sustainability

MDPI

Article

The Indonesian Digital Workforce Gaps in 2021–2025

Gati Gayatri [1,*], I Gede Nyoman Mindra Jaya [2] and Vience Mutiara Rumata [1,3]

1 Research Center for Society and Culture, The Research and Innovation Agency of the Republic of Indonesia, Jalan Jenderal Gatot Subroto 10, Jakarta 12710, Indonesia
2 Department of Statistics, The Faculty of Math and Science, The University of Padjadjaran, Bandung 45363, Indonesia
3 Faculty of Communication Science, The University of Esa Unggul, Jalan Arjuna Utara, Jakarta 11510, Indonesia
* Correspondence: gati.gayatri@brin.go.id

Abstract: The development and advancement of information and communication technologies have led to major changes in industry and the labor system in Indonesia. In the context of the digital economy, Indonesia needs to immediately improve digital labor policies based on research results. However, studies on Indonesian digital workforces mostly come from global nonacademic publications, which acknowledge the limitation of the workforces. This study addresses the gaps between the supply and demand of digital workforces in 2021–2025 by conducting a Bayesian analysis on the data from the 2018 Indonesian Statistics Bureau and the 2020 ILO ICT job demand forecast. According to the findings, the supply of digital workforces will outnumber the demand, which is expected to be 600,000 workers per year. This surplus number poses a new challenge for the government if the available workforce lacks the competencies needed in the industry. According to the study, IT system programmer/developer/administrator/system analyst and IT web designer/developer will still be popular job roles during this time. It is suggested that improving these digital skills in the current and future workforces should be a top priority for the government.

Keywords: digital workforce; supply and demand; Indonesia; 2021–2025

check for updates

Citation: Gayatri, G.; Jaya, I.G.N.M.; Rumata, V.M. The Indonesian Digital Workforce Gaps in 2021–2025. *Sustainability* **2023**, *15*, 754. https://doi.org/10.3390/su15010754

Academic Editor: Carla Maria Marques Curado

Received: 16 November 2022
Revised: 16 December 2022
Accepted: 26 December 2022
Published: 31 December 2022

1. Introduction

The Industrial Revolution 4.0 is the result of recent digital technology developments that have disrupted the processes of production, distribution, and consumption of products and services. This disruption has occurred in nearly all sectors: health, education, politics, public services, finance and trade, commerce, and even manufacturing. The Internet no longer only allows human–computer communication but also human–machine–product communications through smart technologies beyond time and space. Smart automation, integrated product development (physical and digital production), advanced predictive analytics, and business model disruption are the four pillars of this revolution.

This disruption inevitably requires the adoption of new skills beyond ordinary digital literacy. Some of the new skills needed include cloud computing, big data analytics, the Internet of Things (IoT), encryption and cyber security, and artificial intelligence [1,2]. Even robotic technology requires new skills, such as those of mechatronics specialists and industrial cognitive scientists, and automation bionics [3]. Smart factories, which are the essential feature of the 4.0 Industrial Revolution, need skilled workforces that can operate the convergence between mechanical or electronic components and software-based system applications. Globally, smart factories collect at least 2.5 quintillion bytes of data, making this "cyber–physical production system" extremely complex in terms of data management and security [4].

As a result, job requirements are shifting to either entirely new job titles or old job titles with upgraded and expanded skill sets. According to LinkedIn (2022), job roles such as machine learning engineer, business development representative with software as a service (SaaS) skills, user experience researcher, business system administrator with troubleshooting skills, and technical product manager with agile methodologies or software development life cycle skills have grown exponentially in the United States over the last five years [5].

The availability of skilled digital workforces remains difficult, at least in Southeast Asia. A comparative study of four countries—Malaysia, Thailand, Vietnam, and Cambodia—reveals that the biggest proportion of the employed population (approximately 40–60 percent) is in very low digital occupations (jobs that require minimal digital technology, such as chefs who might use computers or smartphones), while the advanced digital skill vocation has the lowest employment proportion, ranging from 0.8% in Cambodia to 4.7% in Malaysia [6]. As previously mentioned, with new emerging job titles and skill set requirements, basic digital skills, such as using search engines to find information or sending emails, are no longer relevant. The industry needs more advanced digital skills that fit specific tasks and functions.

Indonesia is a developing country with great digital economic potential. The value of the country's digital economy is projected to reach USD 146 billion by 2025 and USD 330 billion by 2030, the highest GMV value in the Southeast Asian area [7]. To grasp this potential, the government proposed a national acceleration program for digital transformation that encompasses five priorities: (1) digital and internet infrastructure development; (2) a digital transformation roadmap in strategic sectors, such as public services, social services, education, health, commerce, industry, and broadcasting; (3) the development of a national data center; (4) the development of digitally skilled human resources; and (5) digital regulatory and funding schemes [8,9]. Digitally skilled human resources will probably be the government's primary concern to anticipate the future needs in 2045, when workers of productive age will dominate the population, which will reach approximately 180 million people (while those of an unproductive age will be approximately 80 million) [10]. This is known as the "Indonesia Gold 2045" vision in which one of the goals is to remove the nation from the "middle income trap" [11].

Amid this enormous digital economy potential, the lack of advanced digitally skilled workers remains the nation's biggest challenge. The number of science, technology, engineering, and mathematics (STEM) graduates in Indonesia is quite low compared to other nations, at 0.8 per 100 graduates, compared to Iran (4.2), Russia (3.9), China (3.4), India (2.0), the United States (1.8), and Japan (1.5) [12]. Moreover, the penetration of vocational graduates in the industry is relatively low. The vocational graduates who majored in computer and informatics are the second largest unemployed group after graduates who major in automotive, which reached 246,091 and 373,444 graduates, respectively [13]. The digitally skilled workforce gap does not occur due to the lack of graduates in STEM or others related majors only. Conversely, the gap also occurs when the number of graduates may be outnumbering the numbers of available jobs. Nevertheless, it is common that most of the graduates' competence may not meet the industry's requirements. In addressing this, companies may be either upskilling their current employees in particular digitally skilled areas [14] or obtaining foreign professionals to cover the voids in digital marketing, software engineering, operations, and finance [12]. It is worth noting that the recent Omnibus Act permits enterprises to recruit foreign labor, with authorization from the federal government [15]. Digital start-ups are one of these enterprises.

