Vol. 2, No. 1, 2025
DOI: 10.61975/gjbes.v2i1.60

ORIGINAL ARTICLE

The Influence of Information and Communication Technology and Demographic Variables on the Indonesian Economy: Before and During COVID-19

Ferayanti Ferayanti*, Cut Risya Varlitya, Novi Indriyani Sitepu and Chenny Seftarita

Department of Economics, Faculty of Economics and Business, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia

* Correspondence: ferayanti@usk.ac.id

Article History

Received
10 October 2024

Accepted
20 December 2024

Available Online
28 December 2024

Keywords

ICT
Economic growth
Demographic
E-commerce
COVID-19

Abstract

Changes in population and advancements in information and communication technology (ICT) have significantly transformed the global economy. While the individual effects of these factors on economic growth have been extensively studied, little is known about their interaction, particularly in the context of the COVID-19 pandemic. The pandemic introduced new economic dynamics by altering consumer behavior and accelerating the adoption of digital technology. This study investigates the combined impact of ICT advancements and demographic shifts on Indonesia's economic growth before and after the pandemic. Using panel data from 2015 to 2021, a regression model explores the correlations between these factors. The results reveal that e-commerce, internet usage, and demographic factors positively influence economic growth. However, a negative correlation is observed between economic growth and mobile phone usage. Notably, economic expansion driven by ICT was more pronounced in the pre-COVID-19 period than in the post-pandemic era. To fully harness the potential of digital transformation and sustain growth, government interventions are essential. These include supporting MSMEs in developing digital capabilities, accelerating digital infrastructure development, enhancing digital human resources, streamlining regulations, and leveraging big data to guide policy decisions.

Introduction

The fundamental framework of the Solow [1], states that improvements in the quantity of labor and capital—two components of production—as well as the efficiency with which these factors are employed, are what propel economic progress. Soejoto et al. [2], conducted a study that examined how the Solow variables—investment, labor, technology, natural resources, and human resources—affect economic growth in several Southeast Asian nations. The findings indicate that investment, technology, labor, and natural resources are the factors that significantly impact economic growth, particularly in Indonesia. As Mankiw [3] highlights, technological advancement is crucial to this. Innovation in technology not only boosts output but also opens new markets, encourages competition, and expands customer options. Stated differently, the dynamic interplay between the accumulation of factors of production and ongoing technological innovation leads to economic progress. According to Pohjola [4], information technology investment is a major driver of economic growth. Economic growth is typically higher in nations with greater IT investment.

According to Farhadi et al. [5] Information and Communication Technology (ICT) and the real GDP growth rate per capita are positively correlated. Economic growth is positively correlated with a nation's level of information and telecommunications technology development. This further demonstrates the tendency for nations with fast ICT development to experience faster economic growth. Today, demographic shifts and technological advancements have significantly changed the global economy. The book The Second Machine Age by Brynjolfsson

& McAfee [6] highlights how the digital revolution has altered business, trade, and interaction patterns. ICTs, or information and communication technologies, have emerged as a major force behind digital transformation by enabling quick access to data, process automation, and innovative, effective business models. Changes in the population's age distribution (the proportion of children, adults, and the elderly) have a significant influence on how people behave economically, according to Bloom et al. [7]. With the right policies in place, nations with a high percentage of working-age citizens may benefit from a "demographic dividend" that spurs economic expansion. ICT and population shifts (demography) play a critical role in influencing the world economy. Countries that can effectively harness these two variables—such as policies that encourage innovation and investment, and provide sufficient worker education and training—will find it easier to achieve long-term economic growth.

Meanwhile, the global economy faces both opportunities and challenges due to demographic dynamics, especially the rapid urbanization and population growth in developing nations. According to Gerlan [8] urbanization has increased the demand for public services, housing, and infrastructure. The World Bank [9] reports that the population of developing nations is growing, creating a sizable consumer market, especially for digital goods and services. This is consistent with research conducted by the McKinsey Global Institute [10] which found that population growth and urbanization in developing nations were major drivers of global economic expansion in previous decades.

