Identification of Digital Divide across Indonesian Provinces: the Analysis of Key Factors

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Abstract

Despite the economic and societal benefits of digitalisation and digital transformation, it is necessary to map country's digital conditions and identify the digital divide to formulate an effective strategy. The digital divide should be measured periodically to monitor progress and determine continuous improvement. This paper identifies the current digital divide among provinces in Indonesia. The study uses the hierarchical agglomerative clustering method based on The Indonesian Digital Society Index data from the Ministry of Communication and Informatics. It also analyses some key factors of the digital divide based on data from the Indonesian Bureau of Statistics using the multiple linear regression model. The results show three types of the digital divide across Indonesian provinces related to access, usage, and outcomes of information and communication technology. Gross Regional Domestic Product per capita, Wage/Salary, Proportion of Formal Labor, and Size of the Working-Age Population are identified as factors significantly affecting the digital divide.

Keywords	***DOI***	***JEL code***
Digital transformation, digital divide, hierarchical clustering, linear regression model	*https://doi.org/10.54694/stat.2024.3*	*C38, O39, O53*

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INTRODUCTION

Information and Communication Technology (ICT) offers significant economic benefits and the potential to enhance welfare for individuals throughout their lives (Simamora et al., 2020). Digitalization has created new opportunities for innovation and entrepreneurship (Andita et al., 2022), especially in e-commerce and social media (Bismo et al., 2019). It has also enabled healthcare providers to deliver better and more efficient care through tools like electronic medical records, telemedicine, and remote patient monitoring (Rohmah et al., 2022). Digital technologies have transformed the manner how people learn and access educational resources through tools like online courses, digital textbooks, and educational apps (Block, 2018). Digitalization has helped businesses to automate many tasks, streamline operations, and increase efficiency and productivity (Hartono and Halim, 2020).

Despite these significant benefits, ICT and digital transformation, if not implemented thoughtfully and inclusively, can create a digital divide (Hayre et al., 2021). This divide can manifest in different ways, including disparities in access to computers, smartphones, broadband internet, digital skills, and digital content (Pokrovskaia and Garin, 2022). According to Ferreira et al. (2021) and Jauhiainen et al. (2022) the digital divide has three levels. The first level concerns access to the Internet and various ICTs. The second level relates to differences in digital skills and digital resource use. The third level entails the outcomes of accessing and using technologies.

Indonesia's digital development is essential due to its role as the largest economy in Southeast Asia (Kartiasih et al., 2023) and its strategic geographic position connecting diverse global trade routes. As in other developing countries, some Indonesian regions are much less developed than others, and a digital divide exists between the more developed and less developed regions (Wilantika et al., 2018). Therefore, measuring the digital divide at the regional level in Indonesia is crucial for promoting digital inclusion, economic development, and social equity (Ariansyah et al., 2019). It can help identify areas with limited access to digital technologies and services, the ICT's digital skills and outcomes, and the determinant factors to formulate the most appropriate strategy.

This study aims to determine the digital divide across Indonesian provinces based on the 2022 Indonesian Digital Society Index (Indeks Masyarakat Digital Indonesia, IMDI) published by the Ministry of Communication and Informatics. It applies the hierarchical agglomerative clustering analysis to group provinces based on digital pillar indexes. The groups provide a clearer picture of the digital divide across Indonesian provinces. Then, this study implements the multiple linear regression analysis to analyse the critical factors of the digital divide between the groups using the relevant data sources from the Central Bureau of Statistics of Indonesia (Biro Pusat Statistika, PS).

This paper is unique in its focus on the current differences in digital access, adoption, and usage across provinces in Indonesia. First, instead of using the composite index of digital development to identify the digital divide (Kartiasih et al., 2023; Wilantika et al., 2018; Ariansyah et al., 2019), this study uses the individual IMDI index, namely the Infrastructure Pillar regarding ICT access, the Digital Skills Pillar related to ICT Usage, the Empowerment Pillar, and the Work Pillar related to ICT outcomes. Second, this paper also, for each pillar, highlights the critical factors of disparities of the Indonesian provinces in access to digital technologies and the internet, as well as the digital skills and outcomes of digital technology.

The paper is structured as follows: First, we review the relevant literature, and then we present the methodology used to cluster the Indonesian provinces based on the digitalisation index and the linear regression method to analyse the factors contributing to the digital divide. Next, we present the results and their discussion analysis. Finally, we enclose this paper with conclusions and future research recommendations.

1 LITERATURE REVIEW

The digital divide refers to the gap between individuals, households, businesses, and geographical areas with access and those without access to ICTs and the gap in the efficient use of ICTs. This divide can manifest in different ways, including disparities in access to computers, smartphones, broadband internet, digital skills, and digital content (Pokrovskaia and Garin, 2022). The digital divide has three levels. The first level of the digital divide is the issue of access to the internet and various ICTs. The second level of the digital divide relates to differences in digital skills using digital resources. The third level of the digital divide entails the outcomes of accessing and using ICTs (Ferreira et al., 2021; Jauhiainen et al., 2022).

The digital divide can have significant consequences, as those lacking access to ICTs may be disadvantaged in education (Azubuike et al., 2021), employment, healthcare, civic participation, and social interaction. Moreover, the digital divide can exacerbate existing social and economic inequalities, as it can disproportionately affect disadvantaged groups such as low-income individuals (Singh et al., 2022), rural populations (Zhao et al., 2022), seniors (Yuan and Jia, 2021; Lopez-Ercilla et al., 2021), and people with disabilities (Kolotouchkina et al., 2022).

Identifying the digital divide requires carefully assessing various factors related to the access and use of ICTs. There are some common indicators to measure the digital divide. The first one is internet access (Singh et al., 2022; Arakpogun et al., 2020; Ferreira et al., 2021; Wilantika et al., 2018), which refers to the percentage of households or individuals with internet access to broadband or mobile data.The second one is the ownership of a digital device (Werfhorst et al., 2022). It measures the percentage of households or individuals who own a digital device, such as a computer, smartphone, or tablet. The third one is digital literacy, which measures digital skills and knowledge, such as using digital tools, navigating the internet, and understanding digital content (Ariansyah et al., 2019). The fourth one is the content and services (Pérez-Morote et al., 2020), which measure the availability and quality of digital content and services, such as e-government services, online education, and digital healthcare. Another feature is the geographic location (Sensuse et al., 2019; Zhao et al., 2022). It measures the urban-rural divide and regional differences in access to ICTs.

Measuring the digital divide involves collecting data from surveys (Petrillo et al., 2021), census data (Ferreira et al., 2021), or administrative records (Werfhorst et al., 2022). Then, the data is used to calculate various indicators and assess the level of digital divide across different population groups and geographic regions. Specific methodologies exist for analysing the digitalisation levels and identifying the digital divide. The study by Natalia (2022) used a regression model to determine the digital divide between EU countries during the COVID-19 pandemic. In addition, the study of Morote et al. (2020) used multiple linear regression analysis to identify the relationship between the e-government performance evaluations and citizens' use of e-government and the digital divide. To identify the digital divide among older people, Yuan and Jia (2021) used text mining, the Baidu index, and principal component analysis, while Werfhorst et al. (2022) studied the digital divide in online education using linear regression models.

