Journal of Theoretical and Applied Information Technology
30th April 2024. Vol.102. No 8

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

ANSWER THE USE OF INDUSTRIAL INTERNET OF THINGS FOR INDUSTRY 4.0 INTEGRATION IN THE MANUFACTURING COMPANY

WAHYU SARDJONO[1], WIDHILAGA GIA PERDANA[2], and GUNTUR SALIM[3]

[1]Information Systems Management Department, BINUS Graduate Program - Master of Information Systems Management, Bina Nusantara University, Jakarta, INDONESIA – 11480
[1]wahyu.s@binus.ac.id

[2]Post Graduate Program of Management Science, State University of Jakarta, Jl. R.Mangun Muka Raya No.11 Jakarta Timur, Jakarta 13220, INDONESIA
[2]widhilaga_9917922044@mhs.unj.ac.id

[3]Post Graduate Program, Faculty of Economic Science, University of Trisakti
Jl. Kyai Tapa No. 1 Grogol, Jakarta 11440, Indonesia
guntursalim1979@trisakti.ac.id

*Corresponding author: wahyu.s@binus.ac.id

ABSTRACT

Industry 4.0 production deployment relies heavily on the industrial Internet of Things or IIoT. Manufacturing must overcome the problems and obstacles related to the adoption of industrial technology 4.0 to gain a competitive edge. An overview of the issues that manufacturing must deal with is provided by the research, and it covers finance, human resources, technological integration, management and organization, and security. in addition to approaches that may be used to get beyond these obstacles and incorporate IIoT into the current system, enabling businesses to adopt Industry 4.0.

Keywords: ***I****ntegration, Industry 4.0, Industrial Internet Of Things, Manufacturing, Company*

1. INTRODUCTION

The manufacturing sector is transitioning from automated to "smart" production in the fourth industrial revolution period, and the Internet of Things (IoT) is crucial to the integration of manufacturing physical assets with cyberspace to create cyber-physical systems [1]. To achieve cost-efficiency and effectiveness, IoT integration connects items to the internet and offers cutting-edge services including internet-based operations, maintenance, and diagnostics [2]. The manufacturing sector may become "Smart Manufacturing" with the help of IoT integration, offering additional benefits including increased productivity, flexibility, and quality control. The manufacturing sector holds the most promise for bolstering Indonesia's economy. Around 18% of Indonesia's GDP comes from manufacturing, which makes it necessary to implement new Industry 4.0 technologies as quickly as possible. According to a 2019 McKinsey report, digitalization may increase Indonesia's economic production by $120 billion by 2025, with manufacturing accounting for around $34 billion of the total [3]. However, a McKinsey worldwide survey found that of the businesses that initiated Industry 4.0 pilots, 78% said they did not go any further, even after trials, and 31% said they had not attempted to update the effort for two years or longer[4]. The Ministry of Industry's "INDI 4.0 Award" program, which began in 2019 and awarded 5 companies, continued in 2020 with 13 companies, and finally in 2021 with 27 companies out of 40 participants, demonstrated the evolution of Industry 4.0 implementation in Indonesia.

Journal of Theoretical and Applied Information Technology
30th April 2024. Vol.102. No 8

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Industry Revolution 4.0 has also been greatly hastened by the COVID-19 outbreak [5]. In the fight against the COVID-19 pandemic, the Internet of Things has become a prominent instrument used by society, authorities, healthcare, and business. It is an innovative technological platform that can handle very demanding conditions, such as lockdowns [6]. The chances for manufacturer companies, their plan to capitalize on the quickly developing digital technologies of industry 4.0 and IoT, and their adoption of quick fixes that assist businesses in adjusting to the new norms, such as enforcing safe distances between the workplace and the factory, monitoring employee health, facilitating remote collaboration, and operating digital work instructions, among other things [7].

This study provides possible solutions based on research, empirical practice, and other trustworthy literature, to overcome challenges in implementing the industrial Internet of Things into manufacturing, to accelerate industry 4.0 integration in the new norm conditions and business competitiveness. The essence of Industry 4.0 is IoT which enables the connection of systems, machines, products, and humans, the application of IoT in the industry is called the Industrial Internet of Things (IIoT) [8].