Studies on the digital workforce in Indonesia are dominated by reports issued by well-known global consultants. They may state the potential growth numbers in the report, but the data source used is questionable. On the other hand, studies on this matter by local academicians are insufficient to analyze the digital skilled workforce mismatch, shortage, and gap at the national level. This study addressed how and in what way the digitally skilled workforce gap may potentially exist in 2021–2025 by analyzing supply and demand trends in 2016–2020. Apart from the number, this study also analyzed potential digital skill set gaps within that period. This study is important in two ways. First, this study may provide empirical data, such as the potential digital workforce supply and demand, which are needed by policymakers and executors for digital workforce development in Indonesia. Second, this study may support other relevant nongovernmental stakeholders in Indonesian digital workforce development, such as in education, training, and certification institutions.

Conceptual Framework

The emerging need for an advanced digitally skilled workforce is aligned with the idea of an "information society" in which the production, distribution, consumption, integration, and manipulation of information become the core of economic, political, and cultural activities. The post-industrial society theory, which emphasizes the dominance of knowledge and creativity-based occupations, service-based economy, innovation-based transformation, and computerization, has had a strong influence on the idea of information society theory [16]. The nature of this society allows for continuous changes in technology, economy, occupation, spatiality, and culture, resulting in increased white collar employment and important professional positions, a greater role for intellectuals, more person-to-person employment, a decrease in laissez-faire work patterns, an increase in better work planning, interpersonal relationships becoming more important, and economization becoming sociological [17].

The adoption of digital technologies in the industry is not solely for increasing their products' quality but to transform their business products and processes in vigorous ways to survive in the tight competition of today. Thus, industry needs more and more digitally skilled workers. When recruiting a digital workforce, it is important for a candidate to be able to demonstrate the ability to operate IT strategically and in a transformative way that may go beyond traditional tasks and functions. The digital workforce, mostly dominated by digital natives and digital immigrants, is supposed to have a level of digital fluency that goes beyond data manipulation, creative presentation of information, creative product designs, and ways of working [18].

Scholars try to conceptualize digital skills and propose frameworks that encompass levels or categorizations of digital skills with slightly distinct characteristics (Table 1). Digital skills, in general, refer to skill sets to manage data and information through digital devices, communication applications, and networks. Individuals with these talents may create and disseminate digital material and successfully communicate, collaborate, and solve problems for self-development, social, and task-related purposes.

In this study, digital skills are understood to be specialized or advanced skills that promote the daily use of digital technology for intelligence-related tasks, technical functions for specific purposes, innovation-based outputs, transformative business models, and workplace culture both for the present and the future. According to Presidential Regulation No. 8 of 2012 [23], the Indonesian government has standardized qualifications for education, job training, and work experience (the Indonesian Qualifications Framework, or hereinafter KKNI). The KKNI has nine competency levels that are classified into three groups: an operator group (levels 1–3), a technical/analytical group (levels 4–6), and an expert group (levels 7–9). Based on KNNI, digital workforces are made up of workers or professionals who have ICT skills as a supplement or specialty (expert groups), as well as ICT technicians, analysts, and managers (technical and analytical groups) (Figure 1).

A "digital-skilled workforce gap" exists when the number of available graduates with certain digital skills cannot be absorbed by the industry. This can be caused by a shortage of skilled workers in a company [25–27] or by a shortage of workers with relevant skills for a specific task or function that is required in a company, which is referred to as a skill deficiency or skill mismatch [28–30]. This deficiency eventually may influence the company's performance.

Table 1. Existing digital skills frameworks.

No.	Institution	Classification	Characteristics
1	UNESCO (2018) [19]	Entry-level digital skills	Basic digital devices and online applications functions
		Advanced digital skills	The usage of digital technology for task-related professions transformation
2	OECD (2016) [20]	Generic skills	Daily working skills such as accessing online information or using software
		Specialist skills	Skills for ICT product and services functions, such as cloud computing, network managing, application development, or big data analysis
		Complementary skills	Skills for information, communication, and problem-solving functions
3	ITU (2018) [21]	Basic skills	Basic digital hardware and software literacy skills, such as communication through email or filling out online forms
		Intermediate skills	Skills to use digital technology for profitable and meaningful purposes, such as digital content creator, digital graphic design, and others
		Advanced skills	ICT-related specialists, such as computer programming, network management, artificial intelligence (AI), big data, coding, cybersecurity, Internet of Things (IoT), and mobile app development
4	Zhu et al. (2018) [22]	Basic	Digital literacy
		Applied	Job classifications encompass technical support, animation, computer graphics, digital marketing, enterprise software, graphic design, information management, social media, and system administration
		Software and Hardware	Job classifications encompass computer hardware, computer networking, data storage technologies, game development, mobile application development, product development, scientific computing, signal processing, software development life cycle (SDLC), software testing, and web development
		Disruptive	Job classifications encompass development tools, artificial intelligence (AI), cybersecurity, data science, fintech, human–computer interaction, materials science, nanotechnology, robotics, aerospace engineering, and genetic engineering

The digital-skilled workforce gap in Indonesia gets little attention among researchers. Existing reports or working papers in this matter may show a projection or a map of labor demands in Indonesia. However, these reports show defects to some degrees. In January 2020, a report on Indonesia's critical occupation lists for 2018 was released, containing 35 shortage occupations based on Indonesian Job Codebook classifications [31]. These 35 critical occupations contribute nearly 11 percent of the overall 312 occupations under Indonesian Job Codebook classifications, whereby each of these occupations has specific job titles that are also in shortage. Among these critical occupations, three occupations are in information and communication sectors: (1) professionals in business intelligence (including data management experts, data scientists, DevOps engineers, big data engineers, network engineers, system analysts, digital marketing specialists, and business intelligence analysts); (2) apps and system developers (including app developers, backend developers, web developers, software engineers, programmers, and mobile app developers); and (3) cloud solution architects and UI/UX designers. This study applied "dovetailing" procedures that combine top-down (national labor market analysis based on the existing classification of occupation data) and bottom-up (institutional qualitative analysis) approaches. Even so, this report did not further show the exact number and competency level, based on either international or Indonesian standards, of each job title in shortage. Another World Bank (2018) report suggests a potential shortage of 9 million skilled and semi-skilled ICT workers between 2015 and 2030 [32]. Nevertheless, this report did not show the exact number of shortages each year within that period. In addition to the COL, some reports list job titles that are in high demand in the Indonesian industry. McKinsey (2019) reports those occupations that include digital marketing, software development life cycle (SDLC), human–computer interaction, development tools, data storage technologies, artificial intelligence, data science, and social media specialists. Likewise, ILO (2020a) reports some occupations that include information security analyst, business system analyst, e-commerce specialist, training and development specialist, user acquisition specialist, AI and machine learning specialist, digital transformation specialist, organizational specialist, IT service specialist, people and culture specialist, digital marketing specialist, IoT specialist, and cyber security specialist.