Many researchers have applied clustering as an effective method for identifying digital divides due to its ability to analyse data and identify patterns within varying population groups (Pick et al., 2015). Some studies applied K-means clustering to group regions based on the digital index data (Kartiasih et al., 2023). Unlike K-means clustering, hierarchical clustering does not require a predetermined number of clusters, which is advantageous in exploring the unknown extent of digital divides (Nishida et al., 2014). Some research used spatial analysis to identify the digital divide by geographically mapping variations in digital access and usage (Pick and Nishida, 2015). It enables the visualisation of disparities in internet connectivity, access to digital devices, and digital literacy across different regions (Pick and Nishida, 2015; Lucendo-Monedero et al., 2019).

This geographical perspective is essential because the digital divide often correlates with spatial factors like urban-rural divides, socio-economic disparities, and infrastructural differences (Song et al., 2020). Spatial analysis thus transforms abstract data about digital access into actionable insights with real-world geographical context, making it an indispensable tool in bridging the digital divide.

Economic development plays a significant role in digital technology transformation; wealthier regions tend to have more resources to invest in digital infrastructure and provide their residents with greater access to technological tools and high-speed internet. Disparities in socio-economic and demographic factors predominantly determine the digital divide between regions within a country (Reddick et al., 2020). Additionally, regions with higher levels of educational attainment usually exhibit a smaller digital divide. Education increases awareness and the ability to use digital technologies and attracts industries and investments that enhance digital infrastructure. In contrast, others need more resources, infrastructure, and educational opportunities. Even though some studies analysed different digital divide factors, some aspects are generally applied in many studies. These factors include income per capita, population size, education, and formal workers (Nishida et al., 2014; Song et al., 2020; Kartiasih et al., 2023). These factors combined create a multifaceted digital divide within a country, where some regions advance rapidly in digital adoption and usage.

Identification of the digital divide between provinces in Indonesia is significant due to the large number of regions and the wide range of the digital divide. Moreover, it is crucial to analyse the critical factors of the divide to determine the most effective strategies to overcome it. Therefore, this study reveals the updated status of the digital divide across Indonesian provinces and analyses the key factors.

2 METHODOLOGY

This study aims to identify the digital divide between Indonesian provinces. Moreover, it also analyses the critical factors behind the divide. First, it clusters the provinces based on the digital development index of each IMDI pillar. Then, it uses the QGIS to visualise the clustering results in a map to show the spatial pattern of the digital divide. Second, it applies the multiple linear regression analysis to determine the dominant factors of the digital divide.

2.1 The data

This study identifies the digital divide across provinces in Indonesia based on the 2022 IMDI data published by The Indonesian Ministry of Communication and Informatics in December 2022 (Badan Litbang SDM Kementrian Kominfo, 2022). IMDI measures several aspects of digital participation, including access to digital infrastructure (such as internet connectivity and mobile phone ownership), digital literacy and skills, and digital entrepreneurship. These aspects are categorised into four pillars, namely: the Infrastructure and Ecosystem Pillar (IMDI1), the Digital Skills Pillar (IMDI2), the Empowerment Pillar (IMDI3) and the Work Pillar (IMDI4). Each pillar has a value between 0 and 100 and is constructed of several sub-pillars, as presented in Table 1.

In addition, this research uses relevant data from the BPS to analyse some key factors of the digital divide. The key factors (explanatory variables) used are Gross Regional Domestic Product (GRDP), Wage/Salary (W), Formal Labor (FL), Working-Age Population (WA), Gender Proportion (GNDR), Literacy Rate (LR), Secondary School Participation Rate (SSR), and Tertiary School Participation Rate (TSR). Table 2 presents the details of these factors. Meanwhile, the target variables of the analysis are all IMDI pillars. Čaplánová et al. (2023) present the data used in this study.

Table 1 The IMDI pillars and sub pillars

Pillar	Detail	Sub pillars
Infrastructure and Ecosystem (IMDI1)	This pillar is critical as it becomes the foundation for creating a quality digital ecosystem, which will improve internal adaptability and meet the industrial demands of the digital era.	1. Access and adoption of digital technology
		a. ICT access and usage data
		b. Implemented technology adoption in the business industry sector
		2. Digital Learning Ecosystem
		a. Schools with internet access
		b. Quality of higher education (number of faculties majoring in ICT)
Digital Skill (IMDI2)	This pillar measures people's ability to access, manage, understand, integrate, evaluate, communicate, and create information safely and appropriately through digital technology for employment, decent work, and entrepreneurship.	1. Complementarity
		a. Communication & collaboration
		b. Critical thinking
		2. Knowledge
		a. ICT knowledge
		b. Data literacy
		3. ICT Security
		a. Device security
		b. Personal security
Empowerment (IMDI3)	This pillar focuses on the ability of consumers/users and sellers/ providers to utilise digital technology developments productively.	1. Consumers/users
		a. Digital financial users
		b. E-commerce consumers
		c. Marketplace users
		2. Vendor/Provider
		a. Digital finance provider
		b. E-commerce seller
		c. Marketplace provider
		d. Social media
		e. E-learning provider
		f. E-learning users
Work (IMDI4)	This pillar focuses on two main elements: the demand for and availability of a digital workforce, which enables us to examine digital skill gaps.	1. Demand
		a. Highly demanded digital skills
		b. Company-provided digital training
		c. Digital skills by occupation
		d. Levels of automation and remote working
		2. Supply
		a. Proportion of workers who use the internet at work
		b. Diverse digital skills
		c. Job-related digital skill level
		d. Digital skills training

Source: IMDI 2022 Report document (Badan Litbang SDM Kementrian Kominfo, 2022)

Table 2 Selected explanatory variables used in the analysis

Category	Variable	Code	Description	Unit
Economic	GRDP per capita	GRDP	Gross regional domestic product per capita	Million Rupiah per year
Economic	Wage/salary	W	The average wage/salary per month	Rupiah per month
Economic	Formal labour	FL	The proportion of labour with formal work	Percentage
Demographic	Working age population	WA	Population 15 years of age and over who are working	Percentage
Demographic	Gender	GNDR	The proportion of male-to-female	Percentage
Education	Literation rate	LR	The literacy rate of the population aged 15–59 years	Percentage
Education	Secondary school participation rate	SSR	The school participation rate of the population aged 16–18 years	Percentage
Education	Tertiary school participation rate	TSR	The school participation rate of the population aged 19–24 years	Percentage

Source: Central Bureau of Statistics of Indonesia

2.2 Cluster analysis

By using the IMDI data, this study identifies three types of the digital divide, i.e., disparities of ICT access, usage, and outcomes (Guo and Wan, 2022; Lythreatis et al., 2022; Song et al., 2020). The IMDI1 regards the ICT access, IMDI2 relates to the ICT usage, while the IMDI3 and IMDI4 relate to the ICT outcomes. This study implements the hierarchical clustering analysis (Pérez-Morote et al., 2020) to categorise the digital gap across Indonesian provinces based on each IMDI pillar. Hierarchical clustering is a clustering algorithm used in machine learning and data analysis that groups similar objects or data points to nested clusters based on their similarity. Unlike the K-means clustering, this method does not need the predetermined cluster number. The feature is essential since there is no information about the number of clusters in the IMDI data. Therefore, the clustering of Indonesian provinces based on the IMDI data produces some clusters, and the distance between clusters indicates the difference, which is a sign of the digital divide between them.