2. LITERATURE REVIEW

After the first to third industrial revolution, a 4th industrial revolution arose, known as Industry 4.0, it is a complete change with the automation and digitalization of every unit of the enterprise, such as the manufacturing process [9]. Industry 4.0 could be illustrated as a combined term for technologies of the overall range activity of enterprises and the components of Industry 4.0 that are classified as smart factory / smart manufacturing, IoT, internet of services, and cyber-physical systems [10]. The majority of authors elaborate on the definition of Industry 4.0 which consists of main subjects related to IoT, IIoT, cyber-physical systems (CPS), and others. There are nine main concepts of Industry 4.0, called nine pillars that consist of IoT, cloud computing, additive manufacturing, big data, augmented reality, horizontal and vertical integration, autonomous robots, simulation, and cyber security [11].

Industry 4.0 is the recent modern expression of the merger of the manufacturing industry with the present IoT technology. IoT is illustrated as dynamic and global infrastructure networks, it is built upon standards and interoperable communication protocols and with capabilities to configure itself. The term "things" has various meanings including virtual and physical relationships, having virtual personality identities, physical attributes, using smart interfaces, and connecting to information networks [12]. The term "things" could be described as an extension of the interaction of people and technology such as computers, when viewed in the context of the IoT. Figure 1.

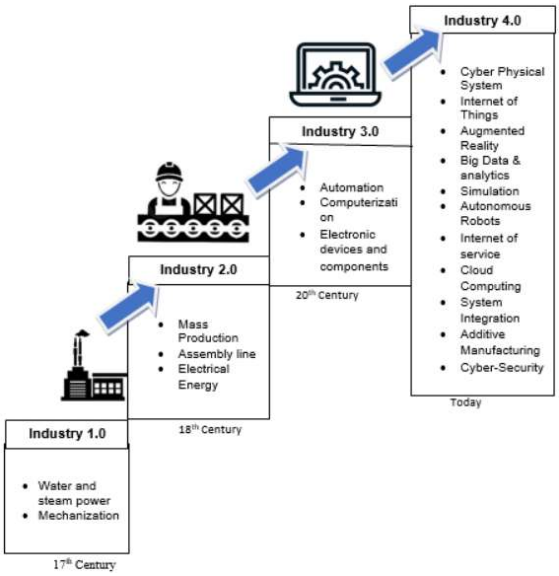

Figure 1. The Industrial Revolution [13]

A specific category of IoT that focuses on applications in industry and modern manufacturing is called the Industrial Internet of Things (IIoT). IIoT links various devices so that they can communicate and interact with each other and interconnects with various control systems like Programmable Logic Control (PLC), Distributed Control System (DCS), and other controllers, as well as connect to enterprise management and cloud manufacturing can be seen in Figure 2. The IIoT application provides an important solution for more effective process control, operation, and evaluation.

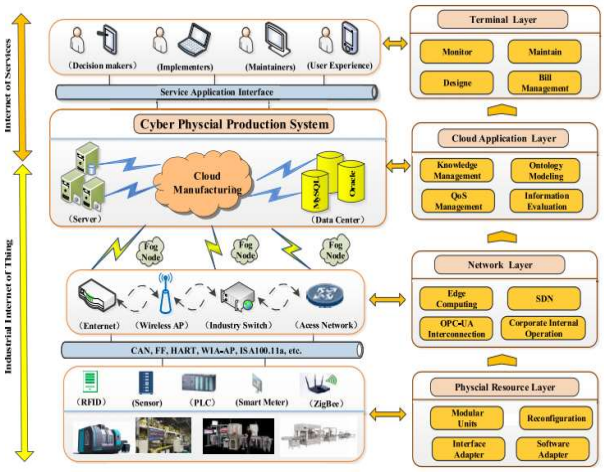

Figure 2. Hierarchical architecture implementation Industry 4.0 on manufacturing [14]

3. METHODOLOGY

Research data used secondary data that was obtained and put together by previous studies or

published. The problems regarding the application of Industry 4.0 in manufacturing is determined through study cases, previous studies, and other literature that have been proven to be true. An answer this problem, the researcher used a literature review as a research methodology. A literature review has an important role as a basis for research, includes the basis for developing knowledge, providing evidence of effects, as a guideline for policies and practices, and it is also used as a basis for developing and sparking new ideas and directions for a particular field [15].

