Adopting open innovation for SMEs and industrial revolution 4.0

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Abstract

Purpose – Industrial Revolution 4.0 is still evolving. The purpose of this paper is to assess the progress of Indonesia in achieving an initiative for Industry 4.0. As the largest country in Southeast Asia, Indonesia plays a critical role in implementing Industry 4.0. In addition, this study proposes an open innovation strategies for small and medium enterprises (SMEs) in facing Industry 4.0, especially in the Indonesian setting. Open innovation is viewed as a long-term innovation model that relies on cross-border commerce between businesses and countries.

Design/methodology/approach – This study undertakes a comprehensive literature review to capture the necessary insights for establishing an early grasp of solution design. A total of 32 sample papers were qualified using a set of selection criteria designed to find the most relevant existing studies in the Industry 4.0 and Indonesia domains. The meta-details as significant discoveries were processed using a content analysis approach. In addition, the research deployed sentiment analysis from text mining to inter-operate and classify (positive, negative and neutral) in-text data using text analysis techniques to identify public sentiment toward Industry 4.0 in Indonesia.

Findings – The key finding is that there is a favorable relationship between digital ecosystem readiness and open innovation adoption for SMEs. While, knowledge management is a critical factor in guiding a country's successful implementation of the open innovation paradigm. Furthermore, some of the major findings revealed that many initiatives for Industry 4.0 are carried out by the private sectors. In regards to the procedure, the role of government is the protection of market regulations. This could be due to preserving fair competition between corporations and SMEs. Local businesses and SMEs should be protected to ensure their survival. In addition, the major cause of the slow adoption of Industry 4.0 in Indonesia is the lack of digital equipment. This is because of the shortage of digital equipment that can create a digital divide between large and small businesses and between industries in the urban and rural areas.

Research limitations/implications – This study discussed some of the most essential issues of SMEs in adopting open innovation that is required for Industrial Revolution 4.0. It focuses on how digital ecosystem's readiness influences open innovation adoption for SMEs in Indonesia. By understanding its current state of readiness, it contributes to the policymakers in deciding how and where to adopt open innovation and develop digital ecosystem and identify which ones might best meet their needs for any developing countries.

Originality/value – This paper is useful to academics, practitioners and policymakers in the fields of technology and public policy. The research provides some initial insights into Indonesia and any developing countries on Industry Revolution 4.0 and the needs for SMEs in adopting open innovation.

Keywords Industrial revolution 4.0, Open innovation, Root cause analysis (RCA), Digital ecosystem, Indonesia

Paper type Literature review

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Introduction

Industry Revolution 4.0 (Industry 4.0) has permeated all various aspects of life, making a huge impact on production, distribution, consumption, data analysis and knowledge discovery. To survive and flourish in Industrial 4.0, any country needs to craft digital transformation, adopting Information & Communication Technology (ICT) in their business processes to create an advantage and then grow to secure the local market and to venture into the global market. Industry 4.0 is a term introduced in early 2011 as German's "High-tech Strategy" initiative to improve its manufacturing industry's competitiveness in 2020 on a global scale. It emerges due to the global demand for a shift in the basic nature of previous automation of manufacturing industries (industrial 3.0) toward greater efficiency by digitalization, automation and internet of things (IoT) in manufacturing processes (Islam *et al.*, 2018; Marr, 2018; Schwab, 2017; Kagermann *et al.*, 2013). Industry 4.0 covers three distinct aspects, including:

(1) technology advances and their integration;

(2) velocity of technology through the internet; and

(3) broad influences that can affect all aspects of human life (Li *et al.*., 2017).

Additionally, Schwab (2017) also mentioned several components that will enable connections between people with unlimited sources through advent technology breakthroughs which includes artificial intelligence (AI), robotics, IoT, autonomous vehicles, 3-D printing, nanotechnology, biotechnology, materials science, energy storage and quantum computing. Research shows that among these components, IoT and wireless sensor network–related researches were the two most researched components (Chung and Kim, 2016; Anshari, 2020).

With this technological advancement, Indonesia is set to keep up with Industry 4.0 by going through several changes especially in the technological aspect. In accordance with the changes, this will further aid in enabling Indonesia to achieve its vision of being a Smart Nation. The lack of necessary skills and infrastructure readiness related to Industrial 4.0 to hinders its development within the country. With the automation and digitalization in Industry 4.0, it can be seen that Industry 4.0 would cause a significant shift in the job market. In the case of Indonesia, not much has been revealed about the country's extent and readiness in moving toward a Smart Nation and Industry 4.0 The need to get a clearer vision on Indonesia's digital infrastructure is pivotal to survive and keep up with the current industrial revolution.

Small- and medium-sized businesses (SMEs) play a critical role in economic development. SMEs have a large impact on the economy as a whole, such as creating jobs, lowering unemployment, contributing significantly to GDP growth and ensuring correct money flow. The SMEs were shown to be responsible for the notable economic growth (Siu, 2005). In facing Industry 4.0, if SMEs depend only on research and development (R&D) then it will take time to produce the desire product; therefore, if they adopt new business innovation model which is open innovation then their effectiveness and efficiency will increase drastically within shorten period of time. Therefore, open innovation has immense impact on SMEs nonetheless ICT also influence positively the adoption of innovation by SMEs (Parida and Örtqvist, 2015). This study will shed light on Industry 4.0 readiness and SMEs' capability in adopting open innovation and at what extent it effect.

Literature review

The term Smart Nation was introduced before the Industry 4.0. Research by Steele-Vivas (1996) argued on the importance of becoming a Smart Nation in the 21st century to survive.

He stated that becoming a Smart Nation included the engagement of all citizens as a collector, producer and consumer of intelligence which in turn will create a Virtual Intelligence Community. Similarly, GovTech Singapore (n.d.) stated that a Smart Nation is where "people and businesses are empowered through increased access to data, more participatory through the contribution of innovative ideas and solutions, and a more anticipatory government that uses technology to better serve citizens' needs." Both of these statements when combined have validated the need to achieve Smart Nation today in order for a nation to sustain and survive economically through the utilization of technology.

