Such as Raw data is processed to informative data manually or needs-driven.
3 = Diagnostic—Examine the causes of reduced product performance or failure.
4 = Predictive—Detect patterns that signal impending events.
5 = Prescriptive—Identify measures to improve outcomes or correct problems

3. How significant the current raw big data process to excel the competitiveness in a corporate perspective? How much it can capture potential market/any other promising improvement?

   Current Condition:

   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

- ***Internet of Things (IoT)***

1. How is your company's awareness regarding the possible use of Internet of Things in your company?

   Current Condition:

   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

   ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = absence.

2 = early awareness, pilot initiatives launched such as oblige some positions to join seminar/training program to raise awareness.
3 = knowledge acquisition, understanding the possible implementation of IoT to which areas in the company, making plans and arrangements with little technology acquisition.
4 = early implementation, technology acquisition/pilot project exists.
5 = beyond existence, IoT is getting advanced and developed.

2. In your company, to what level do units/divisions be connected and support the achievement of seamless data transfer, in order to support business process?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

3. How significant the current implementation of system of connectivity to improve productivity in a corporate perspective? How much it can further influence the competitiveness level of your company?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

- ***Virtualization Technologies***

1. How is your company's awareness regarding the possible use of Virtualization Technologies in your company?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = absence.
2 = early awareness, pilot initiatives launched such as oblige some positions to join seminar/training program to raise awareness.
3 = knowledge acquisition, understanding the possible implementation of VR to which areas in the company, making plans and arrangements with little technology acquisition.
4 = early implementation, technology acquisition/pilot project exists.
5 = beyond existence, VR is getting advanced and developed.

2. In your company, to what level do units/divisions adopt supporting devices (in this case to assist vision such as i.e Virtual Reality (goggles) to see prototype of warehouse layout), in order to support business process?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

3. How significant the current implementation of virtual technologies/any supporting devices to improve productivity in a corporate perspective? How significant/important the use of those devices compared to its investment cost?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

- ***Cloud Computing***

1. How is your company's awareness regarding the use of Cloud in your company? How much do they need Cloud for their daily work/operation?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = absence.
2 = early awareness, pilot initiatives launched such as oblige some positions to join seminar/training program to raise awareness.
3 = knowledge acquisition, understanding the possible implementation of cloud to which areas in the company, making plans and arrangements with little technology acquisition.
4 = early implementation, technology acquisition/investment exists.
5 = beyond existence, cloud is getting advanced and wider implemented.

2. In your company, how intense or to what level do units/divisions use Cloud for their daily work to support business process?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

3. How significant the current implementation of Cloud to improve productivity in a corporate perspective?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

- ***Autonomous Robotics***

1. How is your company's awareness regarding the potential use of robotics in your company? Do your company recognize it important/in plan?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = absence.

2 = early awareness, pilot initiatives launched such as oblige some positions to join seminar/training program to raise awareness.
3 = knowledge acquisition, understanding the possible implementation of robotics to which areas in the company, making plans and arrangements with little technology acquisition.
4 = early implementation, technology acquisition/pilot project exists.
5 = beyond existence, robot is getting well developed.

2. In your company, do units/divisions use autonomous robotics for their daily work to support business process?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

3. How significant the current implementation of Robotics to improve productivity in a corporate perspective? How significant/important the use of robotics compared to its investment cost?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

- ***Additive Manufacturing (AM)***

1. How is your company's awareness regarding the possible use of 3D printing in your company? How much do they need 3D Printing for their production?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = absence.
2 = early awareness, pilot initiatives launched such as oblige some positions to join seminar/training program to raise awareness.
3 = knowledge acquisition, understanding the possible implementation of 3D Printing, making plans and arrangements.
4 = early implementation, technology acquisition/pilot project exists.
5 = beyond existence, 3D Printer is utilized higher.

2. In your company, how intense does the production use 3D Printing for their production?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

3. How significant the current implementation of 3D Printing to improve productivity in a corporate perspective?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

- ***Cybersecurity***

1. How is your company's awareness regarding the possible harmful attack to the IT systems used in your company?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = absence.
2 = early awareness, pilot initiatives launched such as oblige some positions to join seminar/training program to raise awareness.
3 = knowledge acquisition, understanding the possible implementation and importance of cybersecurity, making plans and arrangements with little technology acquisition.
4 = early implementation, technology acquisition/pilot project exists.
5 = beyond existence, cybersecurity is getting advanced and reliable

2. In your company, how advanced is the security system to protect important data for daily operations to support business process?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Depend on security system carried by the devices/no actions taken.
2 = Security in internal data storage.
3 = Security of data through ejectable devices.
4 = Security of data through cloud services.
5 = Security of communications for in-house data exchange.