The literature study is conducted by collecting all information that is needed in research such as data on challenges and problems in applying Industry 4.0 in manufacturing or enterprises. The information is obtained from previous research in the form of journals, articles, or books. The next step is to summarize the problem to be used as a reference and study material in research. In the last step, the researcher conducts a review of the literature in the form of case studies, journals, or books to determine the right solution in answering the problems regarding issues. This study refers to the level of understanding of the researcher.

4. RESULT AND DISCUSSION

According to Mohamed [16] implementing Industry 4.0 is a difficult mission and it needs a long time likely 10 years and more to be realized. Application of this new manufacturing process implicates many aspects and encounters a lot of types of difficulties and issues, including technological, scientific, economic challenges, and social problems as well as political issues. Further examining through previous research through a literature review, the resume issues and challenges regarding the implementation of Industry 4.0 are displayed in Table 1.

Table 1. Issues and Challenges

No.	Autors	Issues and Challenges
1.	Bakhtari et al., 2020	conduct a literature study related to the challenges and benefits of industrial 4.0. where several challenges based on the researcher's understanding grouped into financial issues regarding benefits, integration with existing systems, employee competencies, changes in organizational structure and business processes, cyber security, and loss of staff.
2.	Bakhtari et al. (2020)	Finding that top management does not have a vision of digitalization and the deficiency of education and skills training programs, are issues that have high impetus but low dependence. Associated challenges that have both driving and high dependence consist of investment costs, uncertainty of return on investment, organizational constraints, deficiency of competent labor, data security, deficiency of digital legislation, deficiency of standardization (architecture, infrastructure), deficiency of integration and compatibility, and work interruption. lastly, expiring old business models, is issues that both low dependence and impetus.
3.	Ortt et al. (2020)	The paper studies some of the constraints to the implementation of Industry 4.0, which consist of excessive high-tech solutions and continuous tech improvement being able to overwhelm manufacturing management to make a decision, Lack of technology integration with the existing system, and Lack of competent workforce regarding industry 4.0.
4.	Broto Legowo & Indiarto (2021)	Findings reveal that the most dominant challenges in the implementation of I4.0 in Indonesian manufacturing respectively consist of high investment costs, loss of job availability, employee competencies, human resources knowledge, and digital infrastructure [17].

According to literature related to the issues and challenges of implementing industrial 4.0 in manufacturing, the researchers grouped and concluded various problems in implementing the IIoT in the manufacturing companies in Table 2. These consist of finance, human resources, technology, management and organization, and security.

Table 2. The challenges implementing IIoT Industry 4.0 on manufacturing

No.	Field	Issues and Challenges
1.	Finance	high investment costs, uncertainty of return on investment
2.	Human Resource	Skill training programs and education are lacking, as knowledge of human resources, loss of job availability, and lack of competent workforce.
3.	Technology	digital Infrastructure, lack of standardization about technology, technology integration difficulties, and compatibility with existing technology
4.	Management and organization	top management does not have a vision of digitalization, difficulty deciding technology, organizational constraints, changes in organizational structure and business processes
5.	Security	cyber security, data security

4.1. Finance

Company or organization management must understand IT investment contributes to the achievement of business objectives. Companies that think properly about their return on investment will hesitate to invest in IT. This is the IT Paradox. "IT investment paradox" or the "IT Black Hole": "large sums are invested in IT and seem to be swallowed by a large black hole without rendering many returns" [18]. Investment in IT could be measured using several financial tools such as Return on Investment (ROI), Internal Rate of Return (IRR), Net Present Value (NPV), and Payback Period, which is used to measure tangible parameters. Justification of IT investments is not entirely a matter of financial analysis like return on investment [19]. On the other hand, the invisible or intangible parameters cannot be measured using these tools, so measuring instruments are needed for our investment in IT. Balanced Scorecard approach in the enterprise where proper planning of this IT investment strategy can optimize competitive advantage in the organization, and it also recommends IT investment strategies that be able to be implemented and measure a financial aspect of IT investment in the enterprise [20]. Other approaches using Information Technology Balanced Scorecards (IT BSC) were developed by Van Grembergen (1997). This approach is used to answer the phenomenon called the "IT investment paradox" or the "IT Black Hole": "large sums are invested in IT and seem to be swallowed by a large black hole without rendering many returns" [21]. The business contribution perspective on IT balance scorecards (figure 3.) acquires the value of the business that is made from the IT investments. Measuring IT agility performance using the IT Balanced Scorecard should be a major concern of management in business as because IT investments become more effective and can provide more added value, as well as a tool to support the justification of these investments [22].