Indonesia's national economic landscape is changing as a result of global factors interacting with local phenomena such as the demographic bonus and the growing use of digital technology. The COVID-19 pandemic in Indonesia has accelerated the development of digital transformation. According to the research by Oikonomou et al. [11] areas with higher IT usage before the pandemic had lower unemployment rates during the COVID-19 pandemic compared to areas with lower IT adoption. This demonstrates a link between IT use and labor market resiliency. Higher IT utilization promotes the creation of digital jobs, allowing the economy to better cope with the mobility constraints caused by the pandemic. This was highlighted by Adiningsih [12] who stated that digital transformation in Indonesia experienced significant acceleration during the pandemic. During this period, the use of digital technology by the public and the business sector expanded into various aspects of life, such as working, studying, shopping, and conducting business. This shift was due to the Large-Scale Social Restrictions (PSBB) policy imposed to curb the spread of the virus. As a result, the e-commerce sector experienced rapid growth as more people utilized online platforms to meet their daily needs. According to Prasidya & Dewi [13] the COVID-19 pandemic has encouraged many businesses, particularly Micro, Small, and Medium Enterprises (MSMEs), to migrate to digital platforms as the digital economy expanded, with 3.8 million MSMEs successfully entering the digital ecosystem by the end of 2020. Zou & Cheshmehzangi [14] also noted that the pandemic advanced digitalization in all parts of life and business, causing many individuals to rely on digital technology to meet their basic needs.

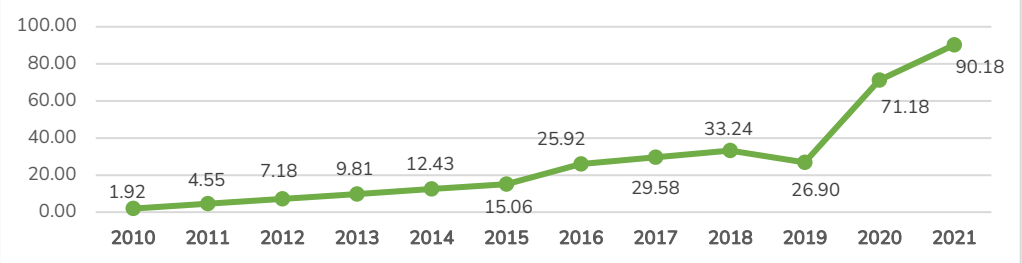

Figure 1. Percentage of e-commerce businesses by province (%).
Source: Statistics Indonesia (BPS) and data interpolation results.

Figure 1 shows the upward trend in the percentage of e-commerce businesses from 2010 to 2018. In 2019, there was a decrease in the percentage due to the COVID-19 pandemic. However, in 2020-2021, along with economic recovery, the percentage of e-commerce businesses experienced a significant increase [15]. This reflects the rapid development of e-commerce businesses in Indonesia during the pandemic, characterized by increased public interest in online shopping and the utilization of digital platforms by businesses to market their products.

The development of e-commerce businesses is supported by increased internet access and the use of digital devices such as smartphones and computers among the public. In addition, Indonesia's large proportion of the productive-age population is also driving the growth of the digital economy. The expansion of e-commerce and digital consumption depends on the productive population, which is made up of individuals in the prime working-age group, typically 15–64 years old [16]. This group, which adopts technology at a high pace, is a major driver of the digital revolution in the modern economy. Bharadwaj et al. [17], assert that the productive age group utilizing digital technology is essential for promoting innovation and growth in the e-commerce sector. During the COVID-19 pandemic, there has been a significant increase in the percentage of households accessing the internet, as well as the use of mobile phones and computers, which are key enablers of internet use. The findings of Nurcaya et al. [18] indicate that MSMEs leveraging IT have experienced improvements in service delivery, customer relationships, and overall operational efficiency.

