Digital Connectivity in Making Indonesia 4.0: A Priority for Digital Transformation

Mei-Teing Chong, Chin-Hong Puah*, Chee-Siong Teh and Mohammad Affendy bin Arip

Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia.

Abstract: Digitalisation is a pillar of Indonesia Maju (Onward Indonesia), as claimed by the Bank Indonesia Governor in the Indonesia Digital Economy and Finance Festival (FEKDI) 2022. As Indonesia aspires to improve its industry competitiveness and become a top-10 global economic powerhouse, the country will need to revamp its economic foundation to accelerate a digital transformation. In recent decades, the economy of Indonesia has shown a strong performance and has now become the 16th largest economy in the world, with a GDP exceeding $1 trillion as of 2020. The scale and quality of digital connectivity affects its digital foundation, which in turn influences the adoption of digital services and processes that result in the level of economic performance. If the government of Indonesia wants to achieve its goal of realizing Indonesia 4.0, it needs to maintain its focus on digital connectivity and make sure that appropriate policies and infrastructure are established to foster its expansion. This study identifies three key focus areas that involve six enablers and 23 indicators to quantify the digital connectivity performance in Indonesia, a review for seven years since 2014, which is named as Indonesia Digital Connectivity Index. Starting from a nascent stage in 2014, Indonesia has seen tremendous improvements in every aspect of its digital connectivity throughout the seven years. To fully unleash the potential of digital transformation in Indonesia, providing better service networks, ensuring affordable access to ICT devices, and improving digital skills among Indonesia's population will remain a key priority for narrowing the digital divide. The roadmap for this initiative necessitates a cooperative effort among numerous stakeholders, including government institutions, associations, industry participants and academic entities.

Keywords: Competitive; Digital connectivity; Digital economy; Indonesia.

INTRODUCTION

Travel the world without leaving home – that is the power of the Internet, one of the greatest innovations ever in our lives. The Internet endows us with infinite possibilities, enables people to connect without boundary, empowers small businesses to access global markets, enriches the education path with remote learning, endues digital innovation in healthcare and enhances our daily lives with great convenience. Digital economy, as the name implies, harnesses the influence of the Internet in the digitalization path and embraces the capability of digital technology in any economic activities, thereby contributing to the economy. In Southeast Asia, Indonesia has become the region's largest digital economy nation in terms of gross merchandise value (GMV), as highlighted in the "e-Conomy SEA[1] 2021" research report collaborated by Google, Temasek and Bain (2022). They also estimate that Indonesia's GMV could reach US$146 billion by 2025, an optimistic prospect that greatly surpasses other nations in the region such as Viet Nam US$57 billion, Thailand US$56 billion, Philippines US$40 billion, Malaysia US$35 billion and Singapore US$27 billion.

In one of the agenda articles presented by Rizki[2] (2022) at the World Economic Forum Annual Meeting 2022[3], Indonesia had reached around 202 million internet users, contributing US$70 billion to its digital economy in 2021. It gained momentum from the deployment of digital-based development as well as the global pandemic COVID-19 that further pushed the need and adoption of digital technology in Indonesia due to various restrictions during the widespread of the coronavirus. Despite the current digital age, there are still some individuals who do not have access to the internet. Indonesia's urban areas showed a reasonable level of households having access to the internet at home in 2020, accounting for 86.8 per cent of the population, but the gap with rural areas is still of concern, as depicted in Fig. (**1**).

In 2019, a substantial number of adults in Indonesia, around 94 million, could not access the internet through a mobile device, and the number of individuals with access to fixed

*Address correspondence to this author at the Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia E-mail: chpuah@unimas.my

[1] It is an on-going yearly research programme since 2016 launched by Google and Temasek, while Bain & Company joined as the lead research partner in 2019.

[2] Kiki Rizki, the Director of Program & Digitalization at Indonesia Chamber of Commerce and Industry (KADIN).

[3] The World Economic Forum Annual Meeting 2022 was held in Davos, Switzerland on 22nd - 26th May 2022.