Similar to studies on demand, studies on digital skill supply in Indonesia are also deficient. A study on this subject only identifies factors that may contribute to an increase in the number of graduates in ICT sectors between 2011 and 2018. These factors include ICT infrastructure usage, demography, economic structure, and education level [33].

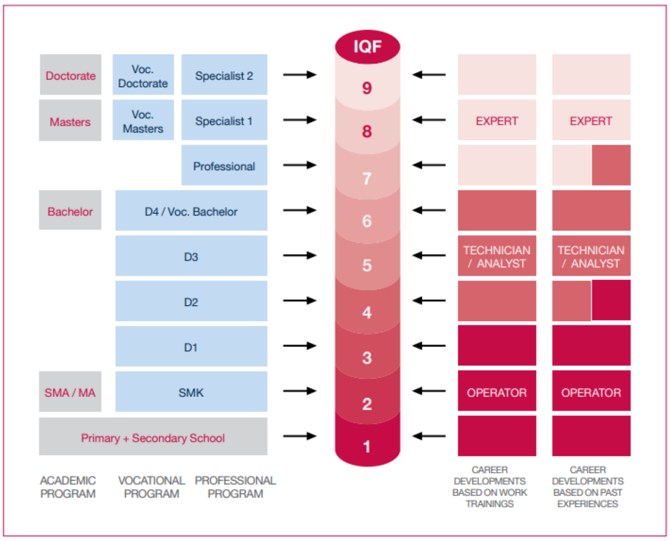

Figure 1. The Indonesian Qualifications Frameworks. Source from the Indonesian Directorate General of Higher Education in 2012 cited in [24].

2. Materials and Methods

The purpose of this study was to forecast the Indonesian digital workforce shortage in 2021–2025 by comparing labor supply and demand over the last five years, 2016–2020. The data on supply were derived from data on tertiary vocational and higher education school graduates that major in STEM and other fields related to communication and informatics that were issued by the Ministry of Education and Culture. The demand data were derived from the rate of employment growth reported in the "National Labor Force Survey" report [34].

This study applied a Bayesian analysis technique that was properly designed for a relatively small sample size and possible missing value data [35]. The Bayesian method was superior for short time series compared to classical time series approaches, such as exponential smoothing or autoregressive integrated moving average, which require a minimum sample size [35]. The method is able to forecast by involving information obtained from observation and prior distributions. The Bayesian method is applied using the R-INLA application program [36]. Notably, the use of a short time series does not permit model comparisons using the in-and-out sample method. To calculate the number of workforces and identify the demand for occupations or job titles, this study employs the Rapid Assessment of Information and Communication Technology Skills Demands in Indonesia data report that was issued by the ILO as the proportional basis of value [37].

3. Results

In this study, the future digitally skilled workforces are those who graduate from both the tertiary vocational schools and the higher-degree universities, particularly those majoring in STEM and other communication and informatics-related fields. They may or may not have received digital course academy training or certification from nonformal educational institutions. Therefore, this study used data on graduates with selected majors from three formal educational institutions in Indonesia: (1) the vocational high school (Sekolah Menengah Kejuruan, or hereinafter SMK); (2) the vocational higher degree (polytechnic); and (3) the higher degree (university) (Table 2). Based on the Indonesian standard's KKNI, the digital skill level of SMK's graduates was considered complementary, while the digital skill level of graduates with higher degrees (vocational and university) was considered complementary and specialist. Both complementary and specialist skills are needed for Indonesian workforces nowadays, apart from soft skills such as leadership, communication, and business/marketing [32].

Table 2. List of selected digital skilled related courses.

No.	Educational Institution	Courses/Majors/Programs
1	The vocational high school	Communication group: Graphic Design, Graphic Preparation, Graphic Production, Visual Communication Design, Animation, Radio Program Production and Broadcasting Engineering, Radio and Television Program Production and Broadcasting Engineering, Film and Television Program Production, Film Production, Marketing/Marketing, Online Business and Marketing. Informatics group: Industrial Automation Engineering, Power Electronics and Communication Engineering, Audio Video Engineering, Communication Electronics Engineering, Mechatronics Engineering, Autotronic Engineering, Information Systems, Networks and Applications, Software Engineering, Computer and Network Engineering, Access Network Engineering, Telecommunication Transmission Engineering, Suitsing Engineering.
2	The vocational higher degree (polytechnic)	Technology group: Management of Informatics Engineering group: Mechatronics, Industrial Electronics Engineering, Telecommunication (including Telecommunication Engineering, and Telecommunication Technology), Informatics Engineering, Computer Engineering (including Computer and Network Engineering), Application Software Engineering, Electronic Engineering, Informatics Engineering, Industrial Electrical Engineering, Manufacturing Electronics Engineering, Systems Information, Information Technology, Computer Control Engineering, Accounting Information Systems, Electrical Engineering, Computer Technology, Statistics, Graphic Engineering, Visual Information Systems, and Server Administration and Computer Networks. Communication group: Mass Communication, Applied Communication, Radio and Television Broadcasting, Journalism, and Graphic Design (including Computer Graphics). Arts group: Network Computer Engineering Technology, Game Animation, Visual Communication Design, Film and Television Production (including Television and Film), Video and TV Film Management and Production, Multimedia Computers, and Visual Information Systems.