Henceforth, it is considered important to assess the digital ecosystem of a nation in its journey of becoming a Smart Nation. A digital ecosystem is an interdependent group of enterprises, people and/or things that share standardized digital platforms for a mutually beneficial purpose, such as commercial gain, innovation or common interest. Digital ecosystems enable you to interact with customers, partners, adjacent industries – and even your competition (Bennett, 2017). Several aspects could be related to the digital ecosystem, for instance, business model, mobile content, information systems (IS) and sustainability (Anshari and Sumardi, 2020; Anshari *et al.*, 2019b). A study that focuses on the thriving of a business with the increasing digital ecosystem that promotes digital disruption has noted the importance of evaluating the threats from this disruption and to start creating a new business model to avoid loss of revenue (Weill and Woerner, 2015).

Digital disruption establishes the digital ecosystem and mobile content found that the success of mobile content lies upon a much-segmented approach to the characteristics and circumstances of the users and the process of interaction and learning are required to be continual (Feijóo *et al.*, 2009). Additionally, according to Tan *et al.* (2015), the digital ecosystem for IS and its capabilities in developing Multi-Sided Platforms (MSP) was found to have a significant difference between stages of development in terms of prior IS capabilities, nature and the outcomes of MSP development. Further, a study on the building of what is known as a Smart Home with minimal energy consumption has an integrated digital ecosystem into the underlying automation systems and the physical processes with the application of AI (Reinisch *et al.*, 2010).

These studies have shown that there are diverse aspects of a digital ecosystem that could be looked upon. However, in attaining a profound digital ecosystem for Indonesia, it is equally essential to assess the foundation that is responsible for operating the technologies, which is the digital infrastructure. According to Spacey (2017), digital infrastructure is an important foundation that provides services that are necessary for the information technology capabilities of a nation, region, city or organization, and it is crucial for a modern nation to acquire this for its economy and quality of life. Some examples of digital infrastructure include mobile telecommunications, communications satellites, network infrastructure, data centers, cloud computing, platforms, systems, applications and IoT.

Based on some literature, this section elaborates more on the important keywords of this study to reach the purpose as well as the objectives of this paper. The important keywords include Industry 4.0, Current Indonesian Digital Economy initiative, Root Cause Analysis.

Industry 4.0

Industry 4.0 or Industrial Revolution 4.0 is a term to define the developmental process in the management on how automation of manufacturing processes and chain productions evolved into having an organization that have customized machineries and to adapt to a more flexible mass production technologies (Luenendonk, 2017). The Fourth Industrial Revolution consists of AI technology, this can be seen through the rapid advancements made on smartphones in correlation to the new innovations made through sophisticated

applications. Due to the fast paced momentum of the development of new innovations, this has caused companies to invest more on their R&D department to be one step ahead of their competitors. This allows the creation of many new technologies such as much thinner smartphones, more Smart televisions and more smarter features being added to Robots to mimic human behavior (Twydell, 2017). The following diagram shows a timeline of the evolution of manufacturing and the industrial sector in general (Figure 1).

The fourth industrial transformation (Industry 4.0) symbolizes the advancement of new digital industrial technology. Industry 4.0's aim is to create a highly integrated production model of customized and digital services and products, with real-time interactions throughout the production process between people, goods and devices through cyber-physical systems (CPS) and IoT to promote the manufacturing factory to be digitized and subsequently turning the traditional factory into Smart Factories (Zhou *et al.*, 2015).

Industry 4.0 is a frontier factor that disrupts the whole process of production, productivity or even the management, the manufacturing process and the labor market. As specified by Rüßmann *et al.* (2015), with CPS, the products are sensors and actuator-equipped to connect and communicate with each other using standard internet-based protocols as well as conducting an analysis of data to calibrate and coordinate themselves to any adjustments and predicting the rate of failure. Zhong *et al.* (2017) further added that cloud computing also has a significant role in "Smart Factory." This suggests that the correlation between IoT, CPS and cloud computing will have a crucial part in the evolution of "Smart Factory."

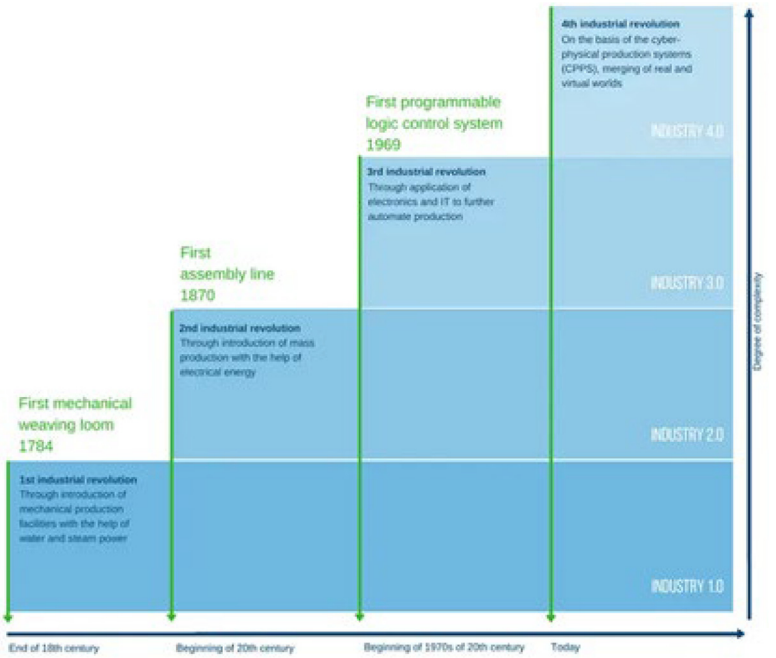


Figure 1.
Timeline of the evolution of manufacturing and the industrial sector

Source: Deloitte (2017)

As stated by Rüßmann *et al.* (2015), there are nine technological pillars in Industry 4.0, namely, Big Data and Analytics, Autonomous Robots, Simulation, Horizontal and Vertical System Integration, IoT, Cybersecurity, The Cloud, Additive Manufacturing and Augmented Reality. Big data and analytic is a technology used to assess the problem, responses, protection, control as well as correctly predict future challenges on broad sets of data collected from several sources (Rüßmann *et al.*, 2015). Bahrin *et al.* (2016) explains that autonomous robots are robots that can perform activities smartly and put emphasis on things such as safety, durability, functionality and cooperation. The program for simulation is designed to take advantage of the information in real-time and to simulate the actual manufacturing mechanism which then enables an engineer to evaluate, examine and refine the setup digitally before any changes are made (Rostkowska, 2014; Rüßmann *et al.*, 2015). As stated by Craig (2013) and Schmalstieg and Hollerer (2016), augmented reality is a real-time representation of a real-world environment, strengthened or improved by projecting simulated software-generated knowledge into it, and the AR technology core features are displays, input devices, trackers and computers. Günther *et al.* (2008) and Zhou *et al.* (2015) explain horizontal and vertical integration as establishing a common and unified data network system which allows for the convergence and linking of various companies, agencies and activities, enabling smooth collaboration and an automated value chain.