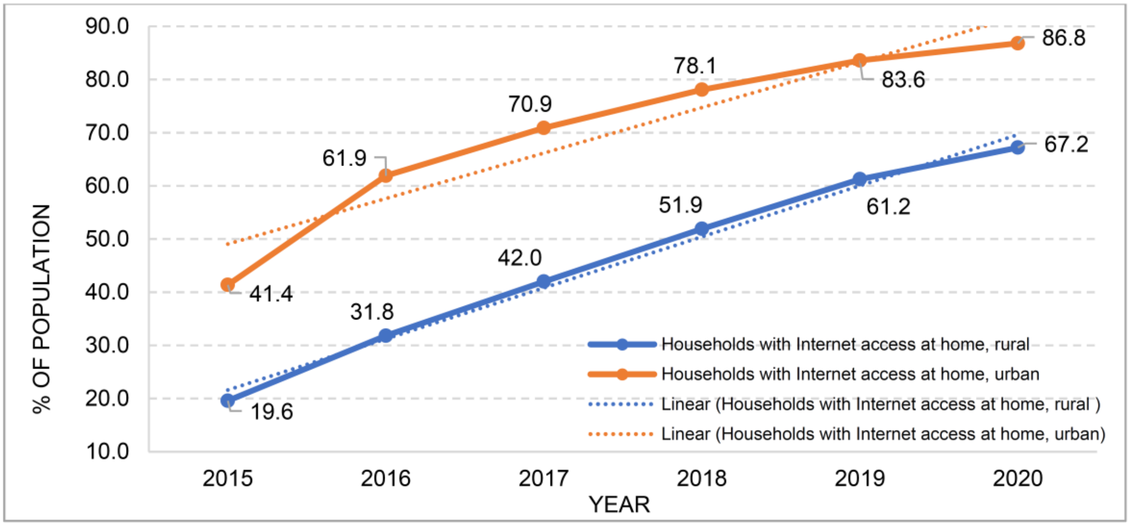


Fig. (1). Indonesian Households in Rural and Urban Areas with Internet Access at Home from 2015 to 2020.

broadband internet was even lower. A significant proportion of these individuals, approximately 80%, were located in non-metropolitan rural areas of Sumatra, Java and Bali, which are the country's three most densely populated islands. Moreover, a considerable percentage of people living in the eastern region of Indonesia, ranging from 60 to 70 per cent, faced insufficient connectivity due to inconsistent service quality.

The divide between Indonesia's digital haves and have-nots reinforces the country's socio-economic disparities. As the World Bank's Beyond Unicorn report shows, young adults are ten times more likely to have mobile internet access than senior citizens. At the same time, those with tertiary education are five times more likely to connect than those whose education is limited to junior secondary attainment or less. In addition, individuals from low-income families are three times less likely to have Internet access than children born in the most prosperous families.

These disparities will hold back economic growth and will widen the social gap as opportunities are seized by those who have Internet access but not those who may need them most. This situation is aggravated by conditions beyond individual control, such as where people live or their families' economic circumstances. This will ultimately create costs for the society in terms of foregone human capital and loss of economic potential. Breaking down barriers to mobile internet connectivity in Indonesia will be crucial to delivering the digital economy's benefits for all.

Before the COVID-19 pandemic, almost 50% of adults in Indonesia did not possess a mobile phone with internet connectivity, such as a smartphone, which presented a significant obstacle to accessing the internet. Despite mobile phones decreasing considerably over the past few decades, they remain unaffordable for numerous people, particularly low-income individuals who would need to spend one-fifth of their monthly expenses to purchase the most inexpensive internet-enabled phone. Moreover, mobile device prices can be considerably higher in rural and isolated regions, where the majority of disconnected individuals reside. Additionally, limited familiarity with digital platforms and services is a hindrance for many people.

Digital connectivity is crucial for creating an environment that supports digital transformation, which has a significant impact on not only e-commerce but also a country's overall economic performance. The Southeast and East Asian regions have the world's fastest-growing online market, with over 360 million internet users and a market size of US $72 billion in 2018. The e-commerce sector is the most dynamic in this region, with a projected annual growth rate of 25%-35% in the next 5-10 years. In 2019, the Internet economy, which includes e-commerce, online media, online travel, and ride-hailing, was valued at over US$100 billion in gross merchandise value (Google and Temasek, 2019).

REVIEW OF LITERATURES

The subject topic of technological advancement in research work is protracted and always fascinating. As claimed that less attention had been paid to developing and less-developed countries, Wang and Chien (2007) thus developed a framework to examine the impact of technological development on economic performance of ASEAN countries. On the same target countries of study, the research done by Bhattacharyay (2010) focused more on the physical infrastructures of connectivity and integration. Abdullaev et al. (2019) pointed out that digital technology is becoming more and more popular in all aspects of human life, and more and more people require fast but low-cost reception of information. Since we are now in the digital era, their studies have greatly inspired and invisibly encouraged us to focus research attention on ASEAN countries as well, but this time is to shed the light particularly on the digital connectivity area.

Research on digital connectivity is getting popular in recent years. Given the geographical immobility issue that is unavoidably faced by certain migrants, Leurs (2014) presented a qualitative case study on Somali migrants in Ethiopia and showed how digital connectivity eased their transnational communication. These invisible connections bring people closer, and digital connectivity definitely can do more beyond this. Graham et al. (2017) recognised the rapid change brought about by digital connectivity that connects millions of Sub-Saharan African citizens to the digital economy, but found that it has a greater impact on high-income countries than on low-income countries. Instead of showing the impact on countries of different income levels, this study reveals the performance of their digital connectedness despite income levels.

