International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-78, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

Digitalization and Productivity: Evidence on Indonesian Large and Medium Industries

Firmansyah[1], Djoni Hartono[2]
[1]The Ministry of Industry of The Republic of Indonesia, Jakarta, Indonesia
[2]Faculty of Economics and Business, University of Indonesia, Depok, Indonesia

ABSTRACT: This article estimates the relationship between digitalization and labor productivity in the manufacturing sector of a developing country represented by Indonesia. Literature investigating the effect of digitalization on labor productivity in the manufacturing sector is still rare in developing countries. Thus, the present study contributes to filling the gap regarding digitalization and labor productivity in developing countries. It used data of 33,577 large and medium industrial companies in Indonesia in 2017 obtained from the Large and Medium Industry Survey 2017 database, Statistics Indonesia. This study used econometric regression in cross-sectional data with labor productivity as the dependent variable and ICT asset proportion as the primary independent variable, representing the digitalization variable. The findings revealed that digitalization is positively and significantly associated with labor productivity in Indonesia's large and medium industries.

KEYWORDS: ICT Asset Proportion, Digitalization, Developing Country, Labor Productivity, Manufacturing Industry.

I. INTRODUCTION

Digitalization has become necessary in the business sectors to compete globally in this Industry 4.0 era. The digital transformation may disrupt the status quo business model in many sectors such as banking, retail, transportation, education, health, energy, and industry. On the positive side, literature discussed that recent technologies might generate many advantages for the industrial process, such as efficient and flexible manufacturing [1] [2], adaptation to decision making [1], and sustainable industry. [3] Yet, most employers are worried about the labor force turmoil if they tried to invest in digital technology, which is suspected as a potential replacement for some workers, i.e., technicians, operators, and administrators. Rifkin (2014) stated that the digital revolution would drastically decrease employment as the marginal costs of production are close to zero in the long-term [4]. Additionally, considering financial aspects, most companies tend to invest their budget in more urgent needs than digital technologies due to budget limitations. A relatively small number of manufacturing companies exploit the benefit of Information and Communication Technology (ICT) in their business processes, particularly in developing countries, due to the uncertain return of digital technology investment in the future. With limited knowledge and financial capacity, the rate of digitalization in developing countries seems slower than that of developed ones at the macro-level. [5] Bell and Pavitt (1993) showed that developed countries' digitalization process is already at the development stage of innovation for technological aspects. [6] In most developing countries, it is still at the adoption stage, including Indonesia. To anticipate the issue, The Government of The Republic of Indonesia has launched a roadmap, namely Making Indonesia 4.0, to disseminate the benefits of digitalization throughout the nation and create a conducive atmosphere for Indonesia's manufacturing sector, especially in terms of implementing digital technology. [7] The effort will be made by ensuring abundant, cheap, and continuous electricity sources, accelerating digital infrastructure development, including high speed and wide-coverage internet access and digital capabilities, encouraging incentives on technology investments, and improving the human resource quality with government cooperation.

Regarding the consequences of work-related issues, this guideline explains a scenario of fundamental structural change. The total labor demand may not necessarily decline, strongly changing in structure, e.g., machines may replace jobs or specific tasks. However, there might be new opportunities for affected workers instead. However, digitalization depends on Government intervention and location, types of industry, and own industry resources. The positive results coming from developed countries may differ in developing countries, especially there must be a high cost incurred with limited financial capacity that most industries in Indonesia are faced with. Thus, the correlation between digitalization investment and productivity in a developing country needs to be discussed. Numbers of studies discover that digitalization can leverage labor income using company productivity enhancement in developed countries. [1] [3] [8] [9] [10] [11] [12] [13] [14] [15] [16] Meanwhile, research related to digitalization on labor productivity in

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-78, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

developing countries is minimal, not using the econometric approach in most cases. [17] [18] To the best of our knowledge, there is still a limited number of quantitative studies analyzing the effect of digitalization on labor productivity in Indonesia. There is no study using ICT proportion as the primary explanatory variable to identify digitalization's association with labor productivity in developing countries. Thus, this study aimed to estimate the relationship between digitalization and labor productivity in Indonesia's manufacturing sector. Looking at previous literature, the hypothesis in this study was that digitalization is positively associated with Indonesian labor productivity in large and medium manufacturing industries.