Cybersecurity is the provision of secure messaging, advanced identities and network authentication to counter cybersecurity threats (Rüßmann *et al.*, 2015; Bahrin *et al.*, 2016). As specified by Wan *et al.* (2014) and Jeschke *et al.* (2017), IoT allows devices to connect and engage with each other with more centralized controller and also decentralized analytic and decision-making to provide feedback in real-time provided the devices are equipped with sensors, actuators or any other instruments that are capable of collecting and sharing information. The cloud system enable faster and more efficient transfer of data across the connected gadgets to the same cloud and it allows the delivery of computing services through visualized and scalable resources over the Internet, thus suggesting that CPS can be associated intelligently with the aid of cloud systems (Stock and Seliger, 2016; Zhong *et al.*, 2017). Last but not least, often described as 3D printing, additive manufacturing is an industrial process of producing a product in an automated method by stashing materials layer by layer to construct 3D structures with little to no wastage (Chua and Leong, 2014; Kuscer and Shen, 2014).

Hozdić (2015) defines smart factory as a scalable and productive manufacturing approach that should satisfy today's demands and reach integration in between the numerous industrial and non-industrial stakeholders that create diverse and sometimes even digital organizations. Roblek *et al.* (2016) stated that Industry 4.0 will ensure that machineries and facilities will reach a high degree of self-optimization, thereby allowing the production process to satisfy the increasingly advanced and skilled product specifications and criteria, resulting in a better, more efficient and competitive production process. In line with this, Sanders *et al.* (2016) agree that the core objectives of industry 4.0 are an intelligent factory and smart manufacturing.

According to Burke *et al.* (2017), there are five key characteristics of a smart factory: connectivity, optimization, transparency, proactivity and agility. Each of these features plays a role in enabling more informed decisions and helps organizations improve the production process. It is important to note that no two smart factories will likely look the same, and manufacturers can prioritize the various areas and features most relevant to their specific needs. Connection is one of the most crucial features in the smart factory. Connecting the underlying systems and resources is needed to produce the information essential for making real-time decisions. Equipped with smart sensors, the data sets can be

consistently extracted from both modern and conventional sources aimed at ensuring the data is constantly updated and show the current situation thus allowing collaboration between suppliers and customers. An optimized smart factory enables operations to be performed with minimum human interaction and high performance. Computerized workflows, resources management, enhanced monitoring and planning, and the smart factory's efficient energy consumption can boost production, uptime and value, as well as lower cost and waste. The data captured in a smart factory are transparent. The transparency in live metrics and tools enable fast and consistent decision making (Anshari *et al.*, 2019a). It also allows an organization to forecast the demand of the customer as well as enable customers to track their orders. Employees and systems should predict and behave proactively until problems and challenges emerge, instead of merely responding to them after they take place (Musa and Idris, 2020; Polak *et al.*, 2019). This function will involve detecting irregularities, restocking and replenishing inventory, recognizing and resolving quality issues and tracking safety and maintenance issues (Coleman *et al.*, 2017). Parrot and Warshaw (2017) argue that manufacturers may incorporate processes like the digital twin throughout the smart factory, allowing them to digitize a procedure and progress above automation and integration into predictive capabilities. The impact in real-time can be seen with the implementation of product changes. Agility can improve factory efficiency and output by reducing changes due to scheduling or product changes, thereby enabling flexible scheduling with minimum interference (Malik *et al.*, 2019).

The main idea of Industry 4.0 is the digitization of industry. The transformation of technology changes due to CPS controls the process, devices and objects which are linked with each other by software via the Internet (Jeske *et al.*, 2018; Anshari, 2020). Hence, this transformation creates fundamental changes affecting how people work currently and how people will work in the future. The working methods are changing which require skills expected to change for the working population or future employees (Anshari *et al.*, 2019c). The work process turns into something much easier and efficient even the technical process using advanced technology is complex but safer by Industry 4.0 (Romero *et al.*, 2018; Tarasov, 2018).

Industry 4.0 uses the power of communications technology and innovative inventions to enhance the development of the manufacturing industry (Kagermann *et al.*, 2013; Ing Tay *et al.*, 2018). Industry 4.0 has distinct characteristics comprised of physical, digital and biological worlds. The new technology brings improvement and significant effects on economics, industries and governments' development plans and it is one of the most significant concepts in the development of the global industry and the world economy (Schwab, 2017; Ing Tay *et al.*, 2018).

Digital economy of Indonesia

Indonesia is Southeast Asia's largest economy, rich in all types of natural resources as well as cultural diversity (OECD, 2019). Indonesia, as the fourth-largest population in the world, plays an important role in the growth of the digital economy. Indonesia has the four largest unicorn companies in Southeast Asia with huge funding. They are Go-Jek, Bukalapak, Traveloka and Tokopedia. Four criteria needs to be met to become unicorn companies: the market value of more than USD 1bn, less than 10 years after establishment, unlisted and technology company (BayCurrent, 2019). The government has set a target of becoming a digital economy and has launched "2020 Go Digital Vision" and "Indonesia's e-Commerce Road Map. 2020 Go Digital Vision will support the growth of the digital ecosystem for agriculture, fishery and small and medium enterprises (SMEs) to digitize, expand their marketing network and increase employment. Indonesia's e-commerce roadmap focuses on

the development of the domestic digital marketplace ecosystem, with its digital economy valued at $40B in 2019 and is expected to grow over $130B by 2025" (Thinkwithgoogle, 2019).

Furthermore, the government of the Republic of Indonesia launched the vision of "Indonesia Digital Economy 2020" and "National Movement of 1000 Digital Start-ups" (Iman, 2018). Recently, Indonesia's Ministry of Industry has developed the vision "Making Indonesia 4.0" as an integrated roadmap for strategies to embrace Industry 4.0. "Making Indonesia 4.0" harnesses technologies such as AI, the IoT, augmented and virtual reality, 3-D printing and next-generation robotics to boost employee productivity and increase the global export market (Kearney, 2019).