Research attentions have also been paid to ASEAN countries to discuss and address digital connectivity as critical digital agenda in order to progress better in terms of digital development in the region, such as Chapman (2018), Anuar (2019), Chen (2020), and Chen and Kimura (2020). The nature of these studies is more of a discussion series and policy priority that remind, inform, and emphasize the issues, challenges and potentials of digital connectivity infrastructure. Different from these studies, our research enlightens the level of digital connectedness quantitatively, so that each ASEAN country has its own score to show its actual performance in digital connectivity over the years.

Some other researches on the various topics of digital-connectivity-related include Pavez et al. (2017), Friederici et al. (2017), Maitland (2018), Oughton et al. (2018), Theo et al. (2018), Gong et al. (2019), and Shi et al. (2020). These studies did not quantify digital connectivity as numbers or scores, but did conceptual research and examined the impact of digital connectivity on other aspects. Indeed, digital connectivity will be the trend and focus of infrastructure development in the future as supported by Gabarró (2020). Nevertheless, digital connectivity also brings forward digital inequality, and it is definitely a hurdle for countries to propel and achieve digital convergence together. This has been highlighted by Katz and Gonzalez (2016) where digital connectivity is an important element to ameliorate social marginalisation in digital disparities. Vu (2017) addressed the issue of the ICT revolution affecting the development and governance of ASEAN countries through ICT diffusion indicators, and some of the elements they have used are referred to and then selected with caution into the indicator basket of this study.

Improving digital connectivity can be a way to reduce the development gap between urban and rural areas. However, this gap existed before the technological revolution and has not been fully addressed despite policy interventions. Previous studies such as Salemink et al. (2017), Park et al. (2019), Esteban-Navarro et al. (2020), Aruleba and Jere (2022), Chaoub et al. (2022), and Morris et al. (2022) have highlighted the issue of rural digital exclusion. This study aims to assess Indonesia's progress in digital connectivity over time, considering the constant evolution of technology.

METHODS AND DISCUSSIONS

As shown in Table **1**, three key areas, six enablers and 23 indicators have been identified, which are related to the infrastructure for establishing digital connectivity in Indonesia. These enablers and indicators are selected based on previous research of digital-related indices framework by various global organizations. The frameworks of Digital Adoption Index (DAI) by World Bank (2016), Network Readiness Index (NRI) by Postulans Institute (2019), Mobile Connectivity Index (MCI) by GSMA (2020), and Digital Economy and Society Index (DESI) by European Commission (2020) are mainly referred in the present study to select the appropriate indicators. The data are consistently collected from the sources such as International Telecommunication Union (ITU), GSMA Intelligence and World Bank for the period from 2014 to 2020.

Data Treatment

After collecting the data, the next step is to process it by addressing any outliers and missing data. Outliers can skew the results of the index scores, for example, if a country has extremely low download speeds compared to other countries, it will score very low and may cause other countries to score relatively high with little variation. To identify outliers, indicators are examined to determine if they have an absolute skewness greater than 2 and kurtosis higher than 3.5, using the formula as follows:

$$\text{Skewness} = \frac{\sum_{i=1}^{N}(Y_i - \bar{Y})^3/N}{s^3} \qquad \text{Eq. (1)}$$

$$\text{Kurtosis} = \frac{\sum_{i=1}^{N}(Y_i - \bar{Y})^4/N}{s^4} \qquad \text{Eq. (2)}$$

If the thresholds are met, one of two treatment approaches is adopted:

- Winsorisation: Winsorisation is a technique used to address outliers by replacing them with less extreme values. Outlier variables are adjusted by trimming them to the nearest value until the indicator falls within the specified ranges for skewness and kurtosis. For example, the indicator "fixed telephone subscriptions per 100 inhabitants" used in this study have an outlier value of 10.3 and the next highest value is 4.2, the former value is replaced with 4.2. This process is repeated until the indicator meets the specified skewness and kurtosis ranges, with a maximum of six observations being adjusted to prevent excessive modification of the dataset. If this method is still insufficient to reduce skewness and kurtosis, another approach is implemented.
- Transformation: As most of the indicators that have high levels of skewness and kurtosis tend to be skewed towards the right, a logarithmic transformation is employed to normalize the indicator and bring it within the desired range. A logarithmic transformation is applied on the indicator "International bandwidth per user (kbit/s)" even though it does not exceed the threshold of skewness and kurtosis. This is because it has bigger values than others, such as 119,998.43 kbit/s and logarithmic transformation can trim it to closer to the other values.

Normalisation

To account for variations in units of measurement and ranges of variation across indicators in an index, normalization is is necessary. The Indonesia Digital Connectivity Index uses the minimum-maximum method, which involves transforming all indicators to fall within a range of 0 and 100 using the following formula:

Table 1. Indonesia Digital Connectivity Index Structure.