The paper contributes to filling the gap, especially the growth of literature in Indonesia, by providing evidence on digitalization in Indonesian manufacturing companies. It also used industry-level latest data in 2017 in manufacture. The manufacturing industry was chosen as it plays a significant role in Indonesia's Gross Domestic Product (GDP). The shock or change in manufacture may significantly improve the Indonesian economy. Additionally, this study may support the government in providing the right policies for manufacturing in Indonesia to compete with other countries and provide a scientific reference for industrial companies in terms of digital technology implementation to increase labor productivity.

This paper is organized as follows. Section 1 provides an introduction, while Section 2 summarizes the literature review. Section 3 focuses on the modeling consisting of empirical model, variable description, and data source. Section 4 provides results and discusses the findings. The last section summarizes the results and concludes the research.

II. LITERATURE REVIEW

Digitalization correlates strongly with information and telecommunication technologies (ICT). UNESCO (2006) defines ICTs as forms of technology used to transmit, store, create, share, or exchange information. [19] The technological equipment and resources referred to computers and their systems, networks, live broadcast or monitoring technology, recorded technology, telephones, and satellites. Other technologies drive digitalization, particularly in the manufacturing sector, i.e., sensor technology and Big Data and Analytics. [20]

In terms of productivity, its definition continues to develop over time, making it not as simple as merely describing the ratio of production efficiency. According to Asian Productivity Organization (2015) and Rasmussen (2013), productivity is defined as the ratio of produced product (output) value with production resources (input) value in the production process, calculated from the output value divided by the input value. [21] [22]

In principle, digitalization will benefit companies in terms of time and cost savings, increased production flexibility and quality of the product, and human resource. [23] These benefits will ultimately leverage the company's efficiency and competitiveness so that its revenue will increase despite using the original amount of inputs. Let assume that there is no significant addition in labor input. It can be considered that an increase in revenue is interpreted as an increase in the company's labor productivity. Implementing ICT technologies enables companies to save more time, energy, and materials for production processes. [15] As a result, workers can complete their tasks faster, so the company will increase its production capacity.

However, there have been several mixed results regarding the correlation between ICT implementation and productivity in empirical studies. Identifying the effect of ICT and research and development (R&D) investment from Indian manufacturing, Khanna and Sharma (2018) found a strong relationship between ICT and R&D investment in generating labor productivity growth, even across different sub-sample. [14] Meanwhile, using long-term panel data, Camina et al. (2020) found that the effect of digitalization depends on which technology was to be assessed. [3] Robotics and efficient production systems may improve productivity, yet other computerization did not boost or explain productivity. A weak signal of correlation is also found in Leviakangas et al. (2017) in the Australian construction sector. [12]

III. MODEL AND DATA

A. Model

The present study's estimation model includes all variables used and their operational definitions (shown in Equation 1). They will be estimated using a cross-sectional regression model transformed in logarithmic values.

$$LP_i = \beta_0 + \beta_1 ICT_i + \beta_2 CAP_i + \beta_3 WAG_i + \beta_4 MAT_i + \beta_5 EXP_i + \beta_6 OWN_i + \beta_7 SZ_i + \beta_8 CAP\_INTSV_i + \sum_{k=1}^{23} \delta_k SEC(k)_i + \varepsilon_i \quad \text{.....(1)}$$

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-78, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

where i is the cross-sectional index unit (companies). LP represents the labor productivity of the companies, which is measured by the logarithmic value of the company's revenue divided by several labors (million rupiahs), as referred to in the literature. [3] [10] [11] [12] [14] [15] [16] [24] [25] ICT represents the ratio of ICT asset value to total capital value (unit ratio). [10] [26] [27]
In terms of control variables, CAP represents the utilization of non-ICT capital [28] [29], which is measured by the logarithmic value of fuel and lubricant consumptions (million rupiahs). [30] [31] [32] WAG describes the logarithmic value of the annual average wage of labor (million rupiahs per person per annum). [3] [16] [33] MAT describes the logarithmic value of materials and consumables consumptions (million rupiahs). [34] [35] [36] The export dummy variable measures the distinction between the exporter and non-exporter company categories, EXP, 1 for exporting company and 0 if otherwise. [14] [15] The study also distinguished companies based on their foreign or local ownership measured by the company ownership dummy, OWN, which is 1 for full or partial foreign ownership and 0 if otherwise. [14] SZ describes the company's size, measured by a dummy variable, 1 for a large company (100 or more employees) and 0 if otherwise. [10] [15] [36] The CAP_INTSV variable describes the company categorization based on capital- or labor-intensive characteristic, which is 1 for the capital-intensive company and 0 if otherwise. [37] To control industry-particular attributes, the study also categorized the type of industrial subsectors as its control variables as in investigations by Doms et al. (2004) and Kroll (2018). [10] [15] It controls for all 24 subsectors in Indonesia based on Indonesia Standard Industrial Classification Codes as attached in Appendix A. [38] The study included all 23 subsectors dummy variable, 1 for the company's relevant subsector and 0 if otherwise. As the base subsector, the study chose the coal and petroleum refinery industry products in its subsector dummy variable estimation (see Appendix A). To test its robustness model, it designed estimation based on variables used in all six models, as shown in Table 3. Model 1 consisted of the least variables, while Model 6 consisted of the complete ones.