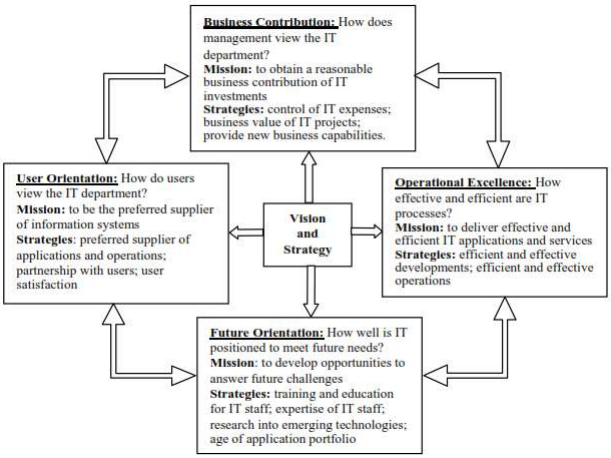

Figure 3. Information Technology Balance Scorecards [23]

The information technology (IT) balance scorecard (Figure 3.) is derived from Kaplan & Norton's balanced scorecard which consists of business contribution (it can help management to value IT investment and align it to business purposes), user orientation (to measure compatibility with user and facilitate them well), operational excellence (the benefit of IT on the application like effective and efficient of the process), and lastly, future orientation (future needs like human resource training programs)

4.2. Human Resource

With the appearance of Industry 4.0 and its application to manufacturing, there is a change in job profiles and skills, so the expertise and competence of the employees will play an important function in the company's success [24]. The emergence of new values occurs due to the combination of tools (such as big data, IoT, and others) and the need for a workforce with special skills, and experts needed to carry out operational activities, installation, and maintenance of these technology tools, so that the implementation of industry 4.0 will be hampered with the shortage of competent manpower.

Benefits in different dimensions for instance simplification of business processes, reduced labor costs, reduced error rates in the amount of inventory, and

more transparent logistics processes, can be obtained by companies implementing Industry 4.0. On the other hand, increasing company efficiency such as production because everything is done by the system will have an impact on reducing the need for human labor, this becomes a much more complex problem that is difficult to solve [25]. So, companies need to empower existing employees by developing other business processes or creating opportunities with development projects.

The manufacturing industry, government, and education need to present education and skills training programs related to the need for expertise in industry 4.0, especially manufacturing management should provide it to their employees for free for future development and to reduce competency gaps. This is conducted to overcome challenges related to limited knowledge, education programs, and training programs.

The improvement of the expertise of human resources, the best solution is through training. With industry 4.0, fulfillments such as skills training, printing of expert staff, the need for competent workers in the installation, operation, and maintenance of sophisticated equipment and system technology, and updating the education system from elementary school to university, become a very important solution. Knowledge and skills required for activities in smart manufacturing are displayed in Table 3.

An alternative solution is to use I4.0 pillars such as cloud computing, namely using the cloud as an e-learning medium. providing training and education according to company needs can use cloud media managed by the company's human resource department. The learning process can provide convenience for employees because it can be accessed anywhere, at any time. and also provides benefits for companies to increase the gap in employee competence for the needs of skilled workers in the field of Industry 4.0 both operational, installation, and maintenance can be shared here. Apart from this, the company can save on maintenance costs and the creation of program learning resources, because employees can share their knowledge, both tacit and explicit [26].