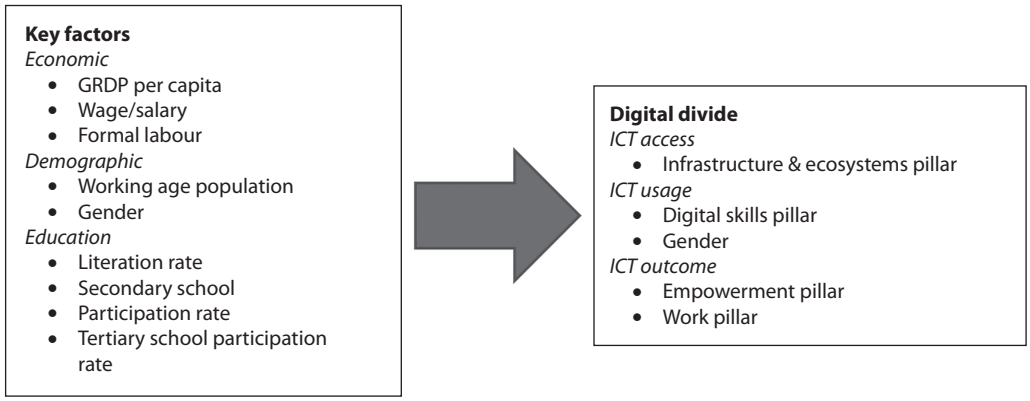
This study uses a hierarchical clustering algorithm, namely agglomerative clustering. This method starts by considering each data point as a separate cluster and then merges the two closest clusters based on a specified distance metric (Van Ruitenbeek et al., 2023). The algorithm continues to merge clusters until all data points are part of a single cluster. The clustering produces a dendrogram, a tree-like diagram showing the hierarchical relationships between the clusters. The dendrogram visualises the clusters, and the algorithm determines the optimal number for further analysis. This research uses Stata software to implement the hierarchical clustering algorithm with Ward's linkage method and Euclidean distance metric. Then, it uses QGIS to visualise maps of the clusters to present the spatial pattern analysis of the digital divide.

2.3 Regression analysis

Furthermore, this study uses statistical methods to analyse several vital factors of the digital divide across provinces in Indonesia. Figure 1 presents the conceptual framework of analysis in this research, which shows the key factors (economic, demographic, and education) and the three types of digital divide. It applies multiple linear regression analysis to determine the relationship between the target variables,

i.e., each of the IMDI pillars defined in Table 1, and the explanatory variables, i.e., key factors, as listed in Table 2. There are four target variables and eight explanatory variables, while the number of observations is thirty-four, which is the number of Indonesian provinces. This study uses the backward elimination method to select the four most significant explanatory variables for each IMDI pillar.

Figure 1 Conceptual framework of digital divide analysis



Source: Own construction

To analyse the critical factors of the digital divide across Indonesian provinces, this study develops the multiple linear regression model:

$$\mathbf{y}_i = \boldsymbol{\beta}_0 + \sum_{k=1}^{q} \boldsymbol{\beta}_k \mathbf{x}_{ik} + \boldsymbol{\varepsilon}_i, \tag{1}$$

where $i = 1, 2, ..., n$; n is observation number; $\mathbf{y}_i$ is i-th observation value of the target variable; $\mathbf{x}_{ik}$ is i-th observation value of k-th explanatory variable; $\boldsymbol{\beta}_0$ is the intercept value of the regression model; $\boldsymbol{\beta}_k$ is k-th regression coefficient; $k = 1, 2, ..., q$; $\boldsymbol{\varepsilon}_i$ is i-th regression error value. The intercept value and regression coefficients are estimated using:

$$\hat{\boldsymbol{\beta}}_k = \left(\mathbf{X}'\mathbf{X}\right)^{-1}\left(\mathbf{X}'\mathbf{y}\right), \tag{2}$$

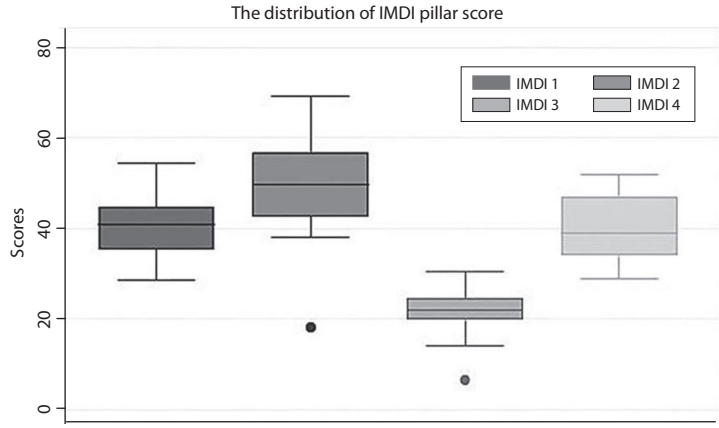
where $k = 0, 1, 2, ..., q$.

This study used Stata software to develop the linear model of each IMDI pillar. Then, it analyses the digital divide's critical factors in each IMDI pillar by identifying the significant coefficients of the linear regression model.

3 RESULTS AND DISCUSSION

This study looks into the variance of the IMDI scores across its four pillars – IMDI1, IMDI2, IMDI3, and IMDI4 – for each Indonesian province, as illustrated in Figure 2. The distribution of data for each pillar within the IMDI highlights substantial differences. Notably, the Digital Skills pillar emerges with the highest median, which indicates that the provinces possess significant potential in terms of human resources equipped with digital skills. In contrast, the Empowerment pillar has the lowest median, which suggests a prevalent shortfall in using ICT productively across most provinces. This discrepancy points to an underutilisation of existing infrastructure and digital competencies. Furthermore, the broader spread observed in the Digital Skills pillar points to a more pronounced disparity in digital skills among the provinces than the variances observed in other pillars.

Figure 2 Data distribution of IMDI pillar score

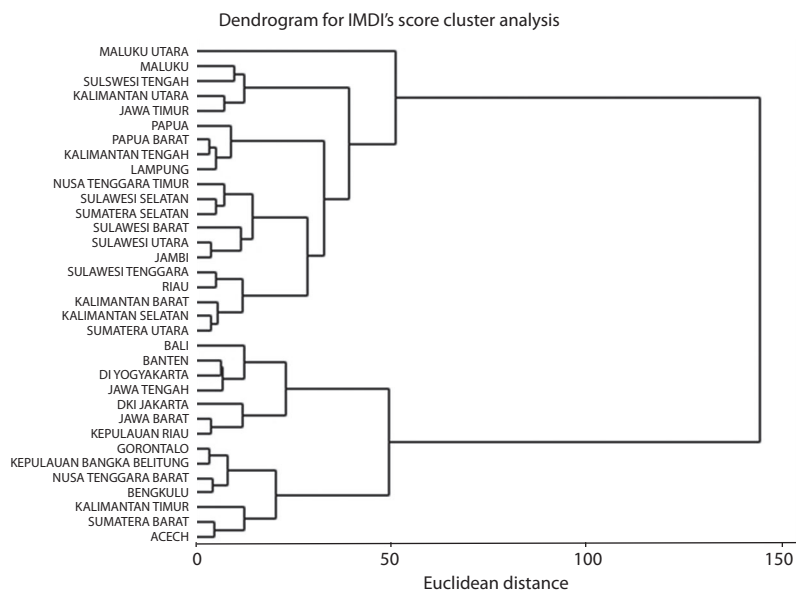


Source: Own construction based on 2022 IMDI data

3.1 Indonesian province clustering regarding the digital divide

This study uses a hierarchical agglomerative clustering approach based on Ward's linkage method and the Euclidean distance to analyse the digital divide and its characteristics among Indonesian provinces. It focuses on the digitalisation scores derived from the four IMDI pillars. The application of this algorithm yields a dendrogram that categorises the provinces into distinct clusters, as depicted in Figure 3. Four main clusters emerge if a dissimilarity threshold is set at fifty, with their respective provincial compositions detailed in Table 3. This classification points to prevalent digital disparities, with only seven provinces (approximately 20.59%) assigned to each cluster 1 and 2.