In regards to digital infrastructure, there were 175.4 million internet users with 338.2 million mobile connections in Indonesia in January 2020. The number of Internet users in Indonesia increased by 25 million (+17%) between 2019 and 2020. Internet penetration stood at 64% in January 2020. While the number of mobile connections in Indonesia increased by +4.6% between January 2019 and January 2020. Mobile connections in Indonesia in January 2020 was equivalent to 124% of the total population. Furthermore, there were 160.0 million social media users in Indonesia in January 2020 increased by 12 million (+8.1%) between April 2019 and January 2020. This means that social media penetration in Indonesia stood at 59% in January 2020 (Kemp, 2020).

In 2019, Indonesian internet users have already passed 150 million (Figure 2). The adoption of mobile broadband services could boost a new era in high-speed connectivity for Indonesia's citizens, expanding the Indonesian economy by $10.5B over the next decade, adding 1% to the country's GDP by the end of 2030 (GSMA, 2020). Indonesia has the highest rate of e-commerce use of any country in the world, with 90% of the country's Internet users, between the ages of 16 and 64, reporting that they have bought products and services online. However, the overall value of the digital marketplace in Indonesia remains relatively low (GlobalWebIndex, 2019). Statista (2019a, 2019b) reports that the average Indonesian e-commerce shopper spends US$89 on online consumer goods purchases previous year, although the figure does not include the amount spent on travel or digital media. Statista also reports that more than 100 million Indonesians purchased consumer goods online in

Source: Datareportal (2019)

Figure 2.
Indonesia Digital Users 2019

2018 and the amount that they spend on grocery products surged by an impressive 30% year-on-year, putting the country firmly in the five fastest-growing online grocery markets in the world. In short, the digital marketplace in Indonesia is huge, growing and promising (Statista, 2019a, 2019b).

Open innovation and small and medium-sized enterprises

In a book titled "Open Innovation: The New Imperative for Creating and Profiting from Technology," Henry Chesbrough originally introduced the concept of open innovation in 2003. (Yahan, 2021). Since then, academic researchers and industrial practices have been drawn to this new paradigm of innovation. Open innovation is a newly established company management concept that aims to improve internal innovation while also extending markets for external invention through the use of purposeful knowledge inflows and outflows in an organization (Chesbrough *et al.*, 2006). In a nutshell, open innovation increases the ability to engage with people, organizations or country outside of one's own organization or country. On the other hand, closed innovation refers to creating anything using just internal sources of information, such as R&D. Based on the application of the open innovation concept, it is divided into three categories: in-bound or outside-in open innovation deals with the knowledge of external organizations by adopting their invention; in-bound or outside-in open innovation deals with the knowledge of internal organizations by adopting their invention; and in-bound or outside-in open innovation deals with the knowledge of internal organizations by adopting their invention (Chesbrough and Crowther, 2006).

Small and medium-sized enterprises (SMEs) are the engine of innovation and make a substantial contribution to global economics (Hoffman *et al.*, 1998). According to the study of Hoffman *et al.* (1998), SMEs are highly linked to technical innovation, which helps them succeed in the market. This study's literature centered on a four-dimensional framework for SMEs adopting open innovation (Bigliardi and Galati, 2018), particularly for Indonesians facing Industry 4.0. This study examines the four Whs-based dimensional structure in depth, including why/why not, what, how and with whom (Bigliardi and Galati, 2018). The first factor considers whether or not SMEs require external knowledge to aid their own innovation process (Bigliardi and Galati, 2018). The first dimension also identifies the elements that encourage or discourage open innovation adoption. As a result, the second dimension emphasizes knowledge exchange facts (Bigliardi and Galati, 2018). Next, the third dimension reflect on how SMEs adopt and practice open innovatio. And the fourth dimension focused on with whom they exchange or share their innovation process (Bigliardi and Galati, 2018).

Root cause analysis and CATWOE

To identify the root cause of a certain problem, the use of analytical tools is needed to get a further understanding regarding the issue. Root cause analysis (RCA) is a tool that helps to identify what, how and why a problem occurs and it also helps in deciding the corrective measures that should be taken (Rooney and Heuvel, 2004). RCA will be used to reach the objectives of this paper. A combination of Fishbone diagram and five Whys will be used as tools for this analysis to give a better understanding of the problem that persists and henceforth produce better-proposed recommendations (Thani and Anshari, 2020). Fishbone diagram was created by Kaoru Ishikawa for the research field of management and it is known as a common tool that is used to indicate a cause-effect analysis for a specific event (Coccia, 2018). Similarly, five Whys is also a tool for root cause analysis that helps to explore the cause-effect relationships of an event and this tool is regarded as a simple tool that is related to the principle of systematic problem-solving by asking "why" questions

(Serrat, 2017). is used as a technique or a tool to answer and address the primary cause of the occurring problem. By finding the primary cause of the occurring problem, it can help to identify or determine what or why the occurring problem is happening. From this, a root cause is being identified and addressed to figure out what to do to prevent repeating problems by producing a permanent solution.

In addition, the research also uses CATWOE analysis to define the root definition process. According to Bergvall-Kåreborn *et al.* (2018), CATWOE helps to understand precisely the problems through the development of the six elements that have different purposes: Customers, Actors, Transformation Process, Worldview, Owner and Environmental constraints. CATWOE is a tool that is used to prepare a rigorous and comprehensive root definition, and as a basis for solving problems with multiple perceptions. This fits perfectly with the framework of incident management as multiple parties are often involved, and the ultimate aim is to find the root problem.

Methods

The main objective of the study is to find and analyze published material in the areas of Industry 4.0 and Indonesian context to produce fresh insights that will help to understand the present state of its readiness. Rowe (2014) provides a framework for performing successful literature reviews to achieve this research objectives. In this research, the five components of Rowe (2014) were used, as shown in Figure 3. As mentioned in the background section, the field of Industry 4.0 is fast growing, and research are being conducted to fulfill the needs of policy's construction. As a result, the study uses only qualifying full research articles from the research domain as sample sources (excluding research notes, brief communication papers, editorial notes, industrial whitepapers and technical and nonacademic documents). The most important aspect of this study is sampling. To acquire the sample, a thorough search was conducted using a five-step process from top to bottom. An extensive search was conducted to compile a list of the majority of articles from reliable databases. All of the papers were chosen from 2010 to 2020. Springer, ScienceDirect, Wiley, Scopus, NCBI, IEEE and ACM were chosen as data collection databases. The first phase gathers articles based on keywords such as "Industry 4.0" and