3. How significant the current implementation of cybersecurity to protect and to have the data secure?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

- ***Simulation***

1. How is your company's awareness regarding the possible use of Simulation in your company?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = absence.
2 = early awareness, pilot initiatives launched such as oblige some positions to join seminar/training program to raise awareness.
3 = knowledge acquisition, understanding the possible implementation of simulation, making plans and arrangements with little technology acquisition.
4 = early implementation, pilot project exists.
5 = beyond existence, simulation is getting reliable and high utilized

2. In your company, how intense does the use of Simulation taking place?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

3. How significant the current implementation of Simulation to improve productivity in a corporate perspective?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Section 7 – Questionnaire Rating

Rate this questionnaire with these metrics.

1=Very low. 2=Low. 3=Moderate. 4=High. 5=Very High.

Comprehensiveness:

(wide-ranging, include all elements)

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

Conceptual reliability and consistency:

(overall consistency, produces similar results under consistent conditions)

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

Relevance to company and applicability:

(state of closely appropriate to company's condition)

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

Systematic structure:

(well in order)

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

Level of detail:

(quality of being detailed)

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

Attachment 3. Revised Questionnaire

validated

Section 1 – Introductory Questions

1. Respondent name: ……..…
   Age: ….. years old
   Email: …….
2. Structural attribute at the company: ……...
3. Starting working year at company: ……
4. Company Name: …….
5. Number of employees:
   a. <100
   b. 100 – 249
   c. 250 – 499
   d. 500 and above
6. Latest annual revenue estimate:
   a. <100 million rupiah
   b. 100 million – 250 million rupiah
   c. 250 million – 500 million rupiah
   d. 500 million rupiah – 1 trillion rupiah
   e. >1 million rupiah

Section 2 – Business strategy

Subdimension Degree of Implementation

1. How would you rate the implementation status of your Industry 4.0 strategy?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Absence, no strategy exists
2 = Early awareness, pilot initiatives launched
3 = Knowledge acquisition, understanding, knowledge used to develop strategy
4 = Early implementation, technology acquisition and strategy is formulated
5 = Beyond existence, strategy is in implementation

2. Have you (your company) communicate your Industry 4.0 vision to workers and departments?

○ yes ○ no

3. If the answer to number 3 is yes, have the workers understood by the proof of any calculated metrics?

○ yes ○ no

Subdimension Collaboration

4. Does your company have partnerships for Industry 4.0 projects?
   Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1= No partnerships for Industry 4.0 projects
2= Planning to have partnerships for Industry 4.0 projects
3=Have partnership going on with academics/researcher/consultant/technology provider/other tier
4= Have partnership with more than one of the mentioned options
5= Have mature and sustained partnership as long term project

Section 3– People and Culture

Subdimension Cross-functional cooperation

1. Is the cross-function cooperation for work assignments/projects already structured, continued, and efficient with the use of technology (gadgets, cloud, etc.)?
   Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=No use of digital technology for cross-function work.
2=Cross-function cooperation is not structured and continuous with digital technology.
3=Cross-function cooperation is structured and continuous with digital technology and cloud.
4=Wider cross-function cooperation, structured and continuous with the help of digital technology leading to efficiency and some 4.0 technologies (cloud, big data analytics, etc).
5=Mature and highly efficient cross-function cooperation, structured and continuous with an efficient use of integrated 4.0 technology: AI, VR, cloud, RFID, big data analytics, etc.

Subdimension Resources on Digital Capability

2. To what extent are employees equipped with relevant skills for Industry 4.0?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Employees have no experience with digital technologies.
2 = Employees have little experience with digital/emerging technologies. No digital skills enhancement.
3 =Only IT department that has employees with digital skills. They use digital tool for knowledge management and skill enhancement.
4 = Most areas of the business have well developed digital skill, use digital tool for knowledge management, and has data analysis capability.
5 = All across the business, cutting edge digital and analytical skills are prevalent.