Figure 3 Dendrogram of Indonesian provinces clustering based on IMDI pillar score



Source: Own construction

Table 3 Clustering of Indonesian provinces based on IMDI pillars

No	Province	Cluster label	Number of provinces in the cluster	Proportion
1	Aceh	1	7	20.59%
2	Bengkulu			
3	Gorontalo			
4	Kalimantan Timur			
5	Kepulauan Bangka Belitung			
6	Nusa Tenggara Barat			
7	Sumatera Barat			
8	Bali	2	7	20.59%
9	Banten			
10	DI Yogyakarta			
11	DKI Jakarta			
12	Jawa Barat			
13	Jawa Tengah			
14	Kepulauan Riau			
15	Jambi	3	19	55.88%
16	Jawa Timur			
17	Kalimantan Barat			
18	Kalimantan Selatan			
19	Kalimantan Tengah			
20	Kalimantan Utara			
21	Lampung			
22	Maluku			
23	Nusa Tenggara Timur			
24	Papua			
25	Papua Barat			
26	Riau			
27	Sulawesi Barat			
28	Sulawesi Selatan			
29	Sulawesi Tengah			
30	Sulawesi Tenggara			
31	Sulawesi Utara			
32	Sumatera Selatan			
33	Sumatera Utara			
34	Maluku Utara	4	1	2.94%

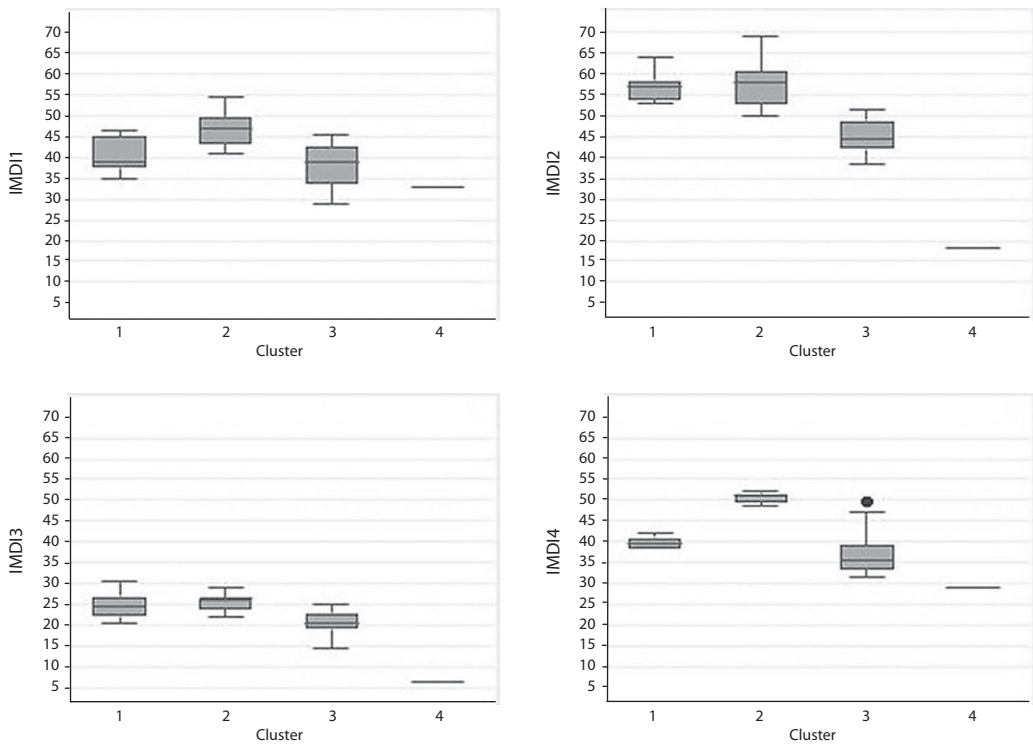
Source: Own construction

Most provinces (nineteen, or 55.88%) are allotted to cluster 3. At the same time, Maluku Utara is the only province in cluster 4, which indicates a pronounced digital divide in this province from the rest due to its unique IMDI scores. Cluster 2, which ranks at the forefront, includes provinces at the forefront of ICT development in Indonesia. This cluster encompasses provinces predominantly in urban areas with robust digital infrastructures, such as Bali, Banten, DI Yogyakarta, DKI Jakarta, Jawa Tengah, Jawa Barat, and Kepulauan Riau. Most of these provinces are strategically located on or near Java Island, close to the nation's capital, except for Bali and Kepulauan Riau. Bali's status as a prime tourist destination has catalysed its ICT advancements, significantly benefiting its tourism sector. Meanwhile, Kepulauan Riau's strategic position near key international maritime routes close to Singapore and Malaysia is vital in its economic and social landscape.

Cluster 1, which holds the second tier in the ranking, is composed of a diverse group of provinces, including four from the Western region – Aceh, Bengkulu, Sumatera Barat, and Kepulauan Bangka Belitung – along with three from the Northern and Eastern territories: Kalimantan Timur, Nusa Tenggara Barat, and Gorontalo. On the other hand, cluster 3, which is positioned third in the hierarchy, encompasses a wide array of provinces across the Indonesian archipelago. This cluster includes four provinces from Sumatera Island, four from Kalimantan Island, six from Sulawesi Island, two from the Papua Islands, and Jawa Timur, Maluku, and Nusa Tenggara Timur. These regions need further development of their ICT infrastructure.

The clustering distinctly points out that Jawa Timur is somewhat behind its counterparts on Java Island. Compared to other Javanese provinces in cluster 2, it falls into cluster 3, the third-ranking group.

Figure 4 The cluster characteristics regarding the mean value of each IMDI pillar



Source: Own construction

This discrepancy indicates the need for focused government and policymaker intervention to propel ICT advancement in Jawa Timur. This could narrow the digital divide between this province and its neighbouring provinces.

Figure 4 depicts the variability in scores for each IMDI pillar across clusters. This highlights the disparate levels of digital maturity among Indonesian provinces. In the Infrastructure and Ecosystem pillar (IMDI1), a significant disparity in median scores can be observed between clusters, which, together with a broad range of scores within each cluster, points to the vast differences in ICT infrastructure across the provinces. A similar pattern can be noted in the Digital Skills pillar (IMDI2), where the differences in median scores are evident between the higher-performing clusters 1 and 2 and the lower-performing clusters 3 and 4. This indicates a pressing need for enhancement in the latter clusters.