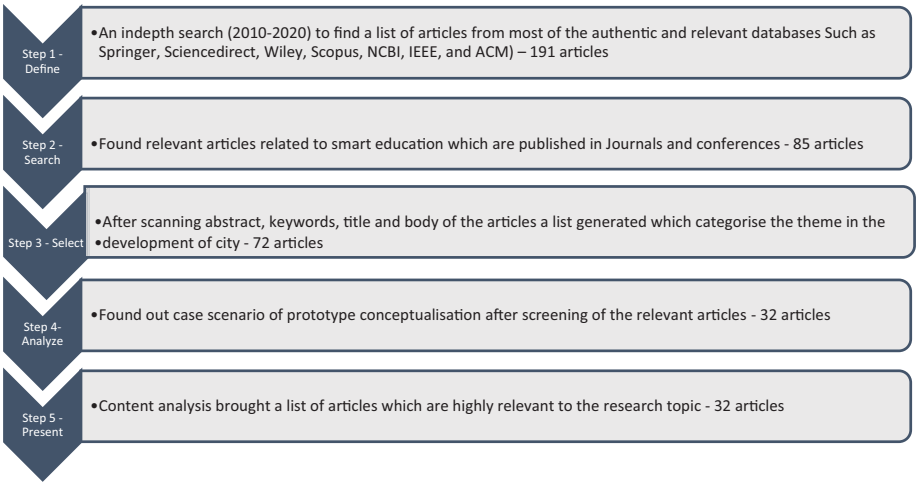


Figure 3.
Steps taken for conducting the review study

"Indonesia" from diverse journals found in the search engine. This search pattern produces a large number of articles that must be filtered to obtain more detailed extractions. Following that, the keyword Industry 4.0 was targeted, and 191 articles were found. A fresh list was constructed after looking at the abstract, keywords, title and body of the article. After that, there is a list of 85 articles. Next, samples with information linked to the case scenario of prototype conceptualization are included, which covers a thorough comprehension of the topic, bringing the total number of articles on the list to 72. In the last step, 32 articles were gathered that follow the conceptual understanding of Industry 4.0 in Indonesia. The final stage is to conduct a content analysis based on the 32 articles that were collected and found to be highly relevant to the study. After the final content analysis, then research deployed the tools to define the root problem by using RCA and CATWOE analysis. The results from research findings were applied in recommendations. The process was iterated by examining the root problems. The CATWOE technique was chosen to analyze and identify the potential problems, factors that relate to it and understanding stakeholder's perspective. The CATWOE technique was developed by David Smyth in 1975. CATWOE is an acronym that stands for six elements for problem-solving: C – Customer, A – Actors, T – Transformation, W – *Weltanschauung* or World view, O – Owner and E – Environment. Furthermore, Root Cause Analysis uses the Fishbone diagram and five Whys . Furthermore, the study deployed text mining analysis focusing on sentiment analysis for Industry 4.0 and Indonesia from the web search and social media conversation on the given keywords.

Analysis

The present problem is detected with the CATWOE analysis and RCA method. The CATWOE analysis is a simple method, which can stimulate thinking to identify the solutions to different issues. It analyzes interactions between the system and processes. It stands for Client, Actors, Worldview, Owners and Environment. To understand the cause of problems in this context, the problem-solving tool RCA has been used. RCA is the tool often used to prevent future outages. DuMoulin (2017) supports this by stating that the goal of the RCA process is "to understand what went wrong and to accurately report the impact of the incident and/or failed change so that results are understood and that a similar incident can be avoided in the future."

Customer

In Industry 4.0, where Smart Factory is implemented, the receiving ends are the customers that orders and purchases products or services from a supplier that produced the demanded items (Khan and Turowski, 2016). In terms of manufacturing, customers might have problems on how fast their orders can be made by suppliers. With Industry 4.0 and transformation to Smart Factory, the process of manufacturing will be more efficient resulting in better quality and faster completion of orders. In this case, the winners are both the suppliers and the customers. In fact, Indonesians are rapidly adapting to any digital transactions seeing it as convenient, practical and rewarding. Convenience refers to a simple process, ease of use and works anytime. Practical works for instant processes with no physical queuing are required and customers may expect more rewards, discounts, cashback and promotions (Thinkwithgoogle, 2019). In addition, the transaction cost is very low or negligible. However, the obvious challenge for the Indonesian government is the recent statistic of unemployment which reached 4.69% in 2019 (Statista, 2019a, 2019b). In addition, transforming to a Smart factory will expect a higher rate for employment because many Indonesian factories are labor-intensive. Therefore, a proper strategy and roadmap is required to implement technologies for Industry 4.0.

Actor

The first few countries that moved toward Industry 4.0 and Smart Factory such as Europe, China and the USA. The USA has started to re-industrialize its manufacturing and producing sectors to walk toward Industry 4.0 and both Europe and China have proposed their strategies for embracing Industry 4.0. The impact of Industry 4.0 lies in the economy (Marcon *et al.*, 2017). To implement the Smart Factory, the factory has to transform such as having automated devices to manufacture products instead of human labor. In addition, the machinery and facilities are required to be equipped with sensors and actuators. Indonesia is one of the fastest-growing economies in the world and the largest in Southeast Asia. It plays a major role in the growth of the global economy, leading tolarge companies in the world investing heavily in Indonesia start-up companies (Baycurrent, 2019). Finding niche sectors is the next agenda for Indonesia before embracing Industry 4.0.

Transformation

Industry 4.0 focuses on the high optimization of machinery and devices that are mainly dependent on CPS, IoT and cloud computing. CPS allow devices that are equipped with sensors and actuators to connect and share information with the help of the IoT and cloud computing. CPS can be objects, products, devices or components that are equipped with sensors and actuators. IoT is the use of the internet or intranet to send information from one device to another. The production data are recorded via sensors (Jazdi, 2014). The collected data is evaluated and stored in the cloud system which will allow the detection of defective products.