The majority of internet users in Indonesia access it through smartphones. This is reflected in data from Badan Pusat Statistik (BPS) [19], which shows that the number of internet-using households reached 82.07%. Mobile phone ownership in Indonesia is also very high, reaching 90.54% in 2021. Meanwhile, household computer ownership experienced a rapid increase in 2018, but since then, its use has continued to decline. This trend is due to the rapid development of smartphone features and design, which have made this platform more attractive to the public. In an article titled Exploring the Development of Smartphone Use in Indonesia, Adisty [20] found that the productive age group uses smartphones the most, with 75.95% of people in the 20–29 age group, 68.34% of people in the 30–49 age group, and 50.79% of those in the 50–79 age group using smartphones. Men make up a larger percentage of smartphone users (67.41%) than women (65.09%), according to the gender distribution of smartphone users.

The growth of the productive-age population is directly proportional to the increase in Indonesia's GDP, which reached IDR 11,118,868 billion in 2021. As seen in Figure 2, Indonesia's economic trend from 2015 to 2021 shows a sustainable recovery. In 2015, Indonesia's GDP was IDR 8,982,517 billion and continued to increase until 2019. However, in 2020, the Indonesian economy experienced a slowdown due to the global COVID-19 pandemic. In 2021, Indonesia's economy recovered, characterized by an increase in GDP [19]. This was noted in the World Bank's 2022 study on Indonesia's economic prospects, which showed steady growth from 2015 to 2021 despite a notable drop in 2020 due to the epidemic.

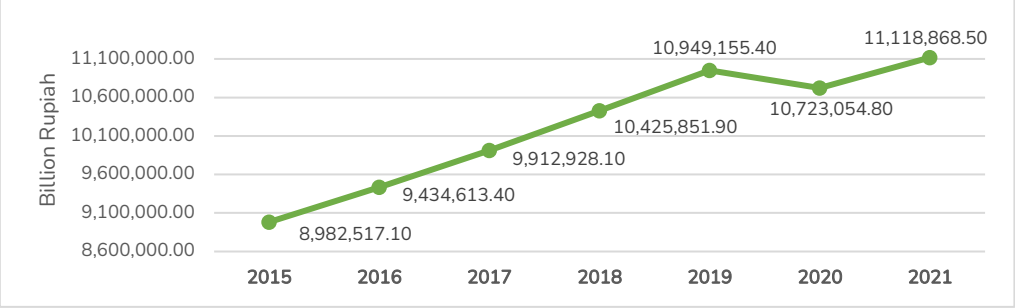

Figure 2. Indonesia's GDP at Constant Prices 2010 by Industry.
Source: Statistics Indonesia (BPS).

Brynjolfsson & McAfee [6] highlighted that ICT is having a major impact on overall economic growth in addition to altering how firms function. through improving the effectiveness of production, distribution, and consumption in all cases. Additionally, ICT plays a significant role in generating new opportunities and income in the digital age. Furthermore, it is said that ICT is a major force behind the modern economy, generating a more effective and responsive system to market demands through e-commerce, internet networks, and digital devices. Waverman et al. [21] asserted that by lowering transaction costs and opening up new markets, investments in the telecommunications industry greatly boost economic growth in developing nations and improve access to information. As the main communication tool, mobile phones boost efficiency and penetration while generating network effects that attract new users. The value of every link rises with the number of connected individuals, propelling economic efficiency and output growth. ICT is instrumental in facilitating the distribution of goods and services, especially for archipelagic countries like Indonesia. The productive age is the period when the population is actively working, and available jobs generally rely on the use of ICT. This also applies to export and import activities of goods and services, which are increasingly dominated by ICT. According to Alwan et al. [22] pandemic caused considerable changes in people's consumption patterns due to mobility constraints that required them to stay home. Many people, including those who were previously unfamiliar with technology, started using e-commerce platforms to address both basic and non-basic demands. The security of online shopping is a key draw because it reduces the chance of virus infection, while direct home delivery options provide added convenience. Work-from-home policies also hastened people's adaptation to digital technologies, making online shopping not merely a temporary solution, but also a new habit that strengthens the transition to a digital economy.