Subdimension Digital Culture

3. To what level does the digital culture be implemented in your company?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = No digital culture

2 = Digital culture exists in board and strategic level
3 = Digital culture exists also in lower/managerial level, partial
4 = Digital culture exists also in operational level
5 = Digital culture exists wholly in corporate level (requiring all workers' awareness)

4. How would you rate the digital culture in your company and the engagement of your colleagues?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = No digital culture
2 = Digital culture exists, but seldom implemented and controlled, no engagement in colleagues
3 = Digital culture exists, implemented partially with little engagement/enthusiasm
4 = Digital culture exists, implemented partially with moderate engagement/enthusiasm (already becoming culture with little proactiveness from colleagues)
5 = Digital culture is well implemented and routine to be reviewed, colleagues are engaged proactively

Section 4 – Customer, products, and service offerings

Subdimension Product Development Collaboration

1. How intense is your collaboration with partners, suppliers and clients for the development of your products and services?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Absence, no collaboration.
2 = Early awareness of needs to collaborate, pilot initiatives launched.
3 = Collaboration exists, understanding the possible scope to collaborate and to which external tier.
4 = Collaboration gets more intense and developed.
5 = Wide (involving multi stakeholder/players) and intense collaboration.

Subdimension Digital Enabler and Digital Features of Services

2. How advanced is the digital enablement of your sales force (mobile devices, access to all relevant system anywhere and anytime, full sales process possible at client site)?
   Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ◉ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1= No digital enablement of sales forces and use of gadgets/online channel
2= Planning to have digital enabler: use of gadgets/online channel
3= Use of gadgets/mobile devices, access to all relevant system anywhere and anytime
4= Use of gadgets/mobile devices, access to all relevant system anywhere and anytime, but is more focused on producing/still planning the smart product.

5= Mature digital features, channel (i.e. online channel), and smart product (i.e. RFID tag)

3. To which extent do you analyze customer data to increase customer insight (e. g. personalized offers to customers based on their personal situation, preferences, location)?

Current Condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=No customer data/insight analysis.
2=Only acquire critical/important customer data, no insight analysis.
3=Acquire customer data with descriptive analysis without further insights.
4=Acquire customer data with predictive insight analysis (knowing which product will be popular due to preference forecast/number of clicks, locations, etc.).
5=Personalized offers (product recommendation) to the customer based on customer insights: preference, situation, location, etc.

Section 5 – Supply Chain

Plan Subdimension

1. Is your supply chain planning already documented and communicated through advanced technologies?

Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Documented in computer database and not communicated.
2=Documented in computer database and thoroughly communicated.
3=Documented in cloud but not well communicated.
4=Documented in cloud and well communicated.
5=Made in cloud collaboratively, real-time communicated.

2. How is the supply chain's big data analysed so far?

Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Data is only stored, no big data analytics.
2=Descriptive—Capture products' condition, environment and operation. Such as Raw data is processed to informative data manually or needs-driven.
3=Diagnostic/Recognition—Examine the causes of reduced product performance or failure. Strong in descriptive analysis.
4=Predictive—Detect patterns that signal impending events. Such as predictive maintenance, predict supplier risk and failure, demand forecasts, automatic warning system in production and distribution.
5=Prescriptive—Identify measures to improve outcomes, correct problems, give alternative solutions. Optimized and transparent production process, digital supplier scorecards and automated improvement tracking, give recommendation to improve service levels, to lower defect rate, etc.

3. How advanced the technologies you use to formulate your supply chain strategy?
   Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Conducted manually/paperwork through group discussion (such as FGD, etc.).
2=Conducted iteratively through real discussion and digital documentation.
3=Conducted iterative and collaborative through real discussion documented in cloud.
4=Conducted iterative and collaborative through real discussion put directly in a platform with a supporting learning capability: predictive (accommodating trigger and suggestion).
5=Conducted iterative and collaborative through real discussion in a platform with a supporting learning capability: prescriptive (accommodating evaluation and update).

4. How much do you rely on technology for your supply chain integration and visibility?
   Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Communication between tiers (such as with supplier) are as needed/reactive, not using digital platform.
2=Basic communication and data sharing exist with suppliers and customers (such as room chat/feature available for CS communication, etc.).
3=Basic communication and data sharing are prevalent and proactive, CS is more responsive.
4=Data transfer exist between key strategic suppliers/customers (e.g. customer inventory levels), bot for CS is available and automated (serving 24 hours straight).
5=Fully integrated with suppliers/customers (e.g. real-time integrated planning), bot includes AI such as with computer vision, neural network, Natural Language Processing, etc. (bot CS such as Google assistant, Siri, etc.).

Source Subdimension

5. How technology-advanced is your sourcing process?
   Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

   Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Sourcing is done manually (offline or through calls).
2=Use combined offline and online (e-sourcing and e-procurement), or already installed an online platform but still use offline for majority of the process.
3=Use combined offline and online (e-sourcing and e-procurement) effectively.
4=Use an online/e-sourcing platform that is enough agile and robust with predictive capability.
5=Use e-sourcing and e-procurement with prescriptive learning capability due to changes, able to accommodate big data for alternatives such as in supplier selection.