On the contrary, the Empowerment pillar (IMDI3) exhibits relatively tiny differences in median scores between and within clusters, suggesting a more uniform distribution of empowerment-related digital capabilities. The Work pillar (IMDI4) shows a considerable variance in median scores between clusters, which points to an uneven distribution of digital workforce opportunities and demands across the provinces. Mainly, Maluku Utara, categorised under cluster 4, requires urgent attention as it has the lowest scores in all IMDI pillars. This indicates a critical need for digital development intervention.

3.2 The type of digital divide in Indonesia

Figure 5 presents the map of Indonesian provinces to reveal the spatial pattern of the digital divide. The figure visualises the digital gap across the Indonesian provinces. Indonesia is a vast country with over 17 000 islands and a population of more than 270 million; like many other developing countries, it faces challenges and needs to reduce the digital divide.

The spatial pattern of the digital divide in Indonesia, as illustrated in Figure 5, highlights significant disparities between urban and rural areas and among the islands. As also stated above, urban centres like Jakarta, Yogyakarta, and Bandung, located mainly on the island of Java, exhibit higher levels of digital connectivity and infrastructure attributed to the concentration of economic activities, educational institutions, and government initiatives. In contrast, remote and rural areas, particularly in regions such as Papua, Maluku, and parts of Kalimantan and Sumatra, suffer from limited internet access and lower digital literacy rates.

Figure 5 Spatial pattern of the digital divide between Indonesian provinces

Source: Own construction

The determinant factors contributing to this divide are multifaceted. Infrastructure development plays a critical role. However, the country's archipelagic nature poses logistical and cost-related challenges in laying fibre-optic cables and establishing reliable internet services. Economic disparities also influence the divide, as individuals in less affluent regions struggle to afford the necessary devices and data plans. Furthermore, educational levels correlate with digital literacy, where areas with lower access to quality education face challenges in effectively adopting and utilising digital technologies. Cultural factors and language barriers further complicate the situation, with a diverse population across thousands of islands with unique cultural and linguistic identities. These complexities necessitate a tailored approach to bridging Indonesia's digital divide and the need to consider each region's unique challenges.

3.2.1 Digital divide in the infrastructure

Internet access and infrastructure stand at the forefront of addressing the digital divide. They are pivotal in establishing a robust digital ecosystem conducive to adapting to and thriving in the digital age. The clustering results reveal a pronounced digital divide across Indonesian provinces. It highlights the advanced infrastructure in Java's provinces and the more modest setup in regions further from Indonesia's current capital, Jakarta. This challenge of insufficient infrastructure is especially acute in remote and rural settings (Nishida et al., 2014), especially in Maluku Utara, an Eastern province formed in 1999 and comprising 1 474 islands, of which only 89 are inhabited. The province's geographical complexity and population density of 41 individuals per square kilometre as of 2021 complicates ICT infrastructure development, leaving many residents with limited or no internet access.

This lack of connectivity hampers the residents' ability to engage with the broader world, access vital information, and partake in the digital economy but also reflects the wider implications of socio-economic constraints on internet access (Reddick et al., 2020). Individuals unable to afford digital devices or internet services are further marginalised, exacerbating the digital divide even in those areas, where infrastructure might be available.

3.2.2 Digital divide in the digital skills

The digital divide also encompasses disparities in internet usage and digital skills (Ariansyah et al., 2019), with the latter referring to individuals' proficiency in utilising digital technologies effectively (Pokrovskaia and Garin, 2022). Internet usage varies by frequency and purpose. It can range from extensive use across work, education, and social interactions to limited activities like checking emails or browsing social media. Digital skills, on the other hand, encompass a range of competencies from online information retrieval and social media navigation to software application usage. Individuals with advanced digital skills can benefit from the full spectrum of digital technologies, while those with limited skills may need to catch up.

Digital skills are influenced by various factors such as age, socio-economic status, education, gender, geographic location, language proficiency, and physical or cognitive disabilities. For instance, older individuals may be less familiar with digital technologies, which affects their ability to acquire new digital skills (Yuan and Jia, 2021). Similarly, people from lower socio-economic backgrounds might have limited access to digital tools, which limits their opportunities to develop such skills (Natalia, 2022). Education level often correlates with digital skill proficiency since higher education provides more chances for formal training (Azmat et al., 2020). Gender disparities also play a role since societal and cultural norms can potentially hinder women's access to digital technology and learning opportunities (Simamora et al., 2020). Also, geographic location significantly impacts access to digital technologies, with rural and remote areas typically facing more significant barriers (Azubuike et al., 2021). Language barriers can further complicate the acquisition of digital skills, which makes using digital technologies more challenging.

People who are not digitally literate may struggle to develop digital skills (Saraeva, 2021; Padhi, 2019). People with disabilities may face physical or cognitive barriers in using digital technologies, which makes it more challenging to develop digital skills (Kolotouchkina et al., 2022).

Based on the clustering results, clusters 3 and 4 reveal a significant gap in digital skills, mainly consisting of provinces in Indonesia's more secluded and rural regions. The geographical challenges in these areas represent substantial obstacles not only for developing essential infrastructure, but also hinder economic growth, social cohesion, and educational advancements. Additionally, the lack of targeted digital literacy programs and inadequate investment in ICT education contribute to the widening digital skills gap. Moreover, socio-economic factors should also be taken into account. Lower-income households in these regions might struggle to afford digital devices and internet services, which limits their opportunities for practice and skill acquisition. Cultural attitudes towards technology and education can also play a role since traditional viewpoints may undervalue the importance of digital skills, particularly among older generations and in more conservative communities. These areas may also experience a brain drain as more digitally skilled individuals move to urban centres for better opportunities. Addressing these multifaceted challenges requires a concentrated effort from governmental and non-governmental organisations to implement inclusive policies and programs.

3.2.3 Digital divide in the outcomes

The third type of digital divide is related to the benefits and outcomes of digitalisation (Song et al., 2020). It refers to the unequal distribution of benefits and opportunities for using digital technologies. It includes differences in access to information, education, employment, healthcare, and civic engagement. For example, people with limited access to digital technologies may have difficulty in accessing online educational resources (Guo and Wan, 2022) or finding job opportunities that require digital skills. They may also have limited access to healthcare resources (Rohmah et al., 2022) as telemedicine and other digital healthcare tools become increasingly important. Additionally, people who cannot fully participate in online civic engagement, such as accessing government services (Andita et al., 2022) or participating in the online political discourse, may be disadvantaged in shaping public policy and public decision-making.