B. Data

The study used secondary data obtained from the Large and Medium Industries Survey 2017, published by Statistics Indonesia in 2019. It used the latest data set of Large and Medium Survey conducted in 2017 and 33,577 large and medium industrial companies (micro-level) in Indonesia. [39]

IV. EMPIRICAL RESULTS AND DISCUSSION

Table 1 and Table 2 show the descriptive statistics of the variables in the model. Table 1 displayed that the average revenue of large and medium industrial companies in Indonesia was Rp. 223 billion in 2017. Furthermore, the average number of workers in large and medium industrial companies in that year was 197 people from all sub-sectors. The minimum number of the worker was 20 people, while the maximum was 55,252 people. Then the labor productivity variable showed an average value of Rp. 1,286 billion per person from all companies.
The average ICT asset value of large and medium industrial companies in Indonesia was Rp. 171 million in 2017. Some companies did not invest funds in ICT infrastructure or equal to Rp. 0 for the value of ICT assets from the survey results. Meanwhile, the highest value allocated by companies for ICT infrastructure investment was Rp. 1,084 trillion. The average value of capital goods for production in all large and medium industries in that year was worth Rp. 54 billion. The average ratio of the ICT proportion to the total capital goods value was 0.003. The utilization value of non-ICT capital goods represented by fuel and lubricants had an average value of Rp. 3 billion. [30] [31] [32] The average total wage value for large and medium industrial workers in Indonesia in 2017 was Rp. 42 million per person annum. The average value of raw materials and supporting materials for large and medium industrial companies in Indonesia was Rp. 74 billion in 2017.

Table 1. Descriptive statistics of quantitative variables

Variable	*Mean*	Std. Dev.	Min. Value	Max. Value
Company's revenue (trillion Rp.)	0.223	2.550	-0.425	302.000
Number of labor (people)	197.000	757.240	20.000	55,252.000
LP (billion Rp. per labor)	1.286	10.168	-14.680	455.018
ICT asset value (billion Rp.)	0.171	8.539	0.000	1,084.000
Total capital value (trillion Rp.)	0.054	0.139	0.000	110.000
ICT (unit ratio)	0.003	0.032	0.000	1.000

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-78, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

Variable	*Mean*	Std. Dev.	Min. Value	Max. Value
CAP (trillion Rp.)	0.003	0.104	0.000	12.500
WAG (billion Rp. per labor per annum)	0.042	0.045	0.000	5.141
MAT (trillion Rp.)	0.074	0.571	0.000	46.400

Observations: 33.577 companies

Furthermore, Table 2 shows that only 2,739 companies exported their products. Meanwhile, the remaining 30,838 companies only marketed their effects on the domestic market in 2017. Based on investment ownership, it can be seen that 3,170 large and medium industrial companies in Indonesia are foreign investment companies, while 30,407 companies are domestic investment companies. Based on the company's size, in 2017, it was recorded that 11,000 companies are belonging to the large company group (having a workforce of 100 people or more) in Indonesia. As many as 22,577 companies are included in the medium-sized company (having a workforce of 20 – 99 people). In terms of intensity of capital goods and labor, capital-intensive industries were as many as 29,542 companies, while labor-intensive companies are recorded at 4,035 companies.

Table 2. Descriptive statistics of qualitative variables

Variable	Value	Number of Observations
EXP	1 = exporter	2,739
	0 = otherwise	30,838
OWN	1 = full or partial foreign ownership	3,170
	0 = otherwise	30,407
SZ	1 = company with 100 employees or more	11,000
	0 = otherwise	22,577
CAP_INTSV	1 = capital intensive company	29,542
	0 = otherwise	4,035