4.3. Technology

The digital structure is important for implementing IIoT in manufacturing as a backbone of Industry 4.0. Manufacturing has to find technological solutions for the integration of their existing infrastructure into digital networks. For example, a fertilizer company in Indonesia that was established in the Industry 3.0 era, underwent several development processes for almost 5 decades and has around 30 factories with different control systems brands and types. Management is faced with many choices because there is no standardization in integration with digital, where each product developer provides solutions for their respective brand systems, it seems that it will cost a lot if you have to replace every control system in each factory into one brand system.

The solution for that case is that companies can take advantage of Open Platform Communications (OPC) for the integration of every factory control system with the internet network. The function of the OPC becomes the basis for interoperability to transfer information vertically from each equipment on the Factory Floor to a control system consisting of various vendors, as well as to provide horizontal interoperability between control system as well as Distributed Control System (DCS), Programmable Logic Controller (PLC), and other controllers, with different industrial communication network systems (Modbus, Profitbus) [27]. In the integration of Industry 4.0, is recommended to apply the Open Platform Communications Unified Architecture (OPC UA). This is by the data security analysis at OPC UA by the German Federal Intelligence Service (BSI), and resulted in very positive reviews. Therefore, the German Industry 4.0 has acknowledged OPC UA technology for it function as communication technology [28]. OPC UA, It has been used as a communication standard in the world of automation that functions as a data exchange and interface that connects data from the field instrument level such as sensors and actuators through control systems (DCS and PLCs and to management systems or enterprise and cloud, so OPC UA becomes Vital in the process at IIOT and provides industry standards as a reliable interface that connects the exchange of information/data from field instruments to control systems and Enterprise management (ERP), shown in Figure 4.

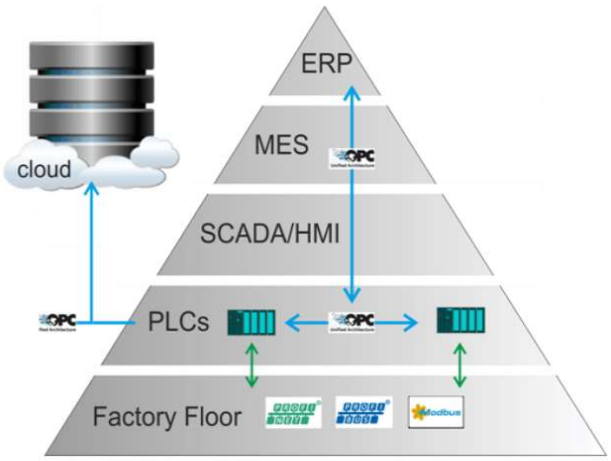

Figure 4. An architecture integration of OPC [28]

Further developments, the German Electrical and Electronic Manufacturers' Association called ZVEI,

developed the industry 4.0 reference architecture model (industry 4.0) namely RAMI 4.0. RAMI 4.0 provides services to other devices through network communication protocols in a basic principle independent of vendors, products, and technologies [29]. OPC UA is recommended for interfaces in communication or data exchange in RAMI 4.0, on the reason of using the same language in communication between devices is based on the similarity of the system architecture and creating data exchange more effectively and efficiently. The IIoT architecture integrated with other pillars of Industry 4.0 in its application in manufacturing can be seen in Figure 2.

4.4. Management and Organization

The application of digital technology I4.0 in the manufacturing industry can be constrained due to the lack of clarity of the objectives of the implementation by the management, as well as management's lack of understanding of the importance of technology for the operational activities of the manufacturing industry, so they are less supportive of it. Management also makes decisions to change the organizational structure for further development towards Industry 4.0. With increasing customer expectations, manufacturing companies need to fulfill their desires, in this case changing business models is something that companies must do to answer these challenges.