Key Area	Enabler	Indicators	Source
Infrastructure	Subscription	Fixed-telephone subscriptions per 100 inhabitants	International Telecommunication Union
		Fixed-broadband subscriptions per 100 inhabitants	
		Mobile-cellular telephone subscriptions per 100 inhabitants	
		Mobile-broadband subscriptions per 100 inhabitants	
Quality of Internet Access	Network Coverage	Percentage of population covered by mobile network	
		Percentage of population covered by 3G networks	
		Percentage of population covered by 4G networks	
	Network Performance	Average mobile broadband download speeds	Ookla's Speedtest Intelligence
		Average mobile broadband upload speeds	
		Average mobile broadband latencies	
	Capacity	Access to electricity	World Bank
		International bandwidth per user	GSMA Intelligence
		Number of secure internet servers per population	International Telecommunication Union
		Number of Internet exchange points (IXPs) per population	
		Spectrum in bands 1-3GHz	
Affordability	Cost	Fixed broadband basket (% of GNI per capita)	
		Mobile broadband prepaid (% of GNI per capita)	
		Mobile cellular basket (% of GNI per capita)	
		Income Inequality	World Bank
	Readiness	Households with a computer at home (%)	International Telecommunication Union
		Households with Internet access at home (%)	
		Individuals owning a mobile phone (%)	
		Individuals using the Internet, total (%)	

$$I_q^t = \left(\frac{x_q^t}{\max(x_1)} * 99\right) + 1 \qquad \text{Eq. (3)}$$

$$I_q^t = \left(99 - \left(\frac{x_q^t}{\max(x_q)} * 99\right)\right) + 1 \qquad \text{Eq. (4)}$$

where 'I' is the normalised min-max value, 'x' represents the actual value and the subscripts 'q' and 'c' represent the indicator and country respectively.

The minimum-maximum method was preferred over other options like rankings and categorical scales as it preserves interval-level information. During the normalisation process, all indicators are adjusted to have a consistent orientation, meaning a higher score always indicates a 'better' performance. This is necessary for indicators that are negatively correlated with digital connectivity and thus Equation 4 is used – for example, basket price as a percentage of GNI per capita and income inequality.

When selecting these data, some selection criteria have been strictly followed. For example, the data needs to be updated regularly so that the research generated from these data is always valid and similar research can be continued in the future. Thus, discontinued data series have been filtered out even though it is relevant to digital connectivity. This study uses a simple aggregation method to averagely weigh all indicators and enablers until the final score is calculated to represent the digital connectivity performance for Indonesia, and it is named as Indonesia Digital Connectivity Index (IDCI). Three aggregation methods are used, i.e. arithmetic mean (AM), geometric mean (GM) and entropy method, where the formula of AM and GM are as follow:

$$\text{AM} = \frac{\sum x_i}{n} \qquad \text{Eq. (5)}$$

$$\text{GM} = \sqrt[n]{x_1 \ldots x_n} \qquad \text{Eq. (6)}$$

According to the definition of entropy method (EM), entropy of the *j*th index is determined by:

$$H_j = -\frac{\sum_{i=1}^{m} f_{ij} \ \text{In}\, f_{ij}}{\ln m} \qquad \text{Eq. (7)}$$

where in:

$$f_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}} \quad \text{Eq. (8)}$$

According to Li et al. (2011), the entropy weight of the *j*th index is then determined by:

$$w_j = \frac{1-H_j}{n-\sum_{j=1}^{n} H_j}, \sum_{j=1}^{n} w_j = 1 \quad \text{Eq. (9)}$$

All six enablers are treated averagely. While for the IDCI, the maximum score is 100, whereby 0 indicates the lowest performance score and 100 indicates the highest performance score. The IDCI is calculated as follows:

$$IDCI_t = (AM_t + GM_t + EM_t)/3 \quad \text{Eq. (10)}$$

RESULTS AND DISCUSSIONS

Table **2** shows the correlation coefficients between the enablers and IDCI, which generally demonstrates a high correlation across all enablers, in which the cost (CT) is moderately correlated with IDCI.

Table 2. Correlation Coefficients of Enablers with IDCI.

	SS	NC	NP	CP	CT	RD	IDCI
SS	1.00						
NC	0.65	1.00					
NP	0.64	0.90	1.00				
CP	0.60	0.98	0.91	1.00			
CT	-0.17	0.48	0.25	0.40	1.00		
RD	0.50	0.89	0.98	0.92	0.33	1.00	
IDCI	0.63	0.99	0.95	0.98	0.45	0.94	1.00

A few years back in 2014, Indonesia's digital connectivity infrastructure and quality of internet access appeared to be in their nascent stage of digitalisation. ICT infrastructure was weak, digital usage was uneven and the readiness to use the Internet was uncommon, although at the time Indonesians seemed to be able to afford the Internet. As time goes by, when digitisation and digitalisation gradually come into concern, Indonesia started to gauge its digital progress. It can be obviously seen in 2015 that the readiness to use the Internet, network performance and Internet capacity were expanded, but the focus on improving poor network coverage was uneven. As the Fig. (**2**) shows, Indonesia's digital landscape has expanded in recent years and showing improvement in all the aspects.