Weltanschauung (world view)

Through smart factories, manufacturing processes will be more efficient. Automated machineries can detect any changes in production faster thus reducing the rate of waste materials and make use of the resources efficiently hence increasing asset efficiency. This links to the lowering of the cost of production because with fewer defects, the amount of expenditure will be reduced as well. The quality of the product will be better and more consistent with automated machinery, compared to human labor, and consequently, improve the quality of products. Product quality influences the safety and sustainability of the Smart factory. When the product produced has high quality, warranty and maintenance cost are minimized (Haseeb *et al.*, 2019). Overall cost will, therefore, vastly reduce. On top of that, the use of automated devices equipped with systems that prioritize high self-optimizationwill reduce the potential human error or injury-causing industrial accidents. Laschinger *et al.* (2012) also stated that the employee satisfaction level will increase due to this and subsequently reduce the rate of turnovers. The worldview for adopting Industry 4.0 is high as internet penetration is projected to be around 50% by 2022 in Indonesia. Users in Indonesia spend an average of 3.9 h per day on mobile internet, doubling that of USA users and quadrapling that of Japan users. The penetration of the smartphone has helped in enhancing the growth of digital buyers (Razzaq *et al.*, 2018; Ahad *et al.*, 2017). In 2017, smartphone penetration was 23.7% (62.7 million users) and projected to increase to 32.1% (89.9 million users) by 2022 (Baycurrent, 2019).

Owner

The real owners are the government that controls the economy and force the manufacturer and factory to move toward Industry 4.0 (Bahrin *et al.*, 2016). The owners of manufacturers have the ultimate decisions whether they would like to implement the Smart factory or not as the needs for each factory are different and the application on some factory may not be

suitable. There are some initiatives from the Indonesian Government to move toward Industry 4.0. Electronic Information and Transactions law stipulated that electronic systems providers are liable for everything that takes place on their electronic systems (that is, website, mobile app and so on) unless they can prove it was the wrongdoing of a third party. Indonesian digital friendly policy provides an economic policy package to promote digital companies, embracement of technology have created a conducive climate for both foreign and domestic investors to invest in Indonesia (Baycurrent, 2019).

Environmental constraints

There are several difficulties and challenges including scientific, technological, economic and social problems as well as political issues (Öztürk, 2017). To implement Industry 4.0, certain technologies are required to support its features. The availability of resources can hinder the adoption of a Smart factory. A financial constraint has a significant impact on transforming a traditional factory to a smart factory as it requires a considerably large amount of money to own the machinery that is equipped with CPS, IoT and cloud computing. Indonesian new consumers, especially millennials, are deeply concerned about the environment. Indonesians are starting to make purchasing decisions which are driven by a desire to live an eco-friendly life that has a low impact on the environment (Thinkwithgoogle, 2019).

Root cause analysis

Based on the literature, to propose some improvements for Indonesia, RCA will be conducted in this section by using a combination of the Fishbone diagram and five Whys. The diagram will show a simple illustration of the cause-effect analysis and five Whys will help in determining the potential root cause (Andersen and Fagerhaug, 2006). Figure 4 shows the effect or the problem identified and is regarded as a slow approach on Industry 4.0 whereas the causes have been divided into four categories, namely, people, procedure, equipment and material. A series of five Whys were applied for each category based on observation and are included in the diagram accordingly.

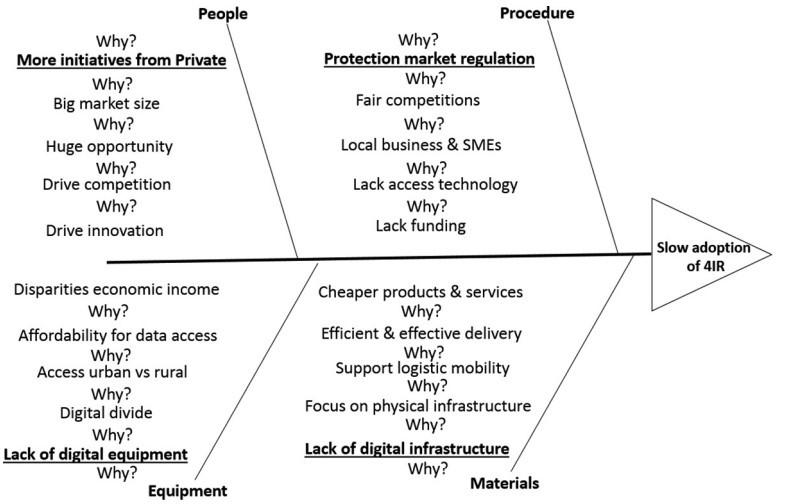


Figure 4.
Combination of Fishbone diagram and 5 Whys

People

Through the analysis, the major cause for this category was identified as many of the contributions to the progress of adopting Industry 4.0 in Indonesia are carried out by the private sectors (Anshari, 2020). It can be seen that there are few startups under government agencies serving the people. For instance, the agriculture sector plays an important role in supporting the national economy and development. There are many jobs and employments absorbed in this sector (Benešová and Tupa, 2017). The government, through cooperation's organization across the country, may be able to support an initiative for Agriculture 4.0. Agriculture 4.0 can become a gateway for the government to support and protect farmers in the Industry 4.0 era. A series of Whys found the possible reasons for this and eventually the root cause was known. It was noted that more contributions from the private sectors is due to a potential of economies of scale in Indonesia. It drives huge possibilities for startups to prevail in competitions in the digital economy of Indonesia. Further, the Whys identified that competition among players leads to innovation. For this category, the most significant reason for the slow approach to Industry 4.0 is due to the other stakeholders' need to actively take part in embracing the Industry 4.0's initiative. These stakeholders include public sectors and citizens. The only challenge for people is upgrading skills and competencies to get optimum benefits from the implementation.

Procedures

In this category, the major cause that was identified is the protection of market regulations. This could be due to preserving fair competition between corporations and SMEs. Local businesses and SMEs should be protected to ensure their survival. Regulations should be governed to support local businesses and SMEs to be ready for Industry 4.0. The government must protect local businesses and SMEs because they can be slow in adopting new technology due to limited funding.

Equipment

This category identified that the major cause of the slow adoption of Industry 4.0 in Indonesia is the lack of digital equipment. This is because the digital equipment that is lacking creates a digital divide between large and small businesses and between industries in the urban and rural areas. This is possibly due to affordability of data access. The root cause of this could be due to the capital access between large and small businesses and economic disparities between the urban and rural areas. Through analysis, although the root cause for this category is derived based on observation, this could possibly be one of the factors that contribute to the major cause. Thus, it is important to note that while making a careful decision to avoid bad circumstances, it is equally important to make a progress instead of being stuck in one place for a long time. Hence, a thorough plan that can improve the digital equipment with the assessment on all aspects of risks should be laid out and eventually carried out. This is important to keep up with the current global phenomenon.

Materials

The major root cause for this category is the lack of digital infrastructure in Indonesia where the most recent infrastructure is focusing on physical infrastructure development. Thus, both priorities digital infrastructure and physical infrastructure should be developed altogether. Materials concerning digital infrastructures such as centralized cloud computing, IoT and AI can be of consideration and implementation.