Table 3. Knowledge and Skills required

Qualifications	Must	Should	Could
Technical Qualifications and Skills	Computer programming Information Technology knowledge and expertise, Knowledge Management,	Computer programming, Information Technology knowledge and expertise, Knowledge Management	Computer programming, Information Technology knowledge and expertise, Knowledge Management
	Data processing and analytics	General knowledge about organizations and technologies	Distinctive knowledge of technologies
	Statistical knowledges	distinctive knowledge of operational processes in manufacturing	Awareness of ergonomics
	Organizational and processual understanding competence related to I4.0 interfaces	Awareness of IT security and data/ protection	Understanding of legal affairs
Personal Qualifications and Skills	Self-management and time management	believe in the newest technologies	
	Adaptability and capability to change	Mindset for continuous learning and improvement	
	Social skills and teamwork Communication skills		

IT governance may be implemented in manufacturing companies that have to implement Industry 4.0. They are an amalgamation of the efforts of executive management (i.e. CEO and CIO) and IT management to implement IT strategies to align with organizational goals to create business value, and they were found to be able to make the right judgment and put in place a framework for accountability in providing a pathway for using IT was paramount for overall enterprise. IT governance can be explained as the organization's capability to plan and control the implementation of IT strategies and ensure alignment with the business, which is carried out by the board of commissioners, board of directors, and IT management. According to [30], the reasons why companies have IT governance are as follows:

1. Provide solutions to IT functions and processes with required quality within limited resources (i.e. budget) and on time.
2. Integrate all IT processes to achieve the business value of IT investments.
3. Control and manage all IT functions for high productivity and efficiency.
4. Handling of all risks of IT functions and processes.

The implementation of IT governance can support management to decide according to the implementation industrial Internet of things in manufacturing and also align business strategy with IT.

4.5. Security

The last issue regarding the implementation of Industry 4.0 in manufacturing is security. With the implementation of IoT in manufacturing, the companies will acquire industry4.0 benefits, like real-time data accusation, control, and monitoring, where the amount of data circulating on the network is massive and non-stop. This data consists of all data circulating within the company and may be confidential information related to the company. Therefore, the manufacturing industry needs to guarantee that information and data are safe and protected from theft, damage, hacking, and others.

The first step is to define the system assets of components in the IIoT and continue to address security threats. Assets are valuable and sensitive resources in the corporate industry. In the IoT system, the assets are the main components consisting of software, hardware, and service. After the IIoT assets are identified, they continue with countermeasures in dealing with cybersecurity threats.

Cybersecurity countermeasures can use three high-level approaches to ensure the safety of the system are as follows:

1. Area hardening, separating the manufacturing unit network from the workplace network, for example, the usage of firewalls and demilitarized zones.
2. Deep defenses, the usage of multiple layers of protection throughout the network as protection against malware from our perimeter as an example.
3. Remote access, for instance, uses a virtual private network in an isolated demilitarized area, to desire remote users.

According to the Industrial Internet Consortium's (IIC) best practice recommendations, a network of industrial Internet of things should can [28]:

1. Supports authentication protocols that offer nonrepudiation at the endpoint level.
2. Permit edge-to-cloud connectivity protected cryptographically.
3. Permit endpoint-to-endpoint connectivity protected cryptographically.
4. Supply trusted data transport using "quantum-resistant cipher suites".
5. Utilize hardware security module for secure key storage.
6. Present inter-operability throughout various vendor systems
7. Support transfer and communication protocol suite support.

IoT is growing very rapidly, therefore IoT development in companies must be correct and efficient, and they can follow the six principles of the National Cyber Security Strategy (NCSS), which consist:

1. **Confidentiality**, keeping data and information from being accessed by unauthorized people such as outsiders.
2. **Integrity**, data is kept authentic and protected from unauthorized data manipulation by irresponsible parties, so that IoT services become reliable.
3. **Availability**, providing operational assurance that IoT can always be utilized by the user.
4. **Authentication**, access to equipment, and people are given appropriately according to their authenticity.
5. **Non-repudiation** is a feature that keeps users from denying the activities they are doing.
6. **Privacy** is the user's right to keep data/information or share it.

Overall, the implementation of the industrial Internet of Things is a key step for manufacturing to reach Industry 4.0. Companies must look at the problem holistically before deciding to solve the problem. Manufacturing companies may face different challenges and need more study to overcome them.

The limitation, the researcher provides several solutions related to the problems or challenges that have been discussed in this paper, individuals both researchers from the world of education and practitioners from industry can take the solutions that have been put forward based on their considerations, but are not limited to that, where other solutions can be taken and applied to certain cases that have been studied in more detail previously. The solutions provided are general descriptions that require more research if applied to more complex specific challenges and before decision-making by company management.