Observations: 33,577 companies

Table 3 reports the estimation results regarding digitalization with labor productivity in large and medium industries based on Equation 1. More detailed information regarding the estimation results is shown in Appendix B. Statistically; all independent variables are simultaneously associated (significant) with labor productivity of large and medium industrial companies in Indonesia in 2017. Table 3 also shows that digitalization is robustly and positively associated with labor productivity of large and medium industrial companies in Indonesia in 2017. These findings are based on all six models' variable coefficient values, even though there are slight differences among each model. These results follow the hypothesis and prove that labor productivity can be improved through digitalization in Indonesia. Following the production theory concepts, technological improvements will impact output production capacity (positive) and cost savings. Another reason that supports these findings may be that the implementation of ICT will drive efficiency improvements in production time, energy, and materials inputs. [40] [15] [41]

Table 3. Estimation results

Dependent Variable: LP						
Independent Variables	**Coefficient**					
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
ICT	0.299***					
	(0.338)	0.547* (0.329)	0.583* (0.331)	0.726** (0.35)	0.689* (0.357)	0.719** (0.365)

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-78, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

CAP	0.023*** (0.004)	0.021*** (0.004)	0.021*** (0.004)	0.058*** (0.004)	0.062*** (0.004)	0.048*** (0.004)
WAG	0.543*** (0.008)	0.536*** (0.008)	0.541*** (0.008)	0.496*** (0.007)	0.511*** (0.007)	0.482*** (0.009)
MAT	0.359*** (0.004)	0.365*** (0.004)	0.367*** (0.004)	0.437*** (0.005)	0.422*** (0.005)	0.429*** (0.005)
EXP	No	-0.291*** (0.019)	-0.267*** (0.019)	-0.119*** (0.019)	-0.087*** (0.018)	-0.067*** (0.018)
OWN	No	No	-0.129*** (0.019)	0.017 (0.018)	0.065*** (0.017)	0.019 (0.017)
SZ	No	No	No	-0.814*** (0.014)	-0.529*** (0.016)	-0.516*** (0.015)
CAP_INTSV	No	No	No	No	0.736*** (0.016)	0.717*** (0.016)
Subsectors Dummy	No	No	No	No	No	Yes
Constant	0.584*** (0.028)	0.589*** (0.028)	0.562*** (0.028)	0.171*** (0.031)	-0.514*** (0.034)	-0.051 (0.078)
Observations (N)	31,587	31,587	31,587	31,587	31,587	31,587
Prob. F-Statistic	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-Squared	0.6180	0.6213	0.6220	0.6733	0.6950	0.7147

Notes : *significant at 10% alpha; **significant at 5% alpha; ***significant at 1% alpha.
The standard error value of all variables is robust to heteroscedasticity issue.

The increase in labor productivity due to digitalization in this study can also be supported by the factor generated from human resources competence. With the implementation of ICT, the labor role becomes more central than conventional routine technical jobs. For example, workers are more needed to manage or troubleshoot machines' connectivity than to operate them by following procedures. As time goes by, the workers' managerial and problem-solving abilities will increase naturally, so that it will have implications in terms of productivity. These benefits are intangibly obtained by workers due to digitization. [42] Besides, the implementation of digitalization is correlated with sensor technology, connectivity, automation, accelerated information exchange, and data analysis, which allows the company to increase its production flexibility. [43] [2] Increased flexibility allows the company to adapt quickly to consumer demand variations to obtain the highest consumer surplus, as stated in The Production Theory [44] As a consequence, both company income and labor productivity will increase due to flexibility improvements.

The estimation results in this study support Doms et al. (2004), Atrostic and Nguyen (2005), Biagi and Parisi (2012), Hall et al. (2012), and Kroll (2018). [10] [15] [27] [24] [45] They also found that the implementation of digitalization is positively associated with labor productivity in the industrial sector. These findings also support a study conducted by Khanna and Sharma (2018, p. 34). [14] They found that companies with low ICT penetration had lower labor productivity than those with high ones in India. In that study, the threshold for the high - low penetration of ICT was also determined by the proportion of ICT assets (the ratio of ICT assets to the total value of capital assets). On the other hand, this study's results showed contradictory results with Ito and Lechevalier (2009,

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-78, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

p. 424). [26] The proportion of ICT assets was negatively associated with labor productivity in the manufacturing industry sector in Japan.

Regarding the elasticity of digitalization on labor productivity, Khanna and Sharma (2018, p. 34) found that an increase in digitization by 1% tended to increase India's industrial labor productivity by 0.06%. [14] Meanwhile, Commander et al. (2011, p. 532) found that an increase in digitization by 1% tended to positively affect an increase in Brazil's industrial labor productivity by 0.1%. [17] Compared with the present study results, the elasticity of digitalization in Indonesia is relatively higher, which increases the ICT ratio by 0.1, associated with an increase in labor productivity by around 7% (refers to Model 6). This finding showed that Indonesia's industrial workforce tends to have better potential than India and Brazil in terms of increasing productivity due to digitization in the company's production process.