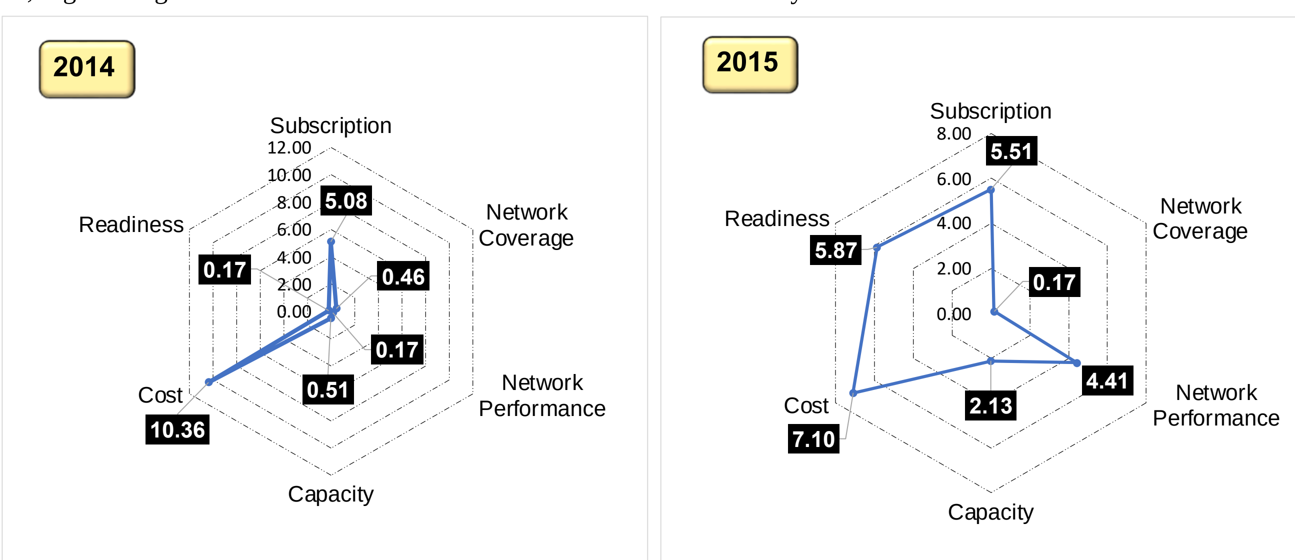
Indonesia's size and geographic complexity compound the challenges. While the country's performance has dramatically improved in the past few years with the introduction of 4G, there are three clear opportunities to further improve Indonesia's infrastructure in the near term:

1. International Linkages

Indonesia heavily relies on accessing international websites like Facebook and Google, making it crucial to consider international connectivity when planning for Indonesia's digital future. However, Indonesia's international capacity is limited, with only 0.01 megabytes per second (Mbps) per user which is significantly lower compared to Singapore's 2.74 Mbps per user. The connectivity is also concentrated, with most lines going through Singapore resulting in non-competitive pricing. Additionally, only three cities (Batam, Dumai, and Jakarta) have 40 per cent of the landing points for international connectivity.

2. Domestic Cable Network

The increase in data traffic in Indonesia is projected to grow six times by 2025, creating a strain on the capacity of the domestic network, including the submarine and overland fibre optic cables. To increase the penetration rate of fixed broadband, which is currently only at 2.5 per cent, it is crucial to expand its availability beyond the greater Jakarta area. This can be achieved by enhancing connectivity in western and central Indonesia and expanding into eastern regions of the country.