5. CONCLUSION

The emergence of Industry 4.0 poses a challenge for Indonesian manufacturing companies to remain competitive and survive in business competition. Through the industrial Internet of Things, manufacturing can connect to IoT and other Industry 4.0 pillars. To obtain competitive advantages, manufacturing must continue to innovate and answer all challenges in obtaining the benefits of implementing Industry 4.0. The study gives a broad overview of the challenges of implementation of the IIoT in manufacturing as well as a solution that can be attempted to overcome it. So that can help the reader to see the implementation of industrial 4.0 in manufacturing challenges and solutions in the bigger picture.

The implication for a manufacturing company, this paper guides the company in dealing with problems that arise during the integration of Industry 4.0 to the company. They need to get an overview of the challenges and solutions and conduct learning more about possible solutions that are suitable to be applied to the problems.

For organizations or other companies, the paper can provide insight that allows it to be applied to other sectors in the application of Industry 4.0 in the current new norm conditions. The solutions related to the challenges discussed in this paper can be adapted based on cases that have similarities so that companies can adopt given solutions.

For the government, the implementation of the IIoT in manufacturing provides help to accelerate the integration process of companies in Industry 4.0, so that they can contribute to help speed up government programs in the application of Industry 4.0. As well as it also helps to increase Indonesia's GDP in the manufacturing sector.

REFERENCES

[1] A. Kusiak, "Smart manufacturing," *International Journal of Production Research*, vol. 56, no. 1–2, 2018, doi: 10.1080/00207543.2017.1351644.

[2] N. Jazdi, "Cyber physical systems in the context of Industry 4.0," 2014. doi: 10.1109/AQTR.2014.6857843.

[3] M. Mohamed, "Challenges and benefits of industry 4.0: An overview," *International Journal of Supply and Operations Management*, vol. 5, no. 3, 2018, doi: 10.22034/2018.3.7.

[4] V. Agarwal, K. Eloot, and A. Patel, "Moving past the 'pilot trap' to unleash Industry 4.0 in Indonesia," *McKinsey and Company*, New York, 2019.

[5] R. de C. Sobrosa Neto, J. Sobrosa Maia, S. de Silva Neiva, M. D. Scalia, and J. B. S. O. de Andrade Guerra, "The fourth industrial revolution and the coronavirus: a new era catalyzed by a virus," *Research in Globalization*, vol. 2, 2020, doi: 10.1016/j.resglo.2020.100024.

[6] R. P. Singh, M. Javaid, A. Haleem, and R. Suman, "Internet of things (IoT) applications to fight against COVID-19 pandemic," *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, vol. 14, no. 4, 2020, doi: 10.1016/j.dsx.2020.04.041.

[7] J. Gache, "Impact Of Covid-19 On Industry 4.0 And Implications For Kenyan Manufacturing," 2020.

[8] G. Lampropoulos, K. Siakas, and T. Anastasiadis, "Internet of Things in the Context of Industry 4.0: An Overview," *International Journal of Entrepreneurial Knowledge*, vol. 7, no. 1, 2019, doi: 10.2478/ijek-2019-0001.

[9] M. Hermann, T. Pentek, and B. Otto, "Design principles for industrie 4.0 scenarios," in *Proceedings of the Annual Hawaii International Conference on System Sciences*, 2016, vol. 2016-March. doi: 10.1109/HICSS.2016.488.

[10] G. Erboz, "How To Define Industry 4.0: Main Pillars Of Industry 4.0. In," *7th International Conference on Management (ICoM 2017)*, no. November. 2017.

[11] O. Vermesan *et al.*, "Internet of Things Strategic Research Roadmap," *Internet of Things Strategic Research Roadmap*, 2009, doi: http://internet-of-things-research.eu/pdf/IoT_Cluster_Strategic_Research_Agenda_2011.pdf.