According to the data provided by the International Labor Organization (2020), the total working population in Indonesia was 125,958,900 people in 2016, far less than in India, which was 480,526,400 people in the same period. [46] With such a large number of workers, the Government of India and owners of industrial companies tend to establish policies that can increase labor demand. Consequently, the implementation of digitalization is relatively unpopular due to some concerns that it could replace labor in the industrial sector. Thus, the implementation of digitalization in India has only a relatively small impact on increasing workforce productivity. These findings are as found by Commander et al. (2011) in their study. [17]

On the other hand, compared to Brazil, the higher productivity of industrial labor in Indonesia is probably due to Brazil's implicit labor productivity. Brazil's labor productivity was relatively high before the implementation of digitization so that the increase in benefits received is somewhat smaller than that in Indonesia. Based on the ILO data, Indonesia's labor productivity is relatively lower than Brazil's, as shown in Figure 1.

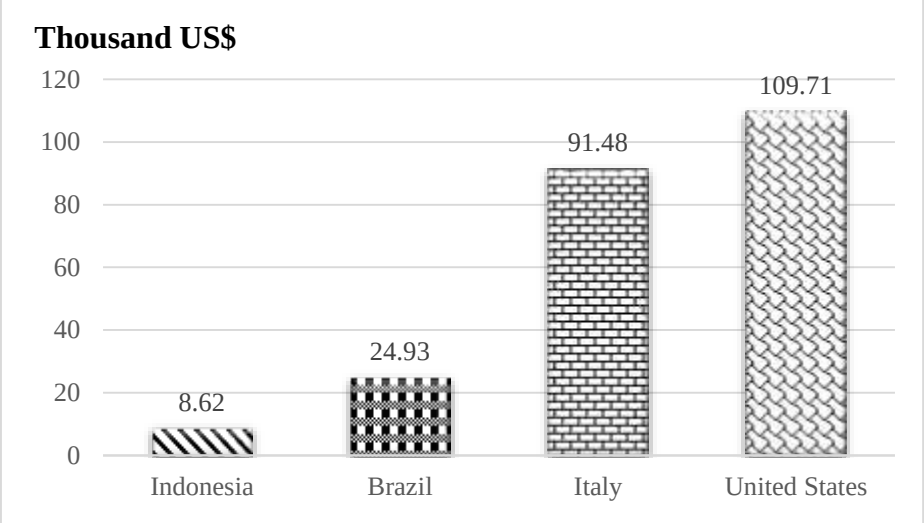

Figure 1. Labor Productivity in Indonesia, Brazil, Italy, and the United States in 2016
Source: International Labour Organization (ILO), United Nations, 2020

In a related study of large and medium industries in the United States, Doms et al. (2004, p. 609) found that an increase in the proportion of ICT assets of 1% was associated with an increase in labor productivity of 0.193%, lower than the results obtained in this study. [10] In Italy, Biagi and Parisi (2012, p. 28) found that an increase in the proportion of ICT assets by 1% had a positive effect on labor productivity by 0.147% in the manufacturing industry sector, also lower than the result obtained in this study. [27] The above studies' comparison results showed that the increase in productivity due to digitalization in developing countries is higher than in developed countries. Like Brazil, this aspect is probably due to the relatively higher tacit labor productivity or familiarity with ICT before implementing digitalization in developed countries. Meanwhile, labor productivity in developing countries is relatively

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-78, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

lower than in developed countries, as shown in Figure 1. Consequently, workers' benefits in developing countries tend to be greater than those received by workers in developed countries due to digitalization.

Furthermore, Table 3 shows that the non-ICT capital goods utilization, the annual average wage of labor, and intermediates inputs cost are positively and significantly associated with labor productivity in Indonesia's manufacturing sector. Compared to the digitization variable, the elasticity of non-ICT capital goods utilization, annual average wage, and intermediates inputs cost are lower than the elasticity of digitization on labor productivity. These findings revealed that the productivity of industrial labor in Indonesia is more sensitive to the intensity of ICT technology implementation than to the investment in non-ICT capital goods, labor wages, and intermediates costs. These findings illustrated that ICT investment plays a more crucial role than other production factors in increasing labor productivity in large and medium industrial sectors in Indonesia.