This analysis of IMDI shows that the digital divide in the form of outcomes is linked to the Empowerment (IMDI3) and Work (IMDI4) pillars. The Empowerment pillar evaluates the capacity of both consumers and providers to leverage advancements in digital technology to enhance productivity effectively. The Work pillar concentrates on the demand for digital workforce and availability dynamics. Based on the clustering results, the disparity between clusters 2 and 1 in the Empowerment pillar is relatively modest. Nonetheless, the gap significantly widens when we compare them to clusters 3 and 4. Furthermore, for the Work pillar, the differences here are stark, with cluster 2 leading over its counterparts. This considerable divide stems from the concentration of digital employment opportunities within urban areas, which typically have superior infrastructure and populations with more refined digital skills. Such observations point to a critical need for a holistic approach from the Indonesian government and other stakeholders. There is a pressing need to enhance digital literacy and skills across the population and foster job creation and entrepreneurial ventures that capitalise on these skills. This approach is essential for bridging the digital divide and ensuring equitable access to the benefits of digitalisation across Indonesia's diverse regions.

3.3 Analysis of the key factors of the digital divide

The digital divide highlights the divide between those with access to digital technologies and skills and those without across various dimensions, including individual, household, business, and geographic levels. The literature identifies a range of factors that contribute to the digital divide (Várallyai et al.,

2015; Lythreatis et al., 2022), including socio-economic factors like GDP per capita, education levels, employment status, income, and infrastructure availability; sociodemographic aspects such as age, gender, and urban versus rural dwelling; and personal factors including trust in technology, motivation to use technology, privacy concerns, and risk perceptions.

In this study, we use multiple linear regression analysis to study some factors underlying the digital divide across Indonesian provinces, drawing on the data from the BPS and IMDI data (Čaplánová et al., 2023). We explore the influence of eight explanatory variables (as listed in Table 2) on the digital divide, as indicated by the IMDI scores for each pillar (Table 1). We implement the backward elimination method to select four explanatory variables of each IMDI pillar with the smallest significance values. To confirm the absence of multicollinearity among the explanatory variables, we examine their variance inflation factor (VIF) values, as detailed in Table 4. With the highest VIF value recorded at 2.77, which is significantly below the commonly accepted threshold of 5, it is evident that the explanatory variables maintain their independence, which ensures the reliability and validity of the model's outcomes (Tarjáni, et al., 2023; Pick et al., 2015).

Table 4 The estimated model parameters for each IMDI pillar

Code	Target variables							
	IMDI1		IMDI2		IMDI3		IMDI4	
	Coeff	VIF	Coeff	VIF	Coeff	VIF	Coeff	VIF
GRDP	0.3029*	2.1						
W							0.3980*	2.0
FL	0.5856**	2.8	0.4377*	1.5	0.6581*	1.6	0.2	1.9
WA			0.3	1.1			0.4476*	1.2
GNDR	–0.7043***	1.4			–0.1	1.3		
LR	–0.2686*	1.9	–0.2	1.6	–0.4551*	1.9		
SSR			0.1	1.2	0.1	1.2		
TSR							0.2	1.1
Constant	0		0		0		0	
R-squared	0.7		0.3		0.3		0.5	

Notes: * significant at 0.05, ** significant at 0.01, *** significant at 0.005.
Source: Own construction

Table 4 presents the results of the regression analysis. Its focus on the Infrastructure and Ecosystem pillar reveals the influence of various factors on the development of ICT infrastructure within Indonesian provinces. The Gross Regional Domestic Product (GRDP) per capita is a significant predictor, having a positive relationship with the Infrastructure and Ecosystems pillar at a five per cent significance level. It suggests regions with higher economic output are better positioned to invest in and enhance their ICT facilities and internet connectivity. Furthermore, the positive regression coefficient of the Formal Labor (FL) (significant at a one per cent level) implies that a higher engagement of formal labour within a province contributes positively to establishing and expanding ICT infrastructure. This could be attributed to the formal sector's demand for efficient communication and information systems, which drive improvements in the digital ecosystem.

The Gender Proportion (GNDR) variable, indicating the ratio of males to females, and the Literation Rate (LR) exhibit negative coefficients, which suggests an inverse relationship with the Infrastructure and Ecosystem pillar. These could point to underlying complexities in how gender dynamics and literacy levels impact the development and utilisation of the ICT infrastructure. The negative coefficients might reflect disparities in access and usage of digital technologies between genders and varied literacy levels, requiring a structured approach and targeted interventions to bridge the digital divide in infrastructure and ecosystems.

The analysis of factors influencing the Digital Skills pillar reveals a significant relationship between the proportion of Formal Labour (FL) within a province and its population's level of digital skills. The positive coefficient associated with Formal Labour (significant at the five per cent level) suggests that an increase in formal employment opportunities correlates with enhanced digital competencies among the workforce. This correlation could be attributed to the formal work environment, which often requires and fosters digital skills development through structured training programs or the day-to-day use of digital tools and technologies. Consequently, regions with higher formal employment rates may provide more opportunities for individuals to acquire and refine their digital skills, thus contributing positively to the overall digital literacy and capabilities within those areas.

The analysis of the Empowerment pillar identifies a significant factor: the proportion of Formal Labour (FL) within a province. The presence of a substantial formal labour force is indicative of higher levels of ICT productivity. This correlation may be rooted in the structured nature of formal employment sectors, which often prioritise and invest in the ICT capabilities to enhance operational efficiencies and foster innovation. As a result, regions with a more significant percentage of their workforce engaged in formal employment are likely to witness an uplift in their ICT empowerment, as these environments typically encourage the use of advanced digital tools, promote digital literacy, and facilitate the practical application of digital skills in problem-solving and decision-making processes.

The analysis of the Work pillar highlights the significance of two key variables: Wage (W) and Working-Age Population (WA), both of which exhibit positive coefficients at a five per cent significance level. This suggests that higher wages and a larger working-age population within a province contribute to the dynamics of digital work in terms of supply and demand. Higher salaries can attract and retain talent within the digital sector, incentivise acquiring digital skills, and foster a competitive digital workforce. Similarly, a larger working-age population provides a broader base of potential digital workers and increases the likelihood of a more vibrant digital employment market.

However, the analysis reveals that the Secondary School Participation Rate (SSR) and Tertiary School Participation Rate (TSR) do not significantly affect the IMDI scores across all pillars. This finding suggests that mere participation in secondary and tertiary education may not directly translate into improved digital infrastructure, skills, empowerment, or work outcomes at the provincial level. It could be due to various factors, such as the quality of education, the relevance of educational content to the demands of the digital economy, and the extent to which digital skills are integrated into the curriculum. This highlights the importance of educational attainment and the need for educational systems to evolve and align more closely with the rapidly changing digital landscape to effectively contribute to reducing the digital divide.

CONCLUSIONS

This study provides new perspectives on the digital divide within Indonesian provinces. Using clustering and multiple linear regression analyses and the IMDI 2022 data, the analysis reveals three types of digital divide: infrastructure, digital skills, and outcomes. The infrastructure gap is especially pronounced, with many regions in Indonesia – particularly in rural and remote areas such as Maluku Utara Province – experiencing considerable difficulties stemming from insufficient internet infrastructure. In contrast, provinces located on Java Island have more advanced ICT infrastructure. This characteristic also applies

to Bali due to its closeness to Java and Kepulauan Riau, which gains an advantage from its strategic position close to key international trading pathways such as those near Singapore. However, with less than 21% of provinces having advanced ICT infrastructure, there is a clear imperative for intensified efforts towards infrastructure development. This need is especially relevant for Eastern Indonesia and rural and isolated regions, where enhancing digital infrastructure can be critical for bridging the digital divide and fostering more equitable access to digital opportunities across the archipelago.