Table 2. *Cont.*

No.	Educational Institution	Courses/Majors/Programs
3	The higher degree (university)	STEM group: Chemistry and Chemical Engineering, Physics, Statistics and Data Science, Applied Statistics and Computerized Statistics, Mathematics (including Mathematics and Science Applications), Computer Science, Computational Science or Science, and Library and Information Science. Technology group: Information Management, Information Systems and Technology, Game Technology, Information Security, Accounting Computing Systems and Accounting computerization, Information Systems, Information Technology (except Information Technology Education), and Automation Engineering (including Automation Engineering Engineering). Engineering group: Informatics Engineering, Software Engineering, Computer Science, Computer Engineering (including Computer and Network Engineering), Electrical Engineering (except Electromedical Engineering, Shipping Electrical Engineering), Telecommunication Engineering (including digital telecommunications networks), Engineering Physics, Computer Systems, Computer Systems Engineering, Mechatronics Engineering, Cartography and Remote Sensing, Telecommunication Engineering or Engineering, Software Engineering Technology, Communication Management (Engineering Field), and Communication Information Management (Engineering Field). Math group: Mathematics and Applied Mathematics (excluding Mathematics Education). Arts and Communication groups: Graphic Design, Journalism (including Islamic Journalism), Communication Studies, Broadcasting (including Islamic Communication and Broadcasting), Media Production Management, Film (including Film and Television Production, Film and Television Production Management), and Media and Communication.

3.1. The Workforce Supply and Demand in 2016–2020

Table 3 shows the number of vocational high school graduates in communication and informatics from 2016 to 2020. The number of graduates in 2018 and 2020 is not available in the report. Even so, the data show that the number of graduates in informatics is higher than for communication. The average number of vocational high school graduates from both courses reached more than 300,000 alumni per year.

Table 3. The vocational high school graduates in 2016–2020. Data source and permission: Directorate of Vocational Education, the Ministry of Education and Culture (2021).

No.	Course	2016	2017	2018	2019	2020
1	Informatics	234,274	204,121	NA	285,643	NA
2	Communication	73,694	61,022	NA	81,744	NA
	Total	307,968	265,143	NA	367,387	NA

Meanwhile, the number of vocational higher degree graduates was the lowest compared to the other two educational institutions, which had an average of 32,500 alumni annually. Graduate data from 2016 to 2020 show a fluctuating trend, particularly in the years 2018 and 2020, which declined significantly compared to those in 2016, 2017, and 2019 (Table 4). The course in technology was the most attractive course in the vocational higher degree institution, at least until 2018, when the number of graduates declined quite significantly in the following years. In contrast, the number of engineering graduates remained relatively stable between 2016 and 2018, before declining significantly in 2019.

Table 4. The vocational high degree graduates in 2016–2020. Data source and permission: Directorate of Vocational Education, the Ministry of Education and Culture (2021).

No.	Course	2016	2017	2018	2019	2020
1	Technology	18,995	17,904	11,994	8489	6956
2	Engineering	15,545	15,061	14,229	25,683	17,699
3	Communication	1449	1892	1803	1760	1527
4	Arts	466	507	558	503	390
	Total	36,455	35,364	28,584	36,435	26,572

The trend for higher degree (university) graduates gradually increased from 2016 to 2019, but it declined in 2020. This tendency occurred at every level: undergraduate (hereinafter S1), master's (hereinafter S2), and doctorate (hereinafter S3). The number of higher degree (university) graduates between 2016 and 2020, with an average of 600,855 graduates per month or approximately 120 thousand per year (Table 5), Graduates of higher education are supposedly workforces of intermediate (IQF levels 4, 5, and 6) and advanced/specialist (IQF levels 7, 8, and 9). According to this data, the number of intermediate-level digitally skilled workforces, which is equivalent to undergraduate (S1) workers, totaled 569,778, while the number of specialists master's (S2) and doctorate (S3) graduates was 29,810 and 1267, respectively.

Table 5. The higher degree (university) graduates in 2016–2020. Data source and permission: Directorate of Vocational Education, the Ministry of Education and Culture (2021).

Year	Course	STEM	Technology	Engineering	Math	Communication and Arts	Total
2016	S1	1135	25,986	53,687	3065	22,024	113,047
	S2	1473	847	2515	291	1623	6458
	S3	146	0	73	-	58	277
2017	S1	11,955	26,736	5489	3045	23,439	11,702
	S2	136	1026	2381	248	1672	6439
	S3	131	0	75	-	85	291
2018	S1	12,176	25,553	54,175	316	25,89	117,794
	S2	1336	865	1892	311	1662	5755
	S3	142	0	108	-	60	310
2019	S1	13,113	24,912	53,898	3401	28,726	120,649
	S2	137	890	2167	239	1668	6095
	S3	163	0	113	-	75	351
2020	S1	10,063	21,614	44,534	2668	25,057	101,268
	S2	1097	998	1699	152	1269	5063
	S3	119	38	73	-	38	268

In addition to the number of graduates of those three formal educations, the supply data may derive from nonformal education that offer professional certificate-based training programs that are delivered by public or private institutions. The Indonesian government launched several professional certificate-based training programs to meet the demand for skilled digital workforces. The Ministry of Communication and Informatics (hereinafter Kominfo), as a leading regulator in the digital sector, launched a "Digital Training Scholarship" to support national development priorities in the last five years. In 2020, there were at least 58,116 participants (public, freshmen, and public sector employees) who received professional training and certificates, most of which originated from international or global technology companies [38].

In addition, the government has a national competency-based standard (Standar Kompetensi Kerja Nasional Indonesia, hereinafter SKKNI). Three SKKNI in the communications, telecommunications, and informatics sectors are available as a reference of professional competency for the industry (including professional certificate-based institutions). Nonetheless, these SKKNI documents are intended primarily for the unskilled and semi-skilled workforce (ICT operators and technicians). So far, the number of vocational high school and degree graduates who have a competency-based certificate is relatively low, at approximately 472,089 (BAPPENAS, 2019). In addition to the government-aided training programs, the other professional certificate-based training providers are in the private sector, including global technology companies, such as Oracle, Microsoft, Google, Cisco, or EC Council. But the number of certificate holders remains unknown.