The estimation results regarding the effect of non-ICT capital goods utilization on labor productivity are in line with Bertschek and Kaiser (2004, p. 399) and Gutierrez (2011, p. 135). [28] [29] However, there are slight differences in the coefficient values, i.e., 0.128 and 0.117, respectively. Regarding the annual average wage of labor, the results also support Ballestar et al. (2019, p. 125). [33] However, the coefficient value found by Ballestar was 0.567, quite similar to the coefficient value found in this study. The estimation results on intermediates inputs are also in line with Becchetti et al. (2003, p. 148) and Castiglione (2012, p. 1757), who found that this variable is also positively associated with labor productivity. [34] [35]

According to the findings of this research on export variable, the labor productivity in exporting companies tends to be lower than that in non-exporting companies oriented to the domestic market only. This finding is in line with Bernard and Jensen (1999) and Sharma and Mishra (2011). [47] [48] They suggest that companies competing in global markets are likely to face more obstacles than companies in the domestic market. In other words, this finding indicates that the global market ecosystem does not always make companies more productive. Companies' difficulty in increasing their profits in the worldwide market can be caused by several factors, including high export costs and the high-intense competition among similar competitors from various other countries. [47] [48]

As for the company ownership variable, there were no significant statistical differences between the foreign ownership companies and local ones in labor productivity. [14] Table 3 shows that labor productivity in large-scale companies tends to be lower than the labor productivity in medium-scale companies, which is in line with Diaz and Sanchez's (2007) argument. [49] The factors that are likely to cause low labor productivity in large-scale industrial companies may be managerial aspects. The more the number of employees in a company, the more difficult it is to manage. [44] Regarding the variable of company characteristics based on the intensity of capital goods or labor, capital-intensive companies tend to have higher labor productivity than labor-intensive companies. Related to the type of sub-sector, based on the information in Appendix B, only the chemical and chemical products industry had higher labor productivity than any other subsectors. Meanwhile, labor productivity in the sub-sectors of the pharmaceutical and traditional medicine industry, base metal industry, electrical equipment industry, motor vehicle industry, trailers and semi-trailers, other transportation equipment industries, and the coal products industry and petroleum refining are statistically insignificant. This result means that those sectors do not show significant differences with different types of industrial subsectors in terms of labor productivity.

V. CONCLUSION

This study aimed to estimate the relationship between digitalization and labor productivity in the manufacturing sector in the developing country represented by Indonesia. It used 33,577 large and medium industrial companies (micro-level) in Indonesia in 2017 obtained from the Annual Manufacturing Survey of 2017 database. An econometric model was used to estimate the association of digitalization proxied by the ratio of ICT asset value to total capital value on labor productivity.

Based on this study's findings, the implementation of digitization in large and medium industries in Indonesia has a positive and significant association with labor productivity, which is in line with the proposed research hypothesis. Besides, the control variables that are significantly associated with labor productivity are non-ICT capital utilization, annual average wage, intermediates inputs cost, export dummy, company size dummy, capital – labor-intensive dummy, as well as all subsectors dummy other than pharmaceutical and traditional medicine industry, primary metal industry, electrical equipment industry, motor vehicle industry, trailers and semi-trailers, and other transportation equipment industries.

This research has been carried out following the existing scientific principles. However, it still has limitations as the digitalization measure in this study did not specifically account for each ICT software and database type's value. The ICT asset proportion variable

was calculated based on the total value of the company's ICT assets and has not been detailed based on the type of device such as Computer-Aided Design, Computer-Aided Manufacturing, sensor technology, Manufacturing Execution System, Cloud Computing, Big Data Server, Additive Manufacturing and so on as been done in other studies. [3] [50]

This study's results positively support any efforts in implementing digitalization in Indonesia since it has been proven to be associated positively with labor productivity in large and medium industrial sectors. To ensure the successful implementation of digitalization in Indonesia, the study proposes policy recommendations to ensure adequate electricity supply and strengthen substantial digital infrastructures throughout Indonesia. The digital infrastructure in question includes quality, connection speed, and internet network bandwidth. Those policy recommendations can stimulate and motivate other companies to implement digitalization in their business processes.