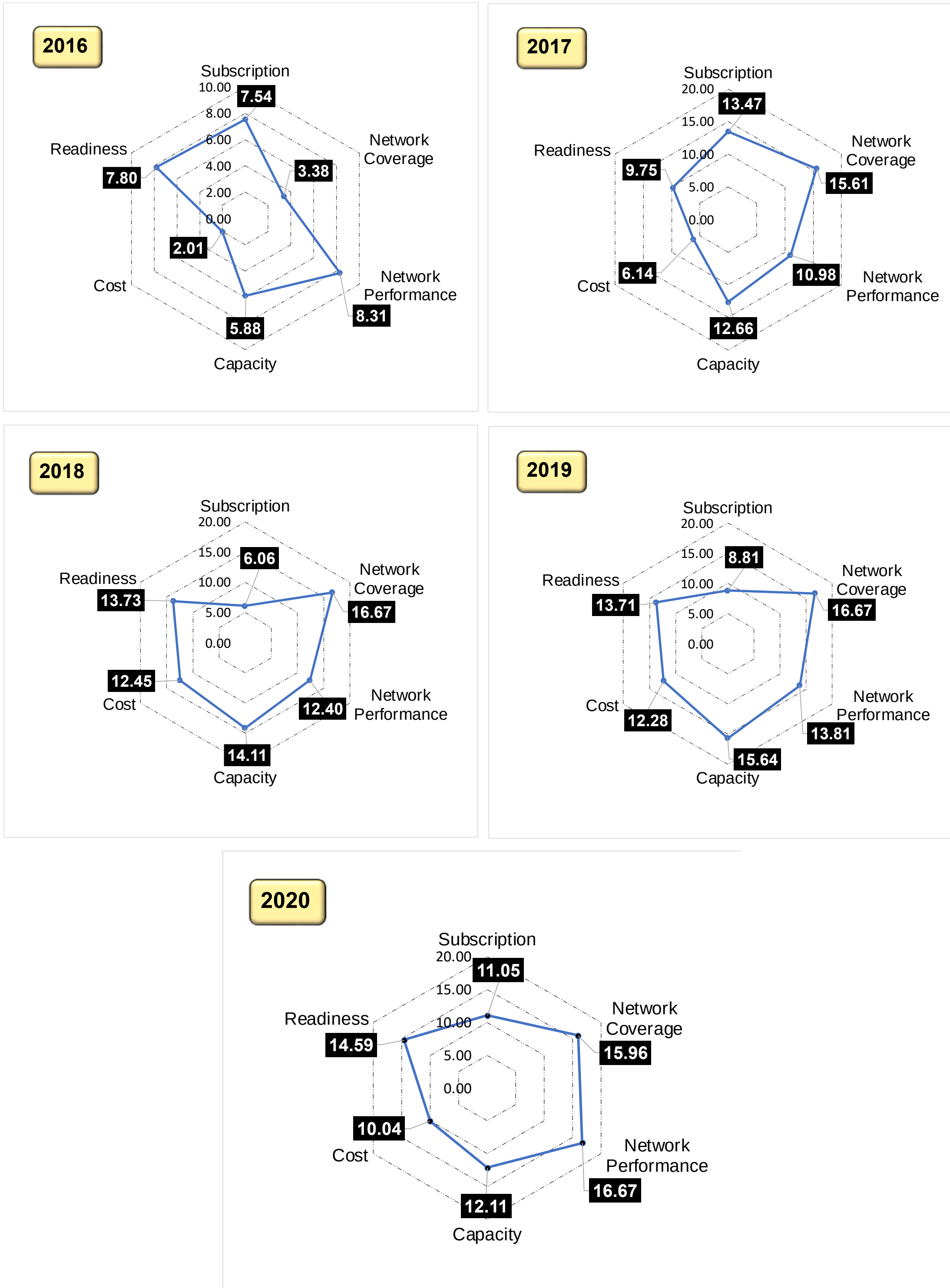


Fig. (2). Scores by Enablers of Indonesia Digital Connectivity Index Across Years from 2014 to 2020.

3. 4G Infrastructure

In 2015, only 23 per cent of Indonesia had access to 4G coverage, which was insufficient to meet the demands of mobile-based services such as e-commerce, gaming, and mobile entertainment. As 73 per cent of Indonesians accessed the internet through mobile broadband, there was a growing need to improve 4G infrastructure outside of Java to increase 4G penetration beyond the previous level of 7.6 per cent. However, with the recent allocation of critical spectrum assets for 4G, operators have already begun to take action to enhance the infrastructure in these areas.

Despite with some differences in values, the final scores calculated using three different aggregation methods actually show similar trends in the results, as shown in Figure 3. Alternatively, this also shows that the weighting aggregation method (EM) used in this study is a robust measure to the

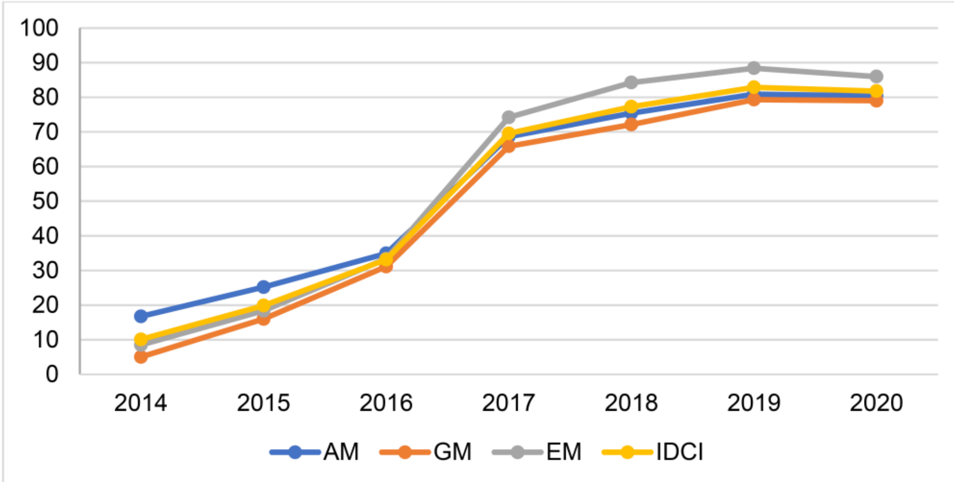


Fig. (3). Trends of Overall Scores Using Different Aggregation Methods.

non-weighting aggregation methods (AM and GM). The outbreak of the COVID-19 pandemic in 2020 had been a challenge for the world, and Indonesia was no exception. Lockdowns, restrictions of movements and quarantine and isolation were implemented to slow the spread and literally caught everyone unprepared. The digital divide was then immediately felt when Internet services in remote areas were hardly available. Based on the data we have retrieved from International Telecommunication Union, the population covered by mobile network, 3G and 4G networks in Indonesia decreased from 2019 to 2020. The access of electricity as published by World Bank also reported decreased in number, from 96.85 percent in 2019 to 96.95 percent in 2020, whereby this nearly two percent of drop actually involved 5.47 million of Indonesian people out of its 273.5 million total population (United Nations, 2021) that had brought a huge impact to its digital connectivity performance.