6. How advanced-in-technology is your inventory policy (order review, replenishment schedule, etc.) made?

Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Adapting inventory policy suitable with the business strategy.
2=Adapting inventory policy from best practices from the result of digital benchmarking with offline platform (descriptive analysis, i.e. Microsoft software).
3=Adapting a continuously updated inventory policy due to market changes, with the help of online platform with descriptive analysis.
4=Adapting both judgment and insight analysis from the used platform (such as warehouse database), has predictive capability such as what-if analysis with forecast.
5=Adapting inventory policy under the help of smart platform (includes prescriptive learning capability).

7. How technology-advanced is your transaction with supplier gone so far?

Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Manual transaction. Manual recording in books/documents offline without automatic updates.
2 = Manual and digital transaction. Recording into the offline platform with automatic updates. Aware and in studies to use integrated platforms (eg ERP).
3 = Manual and digital transaction. Using platforms such as ERP (automatic update and integrated) and cloud but not yet efficient.
4 = Digital transaction. Using a more sophisticated integrated platform with predictive learning capability. Currently in the study of the use of cyber-security technology.
5 = Automatic scheduled digital transactions. Sophisticated (prescriptive) recording platform, secured by a block chain or other 4.0 technology.

Make Subdimension

8. How much you rely on technology to forecast your demand?

Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Conducted manually.
2 = Performed manually or through an algorithm in offline software (eg Microsoft software, etc.).
3 = Conducted through platforms such as integrated ERP for demand forecasting.
4 = Conducted more automatically via cloud, real-time for collaborative work, able to handle bigger data, used by best practices to predict with higher accuracy.
5 = Performed with the help of prescriptive 4.0 technology such as machine learning, deep learning, combined with simulation, etc.

9. How much do you rely on technology to plan your production schedule?

Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Conducted manually, separate from procurement decisions.
2 = Performed manually or through an algorithm in offline software (eg Microsoft standard software, etc.) separated from the procurement department.
3 = Conducted through platforms such as integrated ERP, with input data from the procurement department.
4 = Conducted more automatically via cloud, real-time for collaborative work, used by best practices that are able to handle bigger data to predict with higher accuracy.
5 = Performed with the help of prescriptive 4.0 technology such as cloud (data sharing with procurement), machine learning, deep learning, combined with simulation, etc.

10. How automated and internet-evolved is your production process?

Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Manual operation to machine level.
2 = Reducing labor work/shifting work from operator to quality checker (dealing with turning data into information), being aware and planning for investment in industrial robots.
3 = Using partial industrial robot and other 3.0 (digital) technology and few 4.0 technologies (cloud, RFID, etc.).
4 = Using cloud in some basic installation processes, without paperwork. Starting to use more sophisticated robots, some machines can upload data (IoT) with sophisticated sensors (RFID) and actuators.
5 = Smart production, cyber physical systems, using AI robots, machines connected to each other through the internet (data is automatically and real-time shared with data centers, etc.).

Deliver Subdimension

11. How automated is your warehouse (loading-unloading process, picking, packing, etc.)?

Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = No use of industrial robots (all workers).
2 = Do not use industrial robots, but work with the help of gadgets.
3 = Collaborative use of industrial robots and labour with gadgets.
4 = Use of RFID, robots, IoT, or VR, etc. and the number of workers are leading to lean.
5 = Smart warehouse (with IoT, RFID, AI and VR robots, etc.) and lean number of labour.

12. How much do you rely on technology to make your transportation decision (mode, ownership, etc.)?

Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Adoption of benchmark best practices results with justification.
2 = Adopt broader alternative solutions (such as 3PL, transportation brand, etc.) from various channels with bigger data.
3 = Adopt the optimal solution recommended by offline optimization software (cost minimization and responsiveness maximization) such as through simulation.
4 = Adopt decisions from external recommendations and prescriptive technologies (such as simulations).
5 = Adopt the integration of recommendations for using technology 4.0: big data analytics, simulations, cloud computing, etc.

13. How much do you rely on technology to route your shipment and how flexible is it towards disruption?

Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Manual with reactive re-route.
2=Manual with the anticipated re-route.
3=Use software for Vehicle Routing Problem, with the anticipated re-route.
4=Use software for Vehicle Routing Problem, with the anticipated re-route, with predictive capability, continuous evaluation/updates for routing forecasts (capture traffic and any seasonality on road).
5=Use Real Time Location Services and/or combined with autopilot trucks, etc.