This study examines how Indonesia's economic growth has been impacted by demography and ICT, specifically during and after the COVID-19 pandemic. It looks at demographic factors that influence economic growth, such as the size of the working-age population, in addition to assessing the effects of e-commerce, the internet, computers, and mobile phones. The findings demonstrate that ICT use promotes economic growth, particularly among working-age individuals. It is anticipated that the results will serve as a foundation for sound economic policymaking and provide an empirical understanding of the dynamics of Indonesia's digital economy. The study also finds that Indonesia's economic growth is significantly influenced by ICT use. To accelerate digital transformation and achieve more inclusive growth, the government must enhance ICT infrastructure and access, offer digital training, establish an ecosystem that encourages investment and innovation in the digital sector, and regularly monitor and assess the effects of policies.

Materials and Methods

Research Design, Data and Variables

This study employs both descriptive and analytical research designs, utilizing a quantitative approach. The primary objective of this research is to examine how demographic and ICT factors affect Indonesia's economic growth using panel data. The study's population consists of all Indonesian provinces, with a sample of 34 provinces spanning the years 2015–2021. The factors included in the data are relevant to the goals of the study. Secondary data for this investigation was provided by Statistics Indonesia (BPS). The data collected includes information on the working-age population, as well as data on computers, mobile phones, e-commerce, and internet usage. Table 1 lists the variables used in this study.

Table 1. Research variables.

Variable	Definition	Unit of Measurement	Source
logGDP	Proxies for economic growth.	Trillions Rupiah	BPS
ECOM	Households involved in e-commerce in each province.	Percent	BPS
RTPI	Households with internet access in each province.	Percent	BPS
RTPTS	Households with mobile phones in each province.	Percent	BPS
RTPK	Households with computers in each province.	Percent	BPS
LogDEMO	Productive-age population (15–64 years), calculated in logarithmic form.	Logarithmic value	BPS
D	Dummy variable indicating periods before (0) and after (1) the COVID-19 pandemic.	Indicator (0 or 1)	Author's own calculations

Method of Analysis

The collected data was then organized into panel data for further analysis. A panel data regression model was employed to analyze the data. The following steps were taken during the analysis: First, the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM) were used as estimation models. Second, model tests were conducted using the Chow, Hausman, and Lagrange Multiplier (LM) tests to identify the optimal model. Third, statistical tests, including t-tests, f-tests, and coefficient of determination calculations, were performed to determine the significance of the model. Finally, the regression model was formulated by applying the panel regression model that had been previously developed.

The basic panel data regression used in this study is described in Equation 1 [23].

$$Y_{it} = \beta_1 + \beta_2 X_{2it} + \beta_3 X_{3it} + \varepsilon_{it} \quad (1)$$

Then, the formulation in Equation 1 was adjusted to the panel data regression model used in this study, as shown in Equation 2.

$$LogGDP_{it} = \beta_0 + \beta_1 ECOM_{it} + \beta_2 RTPI_{it} + \beta_3 RTPTS_{it} + \beta_4 RTPK_{it} + \beta_5 logDEMO_{it} + \beta_6 D_{it} + \varepsilon_{it} \quad (2)$$

Where *GDP* represents economic growth, *ECOM* indicates the percentage of e-commerce adoption, *RTPI* refers to the percentage of households using the internet, RTPK denotes the percentage of households using computers, and *RTPTS* corresponds to the percentage of households using mobile phones. *LogDEMO* reflects demographics, specifically the number of individuals of productive age during the demographic bonus era. *D* is a dummy variable, where 0 represents the period before the COVID-19 pandemic and 1 represents the period after the pandemic. The subscript i refers to cross-sectional data for 34 provinces in Indonesia, while t represents the time period from 2015 to 2021.