REFERENCES

1. Brynjolfsson, E., & McAfee, A. (2014). The second machine age: work, progress, and prosperity in a time of brilliant technologies. New York: W.W. Norton & Company.
2. Fragapane, G., et al. (2020). Increasing flexibility and productivity in industry 4.0 production networks with autonomous mobile robots and smart intralogistics. Annals of Operations Research, https://doi.org/10.1007/s10479-020-03526-7
3. Camina, E., Diaz-Chao, A., & Torrent-Sellens, J. (2019). Automation technologies: long-term effects for Spanish industrial companies. Technological Forecasting and Social Change 151 (2020), 119828.
4. Rifkin. J. (2014). The zero marginal cost society: the internet of things, the collaborative commons, and the eclipse of capitalism. Basingstoke: Palgrave Macmillan.
5. Bogoviz, A., et al. (2019). Comparative analysis of formation of industry 4.0 in developed and developing countries. In Popkova, E, et al. (Ed). Industry 4.0: Industrial Revolution of the 21st Century. Volgograd: Springer International Publishing AG, 2019.
6. Bell, Martin, & Pavitt, Keith. (, 1993). Technological accumulation and industrial growth: the contrast between developed and developing countries. Industrial and Corporate Change, Volume 2, Issue 2, Pages 157 – 210, https://doi.org/10.1093/icc/2.2.157
7. Ministry of Industry of The Republic of Indonesia. (2018). Making Indonesia 4.0. Jakarta: Kementerian Perindustrian RI.
8. Brynjolfsson, E., & Hitt, L. (1993). Is information systems spending productive? new evidence and new results. International Conference on Information Systems 1993 Proceeding, 43.
9. Zwick, Thomas. (2003). The impact of ict investment on establishment productivity. ZEW Discussion Paper, 99 – 110.
10. Doms, Mark E., Jarmin, Ron S., & Klimek, Shawn D. (2004). Information technology investment and company performance in US retail trade. Economics of Innovation and New Technology, 13:7, 595-613, DOI: 10.1080/1043859042000201911.
11. Carvalho, L., & Macedo de Avellar, A., P. (2016). Innovation and productivity: empirical evidence for Brazilian industrial enterprises. Revista de Administracao Management Journal 52 (2017), p. 134 – 147.
12. Leviakangas, P., Paik, S. M., & Moon, S. (2017). Keeping up with the pace of digitization: the case of the Australian construction industry. Technology in Society 50 (2017), 33 – 43.
13. Paterson, P., de Silva, S., & Wiskich, T. (2017). Digital productivity: key issues from the literature. Bureau of Communications and Arts Research (BCAR) Occasional Paper, Commonwealth of Australia.
14. Khanna, R. & Sharma, C. (2018). Testing the effect of investments in IT and R&D on labour productivity: new method and evidence for Indian companies. Economic Letters 173 (2018), 30 – 34.
15. Kroll, H., Horvat, D., & Jäger, A. (2018). Effects of automatisation and digitalisation on manufacturing companies' production efficiency and innovation performance. Fraunhofer ISI Discussion Papers - Innovation Systems and Policy Analysis, Number 58.
16. Battisti, M., Belloc, F., & Del Gatto, M. (2019). Labor productivity and company-level TFP with technology-specific production functions. Review of Economic Dynamics 35 (2020), 283 – 300.
17. Commander, S., et al. (2011). ICT and productivity in developing countries: New company-level evidence from Brazil and India. Review of Economics and Statistics, 93 (2), 528-541.

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-78, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