Due to the limited amount of available data, determining the growth of demand for a digitally skilled workforce over the last five years is challenging. The data on ICT-related occupation growth from the National Statistics Agency's annual workforce survey (Survei Angkatan Kerja Nasional, hereinafter Sakernas) was used as the basis for time series data that may reflect demand in this study. Figure 2 depicts the growth of ICT-related occupations from 2016 to 2020. The annual growth within this period is approximately 600,000.

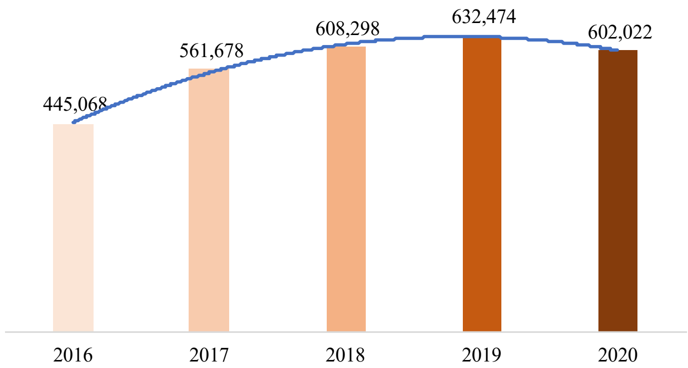

Figure 2. The ICT-related occupational growth in 2016–2020 [34].

3.2. The Digital-Skilled Workforce Forecast in 2021–2025

Based on the available data and the y.o.y comparison between the number of vocational high school, vocational higher degree, and higher degree graduates and the ICT-related occupational growth, there was a workforce deficit from at least 2017 to 2020 (Table 6). Despite a graduate surplus compared to available jobs at the time, the average number of digitally skilled workers in 2016–2020 was 86,300 per year.

Table 6. The workforce gap y.o.y in 2016–2020.

Year	Higher Degree	Vocational Degree	Vocational School	Supply in Total	Occupation in Total	Gap
2016	119,787	36,457	307,962	464,206	445,068	19,138
2017	123,734	35,358	265,156	424,248	561,678	−137,430
2018	123,903	28,599	302,044	454,546	608,298	−153,752
2019	127,041	36,421	367,381	530,843	632,474	−101,631
2020	106,623	26,577	450,278	583,478	602,022	−18,544

To calculate the forecast of a digitally skilled workforce shortage within 2021–2025, the first thing to know is the estimate of the number of graduates in those three educational institutions by means of a Bayesian approach. The results are presented in Table 7.

Table 7. A forecast of the graduate numbers in three educational institutions (2016–2025).

Year	Higher Degree	Vocational Degree	Vocational High School	Total
2016	119,787	36,457	307,962	464,206
2017	123,734	35,358	265,156	424,248
2018	123,903	28,599	302,044	454,546
2019	127,041	36,421	367,381	530,843
2020	106,623	26,577	450,278	583,478
2021	123,598	32,994	469,780	626,372
2022	123,936	33,881	490,531	648,348
2023	126,741	34,720	512,667	674,128
2024	126,999	35,460	536,336	698,795
2025	126,999	36,044	561,706	724,749

3.3. The ICT-Related Occupational Growth in 2016–2020 and Its 2021–2025 Forecast

Based on the Bayesian analysis, there will be at least 3,220,897 occupations, or an average of 600,000 in growth each year, available within the years 2021–2025 (Table 8). According to the Bayesian time series analyses, ICT-related occupations will grow at a similar rate, with an average annual growth of nearly 10,000.

This means that the availability of a digitally skilled workforce will be greater than the availability of occupations, with the average number reaching 30,300 surplus workers per year (Table 9). This finding is in line with previous studies, which predicted that there will be a digitally skilled workforce deficit of at least 9 million in total in 2015–2030, or approximately 600,000 shortages each year [2,12,32,39].

Table 8. The forecast of the digital-skilled workforce demand in 2021–2025.

Year	Bayesian
2016	445,068
2017	561,678
2018	608,298
2019	632,474
2020	602,022
2021	624,492
2022	634,189
2023	644,032
2024	654,023
2025	664,161
Total	6,070,437

Table 9. The supply and demand of the digitally skilled workforce in 2016–2025.

Year	Higher Degree	Vocational Degree	Vocational School	Supply in Total	Occupation in Total	Gap
2016	119,787	36,457	307,962	464,206	445,068	19,138
2017	123,734	35,358	265,156	424,248	561,678	−137,430
2018	123,903	28,599	302,044	454,546	608,298	−153,752
2019	127,041	36,421	367,381	530,843	632,474	−101,631
2020	106,623	26,577	450,278	583,478	602,022	−18,544
2021	123,598	32,994	469,780	626,372	624,492	1880
2022	123,936	33,881	490,531	648,348	634,189	14,159
2023	126,741	34,720	512,667	674,128	644,032	30,096
2024	126,999	35,460	536,336	698,795	654,023	44,772
2025	126,999	36,044	561,706	724,749	664,161	60,588

4. Discussion

This study shows the potential oversupply of up to 151,495 graduates within 2021–2025. This poses challenge for the Indonesian government if this oversupply cannot be absorbed into the industry. Instead of creating a potential digitally skilled workforce, it generates new unemployment, which may eventually increase poverty. The current digital skilled workforce mismatch issue can be exacerbated by this oversupply. In addition, the availability of advanced or expert digital skills in Indonesia is less than one percent [40], whereas the availability of a digitally skilled workforce with basic and intermediate skills is only 50 percent [41]. The SMERU report also mentions that the percentage of digitally over- and under-skilled workers in Indonesia is higher than the OECD's average percentage. In Jakarta, for instance, the digitally over-skilled workers are 14.5 percent or more than 10 percent of the OECD's average, while the digitally less-skilled workers are 4.7 percent or more than 3.8 percent of the OECD's average [41]. Furthermore, the report also states that 54.6 percent of workers occupy jobs that are different from their educational backgrounds, and this percentage is higher than the 39.6 percent of the OECD's average. In other words, the overqualified skilled workforce may perform lower skilled digital tasks and functions or the underqualified skilled workforce may perform higher digital tasks and functions. The higher educational graduates may not have the competency certificates that are required in the industry. The available digitally skilled workers cannot meet the industry's requirements, particularly in start-up industries [42].