[12] B. Chen, J. Wan, L. Shu, P. Li, M. Mukherjee, and B. Yin, "Smart Factory of Industry 4.0: Key Technologies, Application Case, and Challenges," *IEEE Access*, vol. 6, pp. 6505–6519, 2018, doi: 10.1109/ACCESS.2017.2783682.

[13] H. Snyder, "Literature review as a research methodology: An overview and guidelines," *Journal of Business Research*, vol. 104, 2019, doi: 10.1016/j.jbusres.2019.07.039.

[14] A. R. Bakhtari, V. Kumar, M. M. Waris, C. Sanin, and E. Szczerbicki, "Industry 4.0 implementation challenges in manufacturing industries: An interpretive structural modelling approach," in *Procedia Computer Science*, 2020, vol. 176. doi: 10.1016/j.procs.2020.09.306.

[15] R. Ortt, C. Stolwijk, and M. Punter, "Implementing Industry 4.0: assessing the current state," *Journal of Manufacturing Technology Management*, vol. 31, no. 5. 2020. doi: 10.1108/JMTM-07-2020-0284.

[16] M. Broto Legowo and B. Indiarto, "Issues and Challenges in Implementing Industry 4.0 for the Manufacturing Sector in Indonesia," *International Journal of Progressive Sciences and Technologies*, vol. 25, no. 1, 2021, doi: 10.52155/ijpsat.v25.1.2831.

[17] S. Macdonald, "The IT productivity paradox revisited: Technological determinism masked by management method?," *International Journal of Information Technology and Management*, vol. 1, no. 1, 2002, doi: 10.1504/IJITM.2002.001185.

[18] J. Ward and J. Peppard, *Strategic Planning for Information Systems*, Third. Chichester: John Wiley & Sons Ltd, 2002.

[19] H. Hendarti and I. Kurniawan, "Information Technology Investment Strategy Planning: Balance Scorecard Approach," *CommIT (Communication and Information Technology) Journal*, vol. 5, no. 1, 2011, doi: 10.21512/commit.v5i1.551.

[20] W. van Grembergen, "Measuring and improving corporate information technology through the balanced scorecard technique," 1997.

[21] Y. Rdiouat, S. Bahsani, M. Lakhdissi, and A. Semma, "Measuring and Improving Information Systems Agility Through the Balanced Scorecard Approach," *International Journal of Computer Science Issues*, vol. 12, no. 5, 2015.

[22] W. van Grembergen, "The balanced scorecard and IT governance," *ISACA Journal*, vol. 2, 2000.

[23] A. Benešová and J. Tupa, "Requirements for Education and Qualification of People in Industry 4.0," *Procedia Manufacturing*, vol. 11, 2017, doi: 10.1016/j.promfg.2017.07.366.

[24] A. Grenčíková, M. Kordoš, and V. Berkovič, "The impact of industry 4.0 on jobs creation within the small and medium-sized enterprises and family businesses in slovakia," *Administrative Sciences*, vol. 10, no. 3, 2020, doi: 10.3390/admsci10030071.

[25] S. T. Siddiqui, S. Alam, Z. A. Khan, and A. Gupta, "Cloud-Based E-Learning: Using Cloud Computing Platform for an Effective E-Learning," in *Advances in Intelligent Systems and Computing*, 2019, vol. 851. doi: 10.1007/978-981-13-2414-7_31.

[26] D. Roverso, M. Hoffmann, and F. Gran, "Standardised Data Level Integration with OPC," Jan. 2005.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[27] P. Drahos, E. Kucera, O. Haffner, and I. Klimo, "Trends in industrial communication and OPC UA," in *Proceedings of the 29th International Conference on Cybernetics and Informatics, K and I 2018*, 2018, vol. 2018-January. doi: 10.1109/CYBERI.2018.8337560.

[28] O. Bayraktar and C. Ataç, "The Effects of Industry 4.0 on Human Resources Management," 2018, pp. 337–360.

[29] H. Shuaibu, "IT Governance Implementation in Enterprise: A Review," *International Journal of Electrical and Computer Engineering*, vol. 7, pp. 3129–3134, Dec. 2019.

[30] S. de Haes and W. van grembergen, "IT governance and its mechanisms," *Information Systems Control Journal*, vol. 1, pp. 27–33, Dec. 2004.