18. Lovric, L. (2013). Information-communication technology impact on labor productivity growth of EU developing countries. Journal of Economics and Business, 30 (2), 223-245.
19. UNESCO (2006). Using ICT to develop literacy. Bangkok: UNESCO Office Bangkok and Regional Bureau for Education in Asia and the Pacific, United Nations.
20. Gilchrist, Alasdair. (2016). Industry 4.0: the industrial internet of things. New York: Apress Media.
21. Asian Productivity Organization. (2015). Handbook on productivity. Tokyo: Asian Productivity Organization.
22. Rasmussen, S. (2013). Production economics: the basic theory of production optimisation. New York: Springer – Verlag Berlin Heidelberg.
23. Organisation for Economic Co-Operation and Development (2001). Measuring productivity: OECD manual. measurement of aggregate and industry-level productivity growth. Paris: OECD.
24. Hall, B., et al. (2012). Evidence on the impact of r&d and ict investment on innovation and productivity in italian companies. National Bureau of Economic Research Working Paper No. 18053, http://www.nber.org/papers/w18053
25. Diaz Chao, A., et al. (2013). ICT, innovation, wages, and labour productivity. new evidence from small local companies. Revista de Estudios Empresariales. Segunda epoca. Numero: 2 (2013), p. 29 – 45.
26. Ito, Keiko, & Lechevalier, Sebastien. (2009). The evolution of the productivity dispersion of companies: a reevaluation of its determinants in the case of Japan. Rev World Econ (2009), 145: 405 – 429.
27. Biagi, F., & Parisi, M. L. (2012). Are ict, human capital and organizational capital complementary in production? evidence from Italian panel data. Joint Research Center Technical Reports. Seville: European Commission.
28. Bertschek, I., & Kaiser, U. (2004). Productivity effects of organizational change: microeconometric evidence. Management Science 50(3), p. 394 – 404.
29. Gutierrez, Luis H. (2011). ICT and labor productivity in Colombian manufacturing industry. ICT in Latin America: A microdata analysis (2011), 121 – 144.
30. Bosworth, D. (1974). Production functions and skill requirements. In J. S. Wabe (Ed.). Problems in Manpower Forecasting. Saxon House.
31. Bosworth, D. (1976). Production functions: a theoretical and empirical study. Saxon House.
32. Bosworth, Derek L. (1979). Capital stock, capital services and the use of fuel consumption proxies: an appraisal. In Patterson, M., & and Schott, K. (Ed.) The Measurement of Capital. London: Macmillan, 1979.
33. Ballestar, M. T., et al. (2019). Knowledge, robots, and productivity in SME's: explaining the second digital wave. Journal of Business Research, 108, p. 119–131. https://doi.org/10.1016/j.jbusres.2019.11.017
34. Beccheti, L. et al. (2003). ICT investment, productivity, and efficiency: evidence at company level using a stochastic frontier approach. Journal of Productivity Analysis, Vol. 20(2), pp. 143-167
35. Castiglione, C. (2012). Technical efficiency and ict investment in Italian manufacturing companies. Applied Economics, 44:14, 1749-1763, DOI: 10.1080/00036846.2011.554374
36. Koutroumpis, P., et al. (2019). Small is big in ict: the impact of r&d on productivity. Telecommunications Policy.
37. Egger, P., et al. (2001). The international fragmentation of Austrian manufacturing: The effects of outsourcing on productivity and wages. The North American Journal of Economics and Finance, 12:3, 257-272.
38. Statistics Indonesia. (2017). Indonesia standard industrial classification codes. Jakarta: Statistic Indonesia.
39. Statistics Indonesia. (2019). Large and medium industry survey 2017. Jakarta: Statistic Indonesia.
40. Pilat, D. (2004). The economic impacts of ict–what have we learned thus far. In: Conference on the Economics of Communication Technologies. Mannheim, Alemania.
41. Arvanitis, S., & Loukis, E. N. (2009). Information and communication technologies, human capital, workplace organization, and labor productivity: A comparative study based on company-level data for Greece and Switzerland. Information Economics and Policy 21 (2009), p. 43 – 61.
42. Gomez, R. & Pather, S. (2012). ICT evaluation: are we asking the right questions? EJISDC (2012) 50, 5, p. 1 – 14.
43. Gania, I, et al. (2018) Flexible manufacturing systems: industry 4.0 solution. Destech Transactions on Engineering and Technology Research, https://doi.org/10.12783/dtetr/icpr2017/17583
44. Pindyck, Robert S., & Rubinfeld, Daniel L. (2013). Microeconomics (8th ed.). New Jersey: Pearson Education, Inc.

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 06 Issue 01 January 2023
DOI: 10.47191/ijcsrr/V6-i1-78, Impact Factor: 5.995
IJCSRR @ 2023
www.ijcsrr.org

45. Atrostic, B. K., & Nguyen, S. (2005). Computer investment, computer investment und productivity. U.S. Census Bureau, CES The Center of Economic Studies (05-001).
46. International Labor Organization. (2020). ILOSTAT explorer. https://www.ilo.org/shinyapps/bulkexplorer2/
47. Bernard, A., & Jensen, B. (1999). Exceptional exporter performance: cause, effect, or both?. Journal of International Economics. Vol. 47 (1), p. 1 – 25. Elsevier.
48. Sharma, C., & Mishra, R. K.,. (2011). Does export and productivity growth linkage exist? Evidence from the Indian manufacturing industry. International Review of Applied Economics. 25:6, 633 – 652, http://dx.doi.org/10.1080/02692171.2011.557046
49. Diaz, M. A., & Sanchez, R.,. (2007). Firm size and productivity in Spain: a stochastic frontier analysis. Small Bus Econ 30. 315–323 (2008). https://doi.org/10.1007/s11187-007-9058-x
50. Dalenogare, Lucas Santos et al. (2018). The expected contribution of Industry 4.0 technologies for industrial performance. International Journal of Production Economics 204 (2018), p. 383 – 394.

Cite this Article: Firmansyah, Djoni Hartono (2023). Digitalization and Productivity: Evidence on Indonesian Large and Medium Industries. International Journal of Current Science Research and Review, 6(1), 715-724