Upskilling and reskilling are inevitably strategic responses to the digital skill mismatch and gap issues in Indonesia. A survey report by AWS and Alpha Beta shows that 98 percent of respondents believe that digital upskilling is important for their job and career, while 36 percent think that they are not skilled enough for their job roles. This survey also predicts that there are at least 17.2 million Indonesians who need digital training, particularly in cloud computing, cyber security, digital marketing, or digital migration [43,44]. As part of the Short to Medium Term Development Plan (BAPPENAS, 2019), the government aims to increase the number of existing workers with intermediate or advanced digital skills by 50% by 2024. One of Kominfo's strategic priorities is the Digital Talent Scholarship (hereinafter DTS), which is a certificate-based digital training program for Indonesian society from various sociodemographic backgrounds (from household wives to fresh graduate students). DTS aims to advance students' digital skills from beginner to intermediate [38]. It has eight academies, of which two are aimed at future digitally skilled workforces: the Fresh Graduate Academy (hereinafter FGA) and the Vocational School Graduate Academy (VSGA). Even so, the output of this program may be less than the supply. This year, there are at least 281.1 thousand participants who passed the training in all academies in DTS [45]. Yet, it is not clear the extent of the penetration of DTS graduates in the industry.

Future Job Demand in Indonesia

According to the Bayes method, the following occupations are in high demand in Indonesia: (1) IT system programmer/developer/admin/system analyst (450,926); (2) IT web designer and developer (PHP, Magento, WordPress) (322,090); (3) creative content/content creator/creative designer/video editor/graphic designer (257,672); (4) mobile apps developer/android developer/app engineer (257,673); (5) IT software engineer. The results of the analysis showed a tendency that was almost the same as the results of the analysis using the Bayes method (Figure 3).

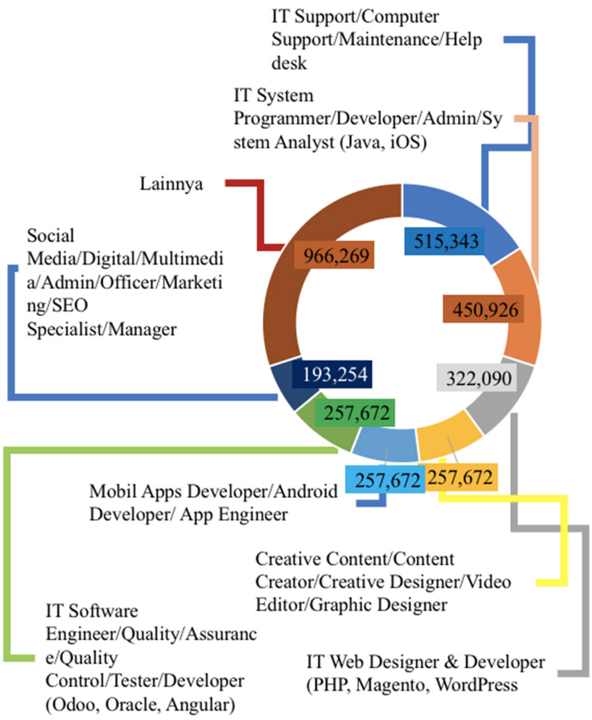

Figure 3. The distribution of the digitally skilled workforce demand forecasted for 2021–2025 based on primary data sources that used the Bayesian method.

The findings confirm previous studies. McKinsey predicts that there will be an additional 300,000 jobs in Indonesia related to technology professionals, such as web developers and IT specialists, who will experience a change in skills towards automation with a proportion of approximately 1% of the total number of jobs in 2030 [12]. This trend will certainly have a direct impact on the increasing need for a digital workforce, such as programmers for online commerce applications or platforms. In addition, due to the rapid growth of e-commerce in Indonesia, it is estimated that the number of e-commerce actors will increase from 4 million in 2019 to 26 million in 2022. The inevitability of the digital transformation in the MSME industry may necessitate the need for a digitally skilled workforce for an online business model that includes financial technology and digital marketing.

The results of this analysis, of course, still need to be interpreted with caution, especially in relation to the large number of workforces in the "other" category of ICT skills. The BPS data used in this analysis were structured by the categorization of ICT work fields according to the KBLI in 2020, where the "other" skills category included the types of ICT skills at that time that did not include future jobs. In the next few years, there is the possibility of the emergence of new fields of work or positions due to the increasing use of ICT in the workplace, and this will certainly encourage an increase in the need for the number of digitally skilled workers in Indonesia. As explained in the Report on the Future of Jobs [2], the fields of future work are data analytics and science, AI and machine learning specialists, big data specialists, digital marketing and strategy specialists, process automation specialists, business development professionals, digital transformation specialists, information security analysts, software and application developers, Internet of Things specialists, project managers, business services and administration managers, database and network professionals, robotics engineers, strategic advisors, management and organization analysts, fintech engineers, mechanics and machinery repairers, organizational development specialists, and risk management specialists. These fields of work may be included in the category of "Other" ICT work fields because they have not been clearly recorded in the KBLI 2020, especially business fields related to future jobs or future ICT jobs and new jobs or positions in the ICT field that are currently beginning to emerge and develop in Indonesia.

5. Conclusions

This study analyzed the digital skills gap in Indonesia through supply and demand. In this study, digital skills were understood to be specialized or advanced skills that promote the daily use of digital technology for intelligence-related tasks, technical functions for specific purposes, innovation-based outputs, transformative business models, and workplace culture both for the present and the future. Based on Indonesia's KKNI, digital workforces are workers or professionals who have ICT skills as complementary and specialist skills (expert groups) as well as ICT technicians, analysts, and managers (technical and analytical groups). The supply of skilled digital workforces is made up of graduates from vocational education (both high school and polytechnic) and higher degree education (universities) who are majoring in STEM, information, and communication programs. There were at least 2,457,321 graduates between 2016 and 2020. While the growth of ICT-related occupations in the same period was based on the Indonesian Statistic Agency's Sakernas data, there were at least 2,849,540 occupations. This means that there was a 392,219-person digital skills shortage during this time.