People and procedure

With the unavoidable root cause (more initiative comes from private companies), the government needs to regulate and protect local businesses as well as SMEs. Public and private organizations should contribute to the progress of Industry 4.0. The most important after digital literacy is the society's digitization which is internet accessibility or penetration within the society (Levy and Wong, 2014). To achieve good internet penetration, a society needs to be provided with good internet infrastructure. This is because Industry 4.0 demands a medium to enable society to interact with front-end systems of applications. In addition, the government is also encouraged to be more active and protective toward local businesses and SMEs to ensure fair competition for all parties. In addition, supporting and protecting local businesses and SMEs would help resiliently with national economies.

Equipment and material

It is encouraged for the government as the major stakeholder in a process to come up with a thorough plan that can help in improving the digital infrastructure and equipment of the nation with a detailed assessment of all of the necessary risks. The plan should be carried out rather than be put in a waiting list and risk Indonesia with the inability to keep up with the global phenomenon and be left far behind. These circumstances may put an impact on the economy of Indonesia as there will be less compatibility in doing business with countries with updated digital infrastructure and equipment that are in line with the trend. Thus, Indonesia needs to have a very skillful and experienced team in deriving plans to achieve the goal of Making Indonesia 4.0. With a skillful and experienced team on areas such as knowledge management and risk management, the outcomes from every plan carried out will be very successful and if not, the risks can be contained diligently.

Open innovation and small and medium enterprises

CATWOE provides the landscape to understand the root cause of the problem. In this section focuses on why SMEs in Indonesia require open innovation in preparing Industry 4.0. There are two main reasons why open innovation should be adopted. The first category is made up of entrepreneurs and financiers, while the second group is made up of innovators. SMEs in the first group must use open innovation to maintain continual growth and generate money (Bigliardi and Galati, 2018). Other researchers, such as Chesbrough and Crowther (2006) and Yun and Mohan (2012), have backed up this claim with their research. In terms of expansion, Csath (2012) claims that SMEs who have already used open innovation are more likely to expand abroad. SMEs, on the other hand, can decrease costs, obtain economies of scale, lower the risk of failure, improve operational flexibility and effectively promote their products by embracing open innovation (Hoffman *et al.*, 2001; Rocheska *et al.*, 2014).

As a result, the second group claimed that because creating new things from scratch takes time, SMEs can speed up their innovation process and successfully produce new items for commercialization by embracing open innovation (Pullen *et al.*, 2008). Another research (Hoffman *et al.*, 2001; van de Vrande *et al.*, 2009), SMEs can fill knowledge and complementary resource gaps as well as build social networks by embracing open innovation. Finally, a recent study looked at how important eco-innovation is for SMEs adopting open innovation to ensure Industry 4.0 readiness.

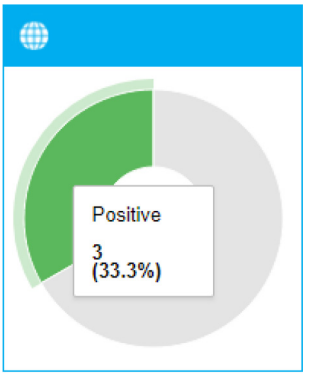
On the other hand, there are some challenges that SMEs have when it comes to adopting open innovation. There are four major barriers that SMEs in Indonesia face when it comes to adopting open innovation. Knowledge, organizational, collaborative and financial-strategic elements. *Knowledge barrier* is very crucial challenge for SMEs because it is very

complicated for them to measure at what extent their knowledge is narrowing and need to search for other sources as well as SMEs feel the risk of imitation by competitors (Bigliardi and Galati, 2016; Verbano *et al.*, 2015). *Organizational barrier* consists of lacking managerial skills to establish an effective collaboration with external partners (Bigliardi and Galati, 2016) also the reluctant attitude of leaders to change the traditional model. *Collaboration barriers* are several challenges for SMEs to collaborate with partner. For SMEs, the big challenge is how they approach the partner, the behavior of partner and cultural differences (Bigliardi and Galati, 2016). Finally, *financial and strategic barrier* is the crucial one as they do not have sufficient backup to support collaborating with outside sources of knowledge (Verbano *et al.*, 2015).

Discussion

This section discusses the results that were obtained through the analysis. The study has shown that the unemployment rate in Indonesia is believed to be amplified by Industry 4.0 given the digital divide in Indonesia is still rather high. Indonesia's unemployment issue on its own is a big topic that needs further studies on the nation's economic standing, financial resources and political landscape to concisely come up with a proper framework that can suppress the employability of the citizens. Though, the digital landscape for younger generations is equipped with digital literacy based knowledge and soft skills. Indonesia has moved toward embracing digital technologies by equipping the younger generations with digital literacy based knowledge on its education systems. It is supported by the Web search mining results that indicated the majority of Indonesians are not aware of Industry 4.0. as shown in Figure 5. The Web search mining was extracted and the sentiment was analyzed from web source data only, excluding the social media conversation on the keywords of #Industry 4.0 AND #Indonesia, only 30% shows positive sentiment about Industry 4.0 in Indonesia.

ASEAN is a major economic power after the EU, the USA, China and Japan. The combined population of ASEAN creates the world's third-largest market with more than 600 million people. Table 1 shows a compressive sentiment analysis for all ASEAN member countries extracted from web search and social media conversation. It shows the subject's sentiment being discussed at all online platforms either Web search, online news, or social



Source: Author's Compilation, Sep 2020

Figure 5.
Sentiment Analysis for #Industry 4.0 AND Indonesia

ASEAN countries	Positive (%)	Negative (%)	Neutral (%)
Brunei	37	7	56
Cambodia	22	5	73
Indonesia	12	4	84
Lao PDR	30	5	65
Malaysia	16	4	80
Myanmar	33	8	59
Philippine	15	2	83
Singapore	21	8	71
Thailand	14	3	83
Vietnam	25	12	63

Source: Authors' Compilation as September 2020

Table 1.
Sentiment analysis of ASEAN countries

media conversation into positive, negative, or neutral. Table 1 shows a compelling result that Indonesia got the lowest positive score amongst ASEAN countries showing only 12% of positive sentiment and highest score in theneutral category with 84%. It indicates that Industry 4.0 is not yet publicly discussed compared to other ASEAN countries.