Table 3. Overall Scores using Arithmetic Mean (AM), Geometric Mean (GM), Entropy Method (EM) and Indonesia Digital Connectivity Index (IDCI).

Year	AM	GM	EM	IDCI
2014	16.75	5.03	8.50	10.10
2015	25.18	15.99	18.37	19.85
2016	34.92	31.13	33.38	33.14
2017	68.61	65.86	74.20	69.56
2018	75.42	72.14	84.27	77.28
2019	80.92	79.32	88.40	82.88
2020	80.42	79.01	85.98	81.80

CONCLUSION

As pointed out by Setiawan et al. (2022), the World Bank (2021) report revealed several focuses that could help reduce the digital divide. First, the mobile network operators in Indonesia will require a better quality of access to spectrum bands as it is necessary to provide stable network services. It is worth concerning that inefficiencies in spectrum allocation will limit coverage expansion and in turn cause network congestion. Unsurprisingly, the unavailability of specific high-frequency capacity bands would indeed hinder the deployment of a more efficient 5G mobile technology. In fact, the regulations derived from the Omnibus Law No. 11/2020 on post, telecommunication and broadcast already imposed a mandatory two-year plan to convert analogue television into digital to preserve the spectrum for the 4G network. In addition, the government could also consider releasing frequency bands that previously used for satellite TV to ease network congestion in urban areas.

Another important step Indonesia needs is to ensure that information and communication technology (ICT) devices, such as computers and internet-enabled phones are accessible and affordable, particularly in rural and remote areas. This can be achieved by improving access to the global digital marketplace and expanding road access to remote villages, which can help reduce price disparities caused by expensive logistics or travel costs. Additionally, there should be targeted educational programs for low-income families to ensure that children can acquire digital skills, preventing intergenerational transmission of "digital poverty" and l digital opportunities.

Last but not least, improving and enhancing the digital skills of the Indonesian population will remain a key priority in bridging the digital divide. For the elderly or the poorest, the likelihood of accessing the Internet increases dramatically with educational attainment, underscoring the link between education and technology adoption. This suggests that to fully reap the promise of digital opportunities, Indonesia will have to build an education system that not only uses digital technologies, but also promotes digital skills and productive use of the internet at all levels of society. Formal education systems as well as community or lifelong learning programs need to provide basic digital literacy, especially for older generations who are still largely unconnected.

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REFERENCES

Abdullaev, F.O., Khamraev, K.I., Arzuova, S.A., and Abdukayumov, A.N. 2019. “Digital Transformation of Market Institutions.” Journal of Southwest Jiaotong University 54(3):1-9.

Anuar, A. 2019. ASEAN’s Digital Economy: Development, Division, Disruption. S. Rajaratnam School of International Studies, RSIS Commentary No. 046.

Aruleba, K., and Jere, N. 2022. “Exploring Digital Transforming Challenges in Rural Areas of South Africa through a Systematic Review of Empirical Studies.” Scientific African 16:e01190.

Bhattacharyay, B.N 2010. “Infrastructure for ASEAN Connectivity and Integration.” ASEAN Economic Bulletin 27(2):200-220.

Chaoub, A., Giordani, M., Lall, B., Bhatia, V., Kliks, A., Mendes, L., Rabie, K., Saarnisaari, H., Singhal, A., Zhang, N., Dixit, S., and Zorzi, M. 2022. “6G for Bridging the Digital Divide: Wireless Connectivity to Remote Areas .” IEEE Wireless Communications 29(1): 160-168.

Chapman, T. 2018. ASEAN and India: Five for the Next Five. Observer Research Foundation Special Report No. 57.

Chen, L. 2020. Improving Digital Connectivity for E-commerce: A Policy Framework and Empirical Note for ASEAN. Economic Research Institute for ASEAN and East Asia Discussion Paper Series No. 327.

Chen, L., and Kimura, F. 2020. “E-commerce Connectivity in ASEAN.” Economic Research Institute for ASEAN and East Asia: Indonesia.

Esteban-Navarro, M. A., García-Madurga, M. A., Morte-Nadal, T., and Nogales-Bocio, A. I. (2020). “The Rural Digital Divide in the Face of the COVID-19 Pandemic in Europe—Recommendations from a Scoping Review.” Informatics 7(4):54.