The analysis highlights significant disparities in digital skills across its provinces, particularly between more developed urban areas and remote, rural regions. Such factors as socio-economic status, education, geographic location, and cultural attitudes play a crucial role in shaping individuals' access to and proficiency in digital technologies. The digital skills gap in less developed provinces is due to infrastructural deficits, limited internet connectivity, and insufficient ICT education. To effectively bridge this divide, it is imperative to implement inclusive digital literacy programs and infrastructure development initiatives that cater to each province's unique challenges, ensuring equitable digital inclusion and participation across Indonesia.

The analysis also reveals a digital divide centred around the unequal distribution of digitalisation's benefits, which impact access to information, education, employment, healthcare, and civic engagement. This divide, which we examined through the IMDI's Empowerment and Work pillars, shows significant disparities, particularly between urban centres and more rural or remote areas. These findings highlight the critical need for comprehensive strategies by the Indonesian government and stakeholders to enhance digital literacy, expand digital infrastructure, and create inclusive opportunities for digital engagement and employment.

The regression analysis confirmed the multifaceted nature of the digital divide in Indonesia and has shown how economic prosperity, wages, formal labour engagement, gender dynamics, literacy levels, and the size of the working-age population influence the development of digital infrastructure, skills, empowerment, and workforce dynamics across Indonesian provinces. Higher GRDP per capita and formal labour positively affect the advancements in ICT infrastructure. Formal labour also positively affects digital competencies and empowerment. While wage and working-age populations have a positive influence on work. This suggests that economic strength and formal employment are crucial in enhancing digital ecosystems. However, the negative associations of gender proportion and literacy rates with infrastructure development highlight complex underlying factors that may contribute to access and usage disparities. Surprisingly, secondary and tertiary education participation rates did not significantly impact digital outcomes. This finding may indicate a need for education systems to adapt to ICT more effectively.

Even though this study provides valuable insights into the digital divide in Indonesia, it is essential to recognise its limitations for a comprehensive understanding of the problem. The reliance on IMDI data from just one year limits the scope of the analysis. This approach may not fully reflect digital development's dynamic and evolving nature and skew the interpretation of current states and trends. Furthermore, the study's dependence on a limited set of variables available in the BPS data means that other influential factors remain unaccounted for, which could be critical for understanding the nuances of the digital divide. These could include cultural attitudes towards technology, specific policy impacts, or the role of private sector initiatives in ICT development.

Given the limitations highlighted in the current study, future research should focus on broadening the scope of the analysis. It would be beneficial to incorporate longitudinal data that spans multiple years, capturing the dynamic nature of digital development and enabling researchers to identify trends and patterns over time. Additionally, expanding the range of variables, such as cultural attitudes towards technology, the impact of specific governmental and non-governmental policies, and private sector initiatives contributions, could uncover other critical factors influencing the digital divide. Also, the qualitative data obtained from interviews or case studies could enrich the analysis and provide contextual depth to the quantitative findings.

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References

ANDITA, C. et al. (2022). Perbandingan Implementasi E-Government Antara Jepang dan Korea Selatan [online]. *Saraq Opat: Jurnal Administrasi Publik,* 4(2): 84–93. <https://jurnal.ugp.ac.id/index.php/SaraqOpat>.

ARAKPOGUN, E. O. et al. (2020). Threading the needle of the digital divide in Africa: The barriers and mitigations of infrastructure sharing [online]. *Technological Forecasting and Social Change,* 161: 120263. <https://doi.org/10.1016/j.techfore.2020.120263>.

ARIANSYAH, K., ANANDHITA, V. H., SARI, D. (2019). Investigating the Next Level Digital Divide in Indonesia [online]. *The 2019 Technology Innovation Management and Engineering Science International Conference* (TIMES-iCON2019), 16–20. <https://doi.org/10.1109/TIMES-iCON47539.2019.9024668>.

AZMAT, F. et al. (2020). Closing the Skills Gap in the Era of Industrial Digitalisation [online]. *Proceedings – 2020 IEEE Conference on Industrial Cyberphysical Systems, ICPS 2020,* 365–370. <https://doi.org/10.1109/ICPS48405.2020.9274788>.

AZUBUIKE, O. B., ADEGBOYE, O., QUADRI, H. (2021). Who gets to learn in a pandemic? Exploring the digital divide in remote learning during the COVID-19 pandemic in Nigeria [online]. *International Journal of Educational Research Open,* 2: 100022. <https://doi.org/10.1016/j.ijedro.2020.100022>.

BADAN LITBANG SDM KEMENTRIAN KOMINFO. (2022). *Pengukuran Indeks Masyarakat Digital Indonesia Tahun 2022* [online]. < https://imdi.sdmdigital.id>.

BISMO, A., PUTRA, S., MELYSA. (2019). Application of Digital Marketing (social media and email marketing) and its Impact on Customer Engagement in Purchase Intention: A case study at PT Soltius Indonesia [online]. *Proceedings of 2019 International Conference on Information Management and Technology, ICIMTech,* 109–114. <https://doi.org/10.1109/ICIMTech.2019.8843763>.

BLOCK, B. M. (2018). Digitalization in engineering education research and practice [online]. *IEEE Global Engineering Education Conference, EDUCON,* 1024–1028. <https://doi.org/10.1109/EDUCON.2018.8363342>.

ČAPLÁNOVÁ, A., DARMO, Ľ., ANA RATNA WATI, D. (2023). Data on digitalization in Indonesian provinces [online]. *Zenodo.* <https://doi.org/10.5281/zenodo.10081804>.

FERREIRA, D. et al. (2021). The three levels of the urban digital divide: Bridging issues of coverage, usage and its outcomes in VGI platforms [online]. *Geoforum,* 124: 195–206. <https://doi.org/10.1016/j.geoforum.2021.05.002>.

GUO, C., WAN, B. (2022). The digital divide in online learning in China during the COVID-19 pandemic [online]. *Technology in Society,* 71: 102122. <https://doi.org/10.1016/j.techsoc.2022.102122>.

HARTONO, H., HALIM, E. (2020). The Effect of Digital Capability on Competitiveness through Digital Innovation of E-Travel Business in Indonesia [online]. In: *2020 International Conference on Information Management and Technology ICIMTech,* 615–620. <https://doi.org/10.1109/ICIMTech50083.2020.9211228>.

HAYRE, J., CIRELLI, C., SHARMA, M. (2021). Teledermatology for the many, not the few: Tackling the racial health divide in a digital world [online]. *EClinicalMedicine,* 37: 101007. <https://doi.org/10.1016/j.eclinm.2021.101007>.

JAUHIAINEN, J. S. et al. (2022). Digital divides, the Internet and social media uses among Afghans in Iran [online]. *Technology in Society,* 70: 102057. <https://doi.org/10.1016/j.techsoc.2022.102057>.

KARTIASIH, F. et al. (2023). Inequalities of Indonesia's regional digital development and its association with socioeconomic characteristics: a spatial and multivariate analysis [online]. *Information Technology for Development,* 29(2–3): 299–328. <https://doi.org/10.1080/02681102.2022.2110556>.

KOLOTOUCHKINA, O., BARROSO, C. L., SÁNCHEZ, J. L. M. (2022). Smart cities, the digital divide, and people with disabilities [online]. *Cities,* 123: 103613. <https://doi.org/10.1016/j.cities.2022.103613>.