Section 6 – Information System and Technology

1. In what area of application do you use these technologies in your company?

No	Technology/Investment Done	Application Areas	Functions	Note
1	Example: Augmented Reality	Warehouse	Helps order picking, identify detailed information	Name and types of AR: Vision and GT123 by Google
2	Advanced sensors: RFID, RTLS, etc.			
3	Internet of Things: smart factory, etc.			
4	Big data analytics			
5	Artificial intelligence			
6	Augmented reality			
7	Cloud			
8	Autonomous robots			
9	3D Printing			

No	Technology/Investment Done	Application Areas	Functions	Note
10	Cybersecurity			
11	Simulation			

2. How is your organization awareness towards 4.0 technology?
   The technologies are: big data analytics, Internet of Things, Virtual Reality/Augmented Reality, cloud, AI robot, 3D printing, simulation, cybersecurity (e.g. blockchain), and system integration.

Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1=Absence.
2=Early awareness, pilot initiatives launched such as oblige some positions to join seminar/training program to raise awareness.
3=Knowledge acquisition, understanding the possible technology implementation to which areas in the company, making plans and arrangements with little technology acquisition.
4=Early implementation, technology acquisition exists.
5=Beyond existence, 4.0 technology is getting advanced and developed.

3. How homogenous your company IT architecture?

Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = No homogeneous IT architecture between silos/functional departments.
2 = Homogeneous in several departments.
3 = Almost all IT architecture departments are homogeneous. Using ERP.
4 = Homogeneous architecture at a holding level using ERP and several 4.0 implementations: cloud, IoT, smart sensors / RFID.
5 = Mature architecture. Homogeneous at a holding level and sophisticated (smart factory).

4. How would you rate the transparency and ease of exchange information across departments?

Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = No/little exchange of information, no custom configuration (SOP) that may enable other department requesting internal documents.
2 = Data transferred cross-function by needs/request with layers of approval. Security in internal data storage.
3 = Data transferred through a mix of cloud and hard/ejectable devices (harddisk, flash, etc.) eye to eye.
4 = data transferred through cloud/online media such as email, telegram, etc. (approval done in distant).

5 = Data can be downloaded/be traced for whom it is concerned through an integrated cloud system. Security of in-house data exchange.

5. How would you rate the degree of implementation of Industry 4.0 technologies in your company?

Current condition:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

Target:

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Irrelevant

1 = Absence, no 4.0 technology exists.
2 = Early awareness, pilot initiatives launched.
3 = Knowledge acquisition, understanding the possible use of 4.0 technologies.
4 = Early implementation, technology acquisition.
5 = Beyond existence, 4.0 technology implementation is well developed/survived.

Section 7 – Questionnaire Rating

Rate this questionnaire with these metrics.

1=Very low. 2=Low. 3=Moderate. 4=High. 5=Very High.

Comprehensiveness:

(wide-ranging, include all elements)

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

Conceptual reliability and consistency:

(overall consistency, produces similar results under consistent conditions)

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

Relevance to company and applicability:

(state of closely appropriate to company's condition)

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

Systematic structure:

(well in order)

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

Level of detail:

(quality of being detailed)

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

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The Author, Immarita Dinar Fajriyani, was born on March 22nd 1997 in Banyuwangi, Indonesia. The Author had completed her formal studies at SMAN 1 Glagah Banyuwangi (2012-2014) for the senior high school and Industrial Engineering in Institut Teknologi Sepuluh Nopember Surabaya (2014-2018) for the Bachelor Degree. In late 2018, the Author started to continue to pursue Master Degree of Industrial and Systems Engineering in Institut Teknologi Sepuluh Nopember (ITS) majoring in Logistics and Supply Chain Management. During the study, the Author had involved in projects with lecturers under the collaboration with a state-owned entreprise. In late 2019, the Author has started some research projects such as 1) Skills for Digital Future with Prof. Nyoman Pujawan (ITS), Prof. Caroline Chan (RMIT Australia) and Prof. Helen Rogers (Technische Hochschule Nürnberg Georg Simon Ohm, Germany) and 2) Research for Industry 4.0 Maturity Model with Prof. Kannan Govindan (SDU, Denmark) and Prof. Nyoman Pujawan (ITS). Besides, the Author is actively involved as the Project Manager in a social community supported by LPDP namely REC Indonesia (Reading Enthusiast Circle) since 2018. This community has had its literature projects going on in some cities in and outside of Indonesia (Malaysia and Frankfurt, Germany). For further discussion and suggestion regarding this research, reach the Author at immaritadinar@gmail.com.