Based on the Bayesian method, it was forecasted that the supply of digitally skilled workers will exceed the demand in 2021–2025. The supply will reach at least 3,372,392 graduates, while there will be at least 3,220,897 occupations, or an average of 600,000 each year, available within that period, which means that the supply will be at least 151,495. Even though skilled digital workers are in short supply, this does not necessarily mean something positive. The biggest issues continue to be the mismatch and gap in digital skills.

This study recommends strategic planning to overcome these issues, which include the establishment of a national certification system in the ICT sector so that educational, training, and industrial employment institutions have clear guidelines on developing human resources for digital workers and prospective workers; the development of centers of excellence for industrial and university collaboration and the digital industry for the purpose of forming and enhancing digital skills as well as preparing prospective workers to enter industrial employment; and efforts to develop digital skills and talent training center models (including online training models, which can be applied by stakeholders according to the context of their respective situations and conditions). Furthermore, it suggests increasing apprenticeship and on-the-job training in industrial companies to more effectively and efficiently form new digital skills; talent scouting; and efforts to develop job market information systems and the digital economy business world to bring together job providers and job seekers so that a match between the supply and demand of a digital workforce can be realized.

It is important for the government to continue digital upskilling and reskilling programs that focus on high-demand occupations, such as data analysts, data scientists, information security analysts, business system analysts, e-commerce specialists, training and development specialists, user acquisition specialists, AI and machine learning specialists, digital transformation specialists, organizational specialists, IT service specialists, people and culture specialists, digital marketing specialists, IoT specialists, and cyber security specialists.

Author Contributions: Conceptualization, G.G.; methodology, G.G.; software, I.G.N.M.J.; validation, G.G. and I.G.N.M.J.; formal analysis, G.G. and V.M.R.; investigation, G.G., V.M.R. and I.G.N.M.J.; resources, G.G., V.M.R. and I.G.N.M.J.; data curation, I.G.N.M.J.; writing—original draft preparation, G.G., V.M.R. and I.G.N.M.J.; writing—review and editing, G.G. and V.M.R.; visualization, I.G.N.M.J.; supervision, G.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Ministry of Communication and Informatics of the Republic of Indonesia through the Center of Informatics Application and Information and Public Communication's 2021 annual budget.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The authors thank the other researchers that were part of a team based on a decree by the head of the Research and Human Resources Department of the Ministry of Communication and Informatics of the Republic of Indonesia, number 5/2021.

Conflicts of Interest: All authors declare that they have no conflict of interest. The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Indonesian government, particularly the Ministry of Communication and Informatics of the Republic of Indonesia.

References

1. Fonseca, L.M. Industry 4.0 and the Digital Society: Concepts, Dimensions and Envisioned Benefits. *Proc. Int. Conf. Bus. Excell.* **2018**, *12*, 386–397. [CrossRef]
2. World Economic Forum. *The Future of Jobs Report 2020*; World Economic Forum: Geneva, Switzerland, 2020.
3. Hartman, E.A.; Bovenschulte, M. Skills Needs Analysis for "Industry 4.0" Based on Roadmaps for Smart Systems. In *the Proceedings of the Using Technology Foresights for Identifying Future Skills Needs*; International Labour Organization: Moscow, Russia, 2014.
4. Namjoshi, J.; Rawat, M. Role of Smart Manufacturing in Industry 4.0. *Mater. Today Proc.* **2022**, *63*, 475–478. [CrossRef]
5. Linkedin LinkedIn Jobs on the Rise 2022: The 25 U.S. Roles That Are Growing in Demand. Available online: https://www.linkedin.com/pulse/linkedin-jobs-rise-2022-25-us-roles-growing-demand-linkedin-news/ (accessed on 26 August 2022).
6. Cunningham, W.; Moroz, H.; Muller, N.; Solatorio, A. *The Demand for Digital and Complementary Skills in Southeast Asia*; World Bank: Washington, DC, USA, 2022.
7. Google Temasek; Bain & Company. *E-Conomy SEA 2021: Roaring 20s the SEA Digital Decade*; Bain & Company: Boston, MA, USA, 2021.
8. Cabinet Secretariat Office. *Gov't Announces Five Priorities to Speed Up Digital Transformation*; Cabinet Secretariat Office: New Delhi, India, 2020.
9. Ministry of Foreign Affairs Rapat Terbatas Mengenai Perencanaan Transformasi Digital, 3 Agustus 2020, Di Istana Merdeka, Provinsi DKI Jakarta. Available online: https://kemlu.go.id/portal/id/read/1593/pidato/rapat-terbatas-mengenai-perencanaan-transformasi-digital-3-agustus-2020-di-istana-merdeka-provinsi-dki-jakarta (accessed on 27 August 2022).
10. Wisnumurti, A.A.G.O.; Darma, I.K.; Suasih, N.N.R. Government Policy of Indonesia to Managing Demographic Bonus and Creating Indonesia Gold in 2045. *IOSR J. Humanit. Soc. Sci.* **2018**, *23*, 23–34.
11. *Bappenas Rancangan Teknokratik: Rencana Pembangunan Jangka Menengah Nasional 2020–2024*; The Ministry of National Development Planning, 2019; pp. 1–289. Available online: https://www.bappenas.go.id/datapublikasishow?q=Rencana%20Pembangunan%20dan%20Rencana%20Kerja%20Pemerintah (accessed on 15 November 2022).
12. Das, K.; Wibowo, P.; Chui, M.; Agarwal, V.; Lath, V. *Automation and the Future of Work in Indonesia*; McKinsey & Company: Chicago, IL, USA, 2019.
13. Sudiyono, P.; Satria, N.; Sulistiono, A.A.; Mudrianingrum, Y. *Analisis Daya Serap Lulusan SMK Berdasarkan Kompetensi Keahlian*; McKinsey & Company: Jakarta, Indonesia, 2020.
14. van Laar, E.; van Deursen, A.J.A.M.; van Dijk, J.A.G.M.; de Haan, J. Twenty-First Century Digital Skills for the Creative Industries Workforce: Perspectives from Industry Experts. *First Monday* **2019**, *24*. [CrossRef]
15. Setyowati, D. Mampukah Omnibus Law Atasi Defisit Pekerja Digital Pada Startup? Available online: https://katadata.co.id/desysetyowati/digital/5f87f46cd976b/mampukah-omnibus-law-atasi-defisit-pekerja-digital-pada-startup (accessed on 27 August 2022).