LOPEZ-ERCILLA, I. et al. (2021). The voice of Mexican small-scale fishers in times of COVID-19: Impacts, responses, and digital divide [online]. *Marine Policy,* 131: 104606. <https://doi.org/10.1016/j.marpol.2021.104606>.

LUCENDO-MONEDERO, A. L., RUIZ-RODRÍGUEZ, F., GONZÁLEZ-RELAÑO, R. (2019). Measuring the digital divide at regional level. A spatial analysis of the inequalities in digital development of households and individuals in Europe [online]. *Telematics and Informatics,* 41: 197–217. <https://doi.org/10.1016/j.tele.2019.05.002>.

LYTHREATIS, S., SINGH, S. K., EL-KASSAR, A. N. (2022). The digital divide: A review and future research agenda [online]. *Technological Forecasting and Social Change,* 175: 121359. <https://doi.org/10.1016/j.techfore.2021.121359>.

NATALIA, G. (2022). An inverted digital divide during Covid-19 pandemic? Evidence from a panel of EU countries [online]. *Telematics and Informatics,* 72: 101856. <https://doi.org/10.1016/j.tele.2022.101856>.

NISHIDA, T., PICK, J. B., SARKAR, A. (2014). Japan's prefectural digital divide: A multivariate and spatial analysis [online]. *Telecommunications Policy*, 38(11): 992–1010. <https://doi.org/10.1016/j.telpol.2014.05.004>.

PADHI, L. K. et al. (2019). Strategies of Learning: A Methodology of Teaching Language Through Digitalisation [online]. *International Conference on Advanced Communication Technology, ICACT,* 697–702. <https://doi.org/10.23919/ICACT.2019.8702001>.

PÉREZ-MOROTE, R., PONTONES-ROSA, C., NÚÑEZ-CHICHARRO, M. (2020). The effects of e-government evaluation, trust and the digital divide in the levels of e-government use in European countries [online]. T*echnological Forecasting and Social Change,* 154: 119973. <https://doi.org/10.1016/j.techfore.2020.119973>.

PETRILLO, A., DE FELICE, F., PETRILLO, L. (2021). Digital divide, skills and perceptions on smart working in Italy: From necessity to opportunity [online]. *Procedia Computer Science,* 180: 913–921. <https://doi.org/10.1016/j.procs.2021.01.342>.

PICK, J. B., NISHIDA, T. (2015). Digital divides in the world and its regions: A spatial and multivariate analysis of technological utilization [online]. *Technological Forecasting and Social Change,* 91: 1–17. <https://doi.org/10.1016/j.techfore.2013.12.026>.

PICK, J. B., SARKAR, A., JOHNSON, J. (2015). United States digital divide: State level analysis of spatial clustering and multivariate determinants of ICT utilization [online]. *Socio-Economic Planning Sciences,* 49: 16–32. <https://doi.org/10.1016/j.seps.2014.09.001>.

POKROVSKAIA, N. N., GARIN, A. K. (2022). Strategies for Bridging the Digital Divide by Enhancing Communication Competence [online]. *The 2022 Communication Strategies in Digital Society Seminar ComSDS,* 166–170. <https://doi.org/10.1109/ComSDS55328.2022.9769146>.

REDDICK, C. G. et al. (2020). Determinants of broadband access and affordability: An analysis of a community survey on the digital divide [online]. *Cities,* 106: 102904. <https://doi.org/10.1016/j.cities.2020.102904>.

ROHMAH, A. A., RACHMAWATI, R., MEI, E. T. W. (2022). Digital Transformation of Health Service through Application Development in Handling COVID-19 in Indonesia [online]. *The 2022 International Conference on ICT for Smart Society (ICISS).* <https://doi.org/10.1109/ICISS55894.2022.9915235>.

SARAEVA, N. (2021). The role of digitalization in the process of teaching a foreign language and in the formation of a foreign language competence of future specialists [online]. *The 1st International Conference on Technology Enhanced Learning in Higher Education, TELE 2021,* 104–106. <https://doi.org/10.1109/TELE52840.2021.9482521>.

SENSUSE, D. I. et al. (2019). Digital Divide in Sumatra Island, Indonesia [online]. *The Fourth International Conference on Informatics and Computing (ICIC).* <https://doi.org/10.1109/ICIC47613.2019.8985774>.

SIMAMORA, C. M., NINGSIH, R., PERDAGANGAN, P. (2020). Inklusivitas Ekonomi Digital Di Indonesia: Perspektif Gender Dan Penciptaan Lapangan Kerja (Studi Kasus Kampung Marketer). *Journal of Trade Development and Studies Cendekia Niaga,* 4(2): 39–52.

SINGH, S., SINGH, U. S., NERMEND, M. (2022). Decision analysis of e-learning in bridging digital divide for education dissemination [online]. *Procedia Computer Science,* 207: 1970–1980. <https://doi.org/10.1016/j.procs.2022.09.256>.

SONG, Z., WANG, C., BERGMANN, L. (2020). China's prefectural digital divide: Spatial analysis and multivariate determinants of ICT diffusion [online]. *International Journal of Information Management,* 52: 102072. <https://doi.org/10.1016/j.ijinfomgt.2020.102072>.

TARJÁNI, J. A., KALLÓ, N., DOBOS, I. (2023). Evaluation of Digital Development Based on the International Digital Economy and Society Index 2020 Data [online]. *Statistika: Statistics and Economy Journal,* 103(3): 355–373. <https://doi.org/10.54694/stat.2023.21>.

VAN RUITENBEEK, R. E., KOOLE, G. M., BHULAI, S. (2023). A hierarchical agglomerative clustering for product sales forecasting [online]. *Decision Analytics Journal,* 8: 100318. <https://doi.org/10.1016/j.dajour.2023.100318>.

VÁRALLYAI, L., HERDON, M., BOTOS, S. (2015). Statistical Analyzes of Digital Divide Factors [online]. *Procedia Economics and Finance,* 19(15): 364–372. <https://doi.org/10.1016/s2212-5671(15)00037-4>.

WERFHORST, H. G., KESSENICH, E., GEVEN, S. (2022). The digital divide in online education: Inequality in digital readiness of students and schools [online]. *Computers and Education Open*, 3: 100100. <https://doi.org/10.1016/j.caeo.2022.100100>.

WILANTIKA, N. et al. (2018). Grouping of Provinces in Indonesia According to Digital Divide Index [online]. *The 6th International Conference on Information and Communication Technology (ICoICT) Grouping,* 380–388. <https://doi.org/10.1109/ICoICT.2018.8528753>.

YUAN, Z., JIA, G. (2021). Profiling the digital divide of the elderly based on Internet big data: evidence from China [online]. *Data Science and Management*, 3: 33–43. <https://doi.org/10.1016/j.dsm.2021.10.001>.

ZHAO, L., CAO, C., LI, Y., LI, Y. (2022). Determinants of the digital outcome divide in E-learning between rural and urban students: Empirical evidence from the COVID-19 pandemic based on capital theory [online]. *Computers in Human Behavior*, 130: 107177. <https://doi.org/10.1016/j.chb.2021.107177>.