The other challenge is the Human Development Index in Indonesia is ranked 111 out of 189 countries in 2018, showing that much progress is needed toward education, quality of life and income. Moreover, the youth generation is seen to readily embrace and accept the use of smartphones and internet usage, which is a positive behavior toward the creation of a smart nation in the future. Digital infrastructure should be emphasized for the nation's development because it is the main necessity to successfully implement the digitization of things in Industry 4.0. Industrial 4.0 itself is a topic that is very infant in academia to conclude its effect on employability on a macro-scale. Hence, further studies should be performed while considering other factors that would be influenced by Industry 4.0.

Implications from the research provide the analysis Indonesia can adopt to improve its approach toward adopting Industry 4.0. It is expected that the relevant parties can carry out a corrective action plan to create better initiatives for Indonesia.

Small and medium enterprises, open innovation and Industry 4.0

A number of factors have contributed to the drivers of Industry 4.0 nowadays including SMEs which include the most important factors such as data, connectivity and customers (Newman, 2018). SMEs are becoming more intelligent as well as efficient with the existence and functionalities of big datas. In addition, businesses around the world are now able to connect and communicate with each other in a virtual manner where this enables them to expand their networking base to resolve issues between key stakeholders such as the business, customers and the suppliers. Another party that may also be considered as the largest driver of Industry 4.0 are the customers as they provide the demands and expectations which claim to be dynamic in a fast scale; hence, businesses need to be able to stay put on the same level resulting in positive feedback from customers.

Reduction costs is one of the many changes driving Industry 4.0. There are also exciting new technologies on the verge of disrupting the manufacturing industry, improving product quality, maximizing production, increasing preventative maintenance and reducing downtime (Newman, 2018). Connected customers, customized experience. Social media has become one of the major platforms where people are connected which leads to the success

and expansion of businesses, and this includes those in the transportation industry too where they are able to connect with the customers as well as obtaining their data analytics.

Empowered employees. According to Newman (2018), empowerment happens when there is transparency and accessibility toward the company's information being provided to the employees. Newman (2018) also stated that "New collaboration platforms and tools make it easy for employees to access everything they need, from anywhere, using the device of their choosing." As a result of practicing transparency, it is easier for SMEs to keep their focus on matters such as decision-making process.

For instance, optimized production, changes in production have shown to be improving due to the constant technological innovations and are, therefore, flexible to meet the demands from consumers. There are a number of beneficial factors to be considered as successful ever since the innovation period and this includes the availability of cloud analytics toward businesses of any scale today (Newman, 2018). Transformed products. With obvious improvements that are available in today's digitized world such as self-monitory features in vehicles for checking their gas usage, have saved companies a great amount of money or cost that could go up to millions per year. Apart from this, it encourages businesses or companies to be more innovative and improve their products from time to time, with the help of data analytics that they manage to gather (Newman, 2018).

Nowadays, cross-border e-commerces are opening up their boundaries to build a sustainable business relationship. To enhance the activities effectively and efficiently *the* role *of digital ecosystem in Indonesia is imminent*. It has found that digital ecosystem readiness can help businesses regarding designing, manufacturing, R&D, distribution, sales and feedback (information and communication technology in business, n.d.). Compared to the analog communication approach Industry 4.0 provides plenty facilities in businesses. Though there are many advantages for business but there are some challenges also. The main challenges is digital ecosystems readiness. For instance, if SMEs failed to manage server properly, they might face cyber-attack which can destroy the company's intangible resources. And sometimes end up with a huge amount of ransom. So these would be burden for SMEs, as they suffer resource scarcity. And in developing country cybercrime is very common as not many expert handle the digital infrastructures. Apart from that the maintenance cost also very high especially a reliable digital infrastructure.

The importance of knowledge management in open innovation adoption for Industry 4.0: to implement open innovation paradigm, the proper knowledge management is inevitable (West *et al.*, 2006). As open innovation requires the systematic exploration of necessary knowledge. To search, collect, store, maintain and proper using information, an organization must have to have better knowledge management system. To succeed open innovation strategy a country need to have employee with sufficient amount of knowledge management capability. Moreover, open innovation is company seek for resources which time consuming to invent within the country but easily available in other countries. So in the definition it is clear that open innovation required extensive search. In this case if the public efficient enough they can find the essential information with shorten period of time. As the public well aware about issues they can make right decision with minimal mistakes. Having proficient in knowledge management the public will have informative and standardized summary of the search which help policymakers to take quick action.

Therefore, in preparing Industry 4.0, the digital ecosystem readiness and knowledge management work together for adopting open innovation by SMEs in Indonesia. As the main target of open innovation for SMEs in Indonesia is shortening the R&D process, use existing resources which available in other country so digital ecosystem play significant role for sharing information and building communication with other countries where knowledge

management need to accumulate the acquired information and process according to the need. This paper provides insightful notion about adopting open innovation and knowledge management for Indonesia. Also, it is found from the literature that SMEs have scare resources in terms of human, financial and other, Industry 4.0 must become enabler to compile and chose the effective and required resources. Finally, SMEs in Indonesia requires open innovation for preparing Industry 4.0. Open innovation focus on highly on collaborative nature which is consider as sustainable process of innovation that reduce the cost, save time and build up the network outside the company as a result the market is also expanding. On the other hand, as the characteristics of open innovation is searching for the available resources so the importance of knowledge management is compulsory for accumulating and selecting the best suited result.

Conclusion

Open innovation is considered as new paradigm of business innovation model. The main component of open innovation is collaboration. Through collaborating with company or business partner or other source of R&D options, company exchanges the ideas or resources which highly used in product development. Open innovation allows SMEs to reduce cost and time. Therefore, there are many studies conducted on this topic based on large company but hardly found the adoption process of open innovation in SMEs and in the context of Industry 4.0. Some good progress as well as challenges were found when researching the incorporation of Industry 4.0 in Indonesia. This preliminary study helps Indonesia to be in line with the global phenomenon in preparation for Industry 4.0. Indonesia has set its direction into a leading digital economy in Southeast Asia; therefore, the improvement of its digital infrastructure, equipment and people involvement are critical for success. RCA and CATWOE were conducted in this study as an alternative to identify the cause-effect relationship for the lack of approaches, and the results from this analysis have helped to propose some recommendations that can be implemented. This includes:

- more involvement by the other stakeholders;
- more investment in digital infrastructure;
- regulations for the protection of local businesses and SMEs; and
- improving digital literacy and reducing the digital divide between large and small businesses and between rural and urban area.

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