16. Bell, D. *The Coming of Post-Industrial Society*; Harper Colophon Books; Basic Books: New York, NY, USA, 1974.
17. Webster, F. *Theories of the Information Society*; Routledge: London, UK, 2006.
18. Colbert, A.; Yee, N.; George, G. The Digital Workforce and the Workplace of the Future. *Acad. Manag. J.* **2016**, *59*, 731–739. [CrossRef]
19. UNESCO. *Digital Skills Critical Jobs and Social Inclusion 2018*; UNESCO: Paris, France, 2018.
20. OECD. *New Skills for the Digital Economy: Measuring the Demand and Supply of ICT Skills at Work*; OECD Digital Economy Papers; OECD: Paris, France, 2016.
21. ITU. *Digital Skills Toolkit*; ITU: Geneva, Switzerland, 2018.
22. Zhu, T.J.; Fritzler, A.; Orlowski, J. *Data Insights: Jobs, Skills and Migration Trends Methodology & Validation Results*; World Bank Group: Washington, DC, USA, 2018.
23. Government of Indonesia. *Kerangka Kualifikasi Nasional Indonesia*; Peraturan Presiden: Indonesia, 2012. Available online: https://peraturan.bpk.go.id/Home/Details/41251/perpres-no-8-tahun-2012 (accessed on 15 November 2022).
24. Kadir, S.; Nirwansyah; Bachrul, B.A. *Technical and Vocational Education and Training in Indonesia: Challeges and Opportunities for the Future*; National University of Singapore: Singapore, 2016.
25. Ceric, A.; Ivic, I. Construction Labor and Skill Shortages in Croatia: Causes and Response Strategies. *Organ. Technol. Manag. Constr. Int. J.* **2020**, *12*, 2232–2244. [CrossRef]
26. Paul, S. An Analysis of the Skill Shortage Problems in Indian IT Companies. *Soc. Sci.* **2018**, *7*, 159. [CrossRef]
27. Richardson, S. *What Is a Skill Shortage?* National Institute of Labour Studies Inc.: Adelaide, Australia, 2007.
28. CEDEFOP. *Insights into Skill Shortages and Skill Mismatch: Learning from Cedefop's European Skills and Jobs Survey 2018*; European Centre for the Development of Vocational Training: Thessaloniki, Greece, 2018.
29. Foroughi, A. Supply Chain Workforce Training: Addressing the Digital Skills Gap. *High. Educ. Ski. Work.-Based Learn.* **2021**, *11*, 683–696. [CrossRef]
30. Morris, D.; Vanino, E.; Corradini, C. Effect of Regional Skill Gaps and Skill Shortages on Firm Productivity. *Environ. Plan. A: Econ. Space* **2020**, *52*, 933–952. [CrossRef]
31. *World Bank Indonesia's Critical Occupations List 2018*; World Bank: Washington, DC, USA, 2020.
32. World Bank. *Preparing ICT Skills for Digital Economy: Indonesia within the ASEAN Context 2018*; World Bank: Washington, DC, USA, 2018.
33. Marsela, N.M.K.; Limbongan, K. *Indonesian ICT Workers: Determinants and Strategy to Support National Digital Transformation*; Asian Development Bank: Tokyo, Japan, 2021.
34. BPS. *Keadaan Angkatan Kerja Di Indonesia—Agustus 2020*; Badan Pusat Statistik: Jakarta, Indonesia, 2020.
35. Hyndman, R.J.; Kostenko, A.V. Minimum Sample Size Requirements for Seasonal Forecasting Models. *FORESIGHT* **2007**, *6*, 12–15.
36. Blangiardo, M.; Cameletti, M.; Baio, G.; Rue, H. Spatial and Spatio-Temporal Models with R-INLA. *Spat Spatiotemporal Epidemiol* **2013**, *4*, 33–49. [CrossRef] [PubMed]
37. Wiryasti, C.H.; Gunawan, J.; Muhamad, T. *Rapid Assessment of Information and Communication Technology Skills Demand in Indonesia*; ILO: Jakarta, Indonesia, 2020.
38. *Kominfo Connected Indonesia: More Digital, More Advanced (the 2020 Annual Report of the Ministry of Communications and Informatics of the Republic of Indonesia)*; Minister of Communications and Informatics of the Republic of Indonesia: Jakarta, Indonesia, 2020.
39. Tan, K.S.; Tang, J.T.H. New Skills at Work: Managing Skills Challenges in ASEAN-5. In *Research Collection School of Economics 2016*; J. P. Morgan: Singapore, 2016.
40. Zulfiyandi, S.E.; Wirawan, F.A.; Tanjung, N.P.S.; Yolanda, R.; Zaini, M.; Andrian, D.; Syafitri, K.; Amaldi, G.; Sidantha, I.N.B. *Ketenagakerjaan Dalam Data 2021*, 4th ed.; Zulfiyandi, S.E., Wirawan, F.A.W., Eds.; Pusat Data dan Teknologi Informasi Ketenagakerjaan: Jakarta, Indonesia, 2021.
41. SMERU. *Strategy Primer Accelerating Digital Skills Development in Indonesia*; SMERU: Jakarta, Indonesia, 2022.
42. Oxford Analytica. *Indonesia's Structural Gaps Impede Its Digital Economy*; Expert Briefings 2021; Oxford Analytica: Oxford, UK, 2021.
43. *Alpha Beta Building Digital Skills for the Changing Workforce in Asia Pacific and Japan (APJ): AWS APJ Digital Skills Study 2022*; Amazon Web Services: Seattle, WA, USA, 2022.
44. Alpha Beta Keterampilan Untuk Masa Depan: Memperkuat Ekonomi Indonesia Dengan Meningkatkan Keterampilan Digital 2021. 2021. Available online: https://fdocuments.net/document/keterampilan-untuk-masa-depan-alphabeta.html?page=1 (accessed on 15 November 2022).
45. DTS Kominfo Digital Talent Scholarship. Available online: https://digitalent.kominfo.go.id/ (accessed on 30 October 2022).