Friederici, N., Ojanperä, S., and Graham, M. 2017. “The Impact of Connectivity in Africa: Grand Visions and the Mirage of Inclusive Digital Development.” The Electronic Journal of Information Systems in Developing Countries 79(1).

Gabarró, P.P. 2020. Digital Connectivity: The Infrastructure of the Future. Inter-American Development Bank Discussion Paper No. IDC-DP-770.

Gong, S., Gu, J. and Teng, F. 2019. “The impact of the Belt and Road Initiative Investment in Digital Connectivity and Information and Communication Technologies on Achieving the SDGs.” K4D Emerging Issues Report. Brighton, UK: Institute of Development Studies.

Google, Temasek Holdings, and Bain & Company. 2019. e-Conomy SEA Spotlight 2019. Retrieved from https://www.bain.com/insights/e-conomy-sea-2019/

Google, Temasek Holdings, and Bain & Company. 2019. e-Conomy SEA Spotlight 2021. Retrieved from https://www.bain.com/insights/e-conomy-sea-2021/

Graham, M., Ojanperä, S., Anwar, M.A., and Friederici, N. 2017. “Digital Connectivity and African Knowledge Economies.” Questions de Communication 32:345-360.

Katz, V.S., and Gonzalez, C. 2016. “Toward Meaningful Connectivity: Using Multilevel Communication Research to Reframe Digital Inequality.” Journal of Communication 66:236-249.

Leurs, K. 2014. “The Politics of Transnational Affective Capital: Digital Connectivity among Young Somalis Stranded in Ethiopia.” Crossings: Journal of Migration & Culture 5(1):87-104.

Li, X., Wang, K., Liu, L., Xin, J., Yang, H., and Gao, C. 2011. “Application of the Entropy Weight and TOPSIS Method in Safety Evaluation of Coal Mines.” Procedia Engineering, 26:2085-2091.

Maitland, C. F. 2018. “Now You See It, Now You Don’t: Digital connectivity in Marginalized Communities.” Computer 51(6):62-71.

Morris, J., Morris, W., and Bowen, R. 2022. “Implications of the Digital Divide on Rural SME Resilience.” Journal of Rural Studies 89:369-377.

Oughton, E., Frias, Z., Russell, T., Sicker, D., and Cleevely, D.D. 2018. “Towards 5G: Scenario-based Assessment of the Future Supply and Demand for Mobile Telecommunications Infrastructure.” Technological Forecasting & Social Change 133:141-155.

Park, S., Freeman, J., and Middleton, C. 2019. “Intersections between connectivity and digital inclusion in rural communities.” Communication Research and Practice 5(2):139-155.

Pavez, I., Correa, T., and Contreras, J. 2017. “Meanings of (Dis)Connection: Exploring Non-users in Isolated Rural Communities with Internet Access Infrastructure.” Poetics 63:11-21.

Rizki, K. 2022. How Digitalization is Accelerating the Growth of MSMEs in Indonesia. Discussion paper at World Economic Forum Annual Meeting 2022. Retrieved from https://www.weforum.org/agenda/2022/05/digitalization-growth-indonesia-msmes/

Salemink, K., Strijker, D., and Bosworth, G. 2017. “Rural Development in the Digital Age: A Systematic Literature Review on Unequal ICT Availability, Adoption, and Use in Rural Areas.” Journal of Rural Studies 54:360-371.

Setiawan, I., Pape, U., & Beschorner, N. 2022, May 13. “How to Bridge the Gap in Indonesia's Inequality in Internet Access”. Retrieved from https://blogs.worldbank.org/eastasiapacific/how-bridge-gap-indonesias-inequality-internet-access

Shi, Y., Chen, M., Qu, T., Liu, W., and Cai, Y.J. 2020. “Digital Connectivity in an Innovative Joint Distribution System with Real-Time Demand Update.” *Computers in Industry*, *123*, 103275.

Theo, M., Sainabou, T., Michael, R., and Frans, L. 2018. Digital Connectivity & E-Commerce: Overview of Financing Flows and Examples of Aid for Trade Support. Economic Research and Statistics Division, World Trade Organization Staff Working Paper No. ERSD-2018-08.

Vu, K.M. 2017. “ICT Diffusion and Production in ASEAN Countries: Patterns, Performance, and Policy Directions.” Telecommunications Policy 41(10):962-977.

Wang, T.Y., and Chien, S.C. 2007. “The Influences of Technology Development on Economic Performance - The Example of ASEAN Countries.” Technovation 27:471-488.

World Bank. 2021. “Beyond Unicorns: Harnessing Digital Technologies for Inclusion in Indonesia”. Retrieved from https://www.worldbank.org/en/country/indonesia/publication/beyond-unicorns-harnessing-digital-technologies-for-inclusion-in-indonesia

World Development Indicators of World Bank. 2022. Retrieved from https://databank.worldbank.org/source/world-development-indicators

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