The FEM, REM, and error component model (ECM) are the three estimation methodologies used. Greene [24] provides an explanation of the fundamental framework of the regression model, as shown in Equation 3.

$$y_{it} = x'_{it}\beta + z'_{i}\alpha + \varepsilon_{it} \quad (3)$$

FEM, REM, and Pooled Regression are considered when selecting the regression model. To examine the impact of ICT and demographic factors on the Indonesian economy, this research model is adjusted based on the previously described panel data regression model.

Results and Discussion

Model Selection

To accurately select the panel models, the Chow, Hausman, and LM tests were conducted. The detailed results are presented in Tables 2, 3, and 4. The F-test (Chow test) is used to determine the most suitable model between CEM and FEM. The Chow test results show that the Period F value is 0.00 < 0.05, indicating the FEM model is preferred based on these criteria. Next, the Hausman test was carried out to choose between FEM and REM. With the Random Period Probability Value at 1.00 > 0.05, the REM model is selected according to the model selection requirements. Finally, the Lagrange Multiplier (LM) test was used to decide between CEM and REM. The Breusch-Pagan test yielded a value of 0.00 < 0.05, leading to the selection of the REM model. Based on the results of the Chow, Hausman, and Lagrange Multiplier tests, the REM is the final model choice.

Table 2. Chow Test.

Effects Test	Statistics	df	Prob.
Cross-section F	2480.5	(33,198)	0.0000
Cross-section Chi-square	1434.4	33	0.0000
Chow Test	H_0: CEM	H_0 : Accepted if the cross section F > 0.05	
	H_a: FEM	H_a : Accepted if cross section F > 0.05	

Table 3. Hausman Test.

Test Summary	Chi-Sq. Statistic	Chi-Sq. df	Prob.
Random cross-section	0.0000	6	1.0000
Hausman test	H_0: BRAKE	H_0: Accepted if probability > 0.05	
	Ha: FEM	H_a: Accepted if probability < 0.05	

Table 4. Lagrange Multiplier (LM) Test.

Test Summary	Cross section	Time	Both
Breusch Pagan	659.86	1.0265	660.89
	(0.0000)	(0.3110)	(0.0000)
Lagrange Multiplier Test	H_0 : CEM	H_0: Accept if Breusch Pagan probability > 0.05	
	H_a: BRAKE	H_a: Accept if Breusch Pagan probability < 0.05	

Regression Results

The results of the regression analysis as shown in Table 5 reveal several insights into the factors influencing GDP growth. The variable ECOM (0.0004) indicates that for every unit increase in e-commerce penetration (such as a 1% rise), the LogGDP will increase by 0.0004%. Although the effect is modest, the statistical significance of this value suggests that e-commerce positively contributes to GDP growth. RTPI (0.0059) shows a more pronounced impact, with LogGDP increasing by 0.0059% for every 1% increase in the ICT Index, implying that IT development has a greater effect on GDP growth than e-commerce. RTPK (0.0002) represents household computer usage, and while it contributes to GDP growth, its effect is relatively small. The negative coefficient for RTPTS (-0.0015) suggests that as mobile phone usage increases, GDP growth may decline, potentially due to factors like unemployment. However, this relationship is not statistically significant. The LOGDEMO (0.0407) variable shows a strong and statistically significant coefficient, indicating that a rise in the productive-age population can significantly accelerate GDP growth, likely tied to population expansion. Finally, the DUMMY variable (-0.0523) reflects the impact of specific events or policies, such as a lockdown during the pandemic. The negative coefficient suggests that these events or policies had a detrimental effect on GDP growth.

Table 5. REM regression results.

Dependent: LogGDP				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	4.1703	0.4673	8.9252	0.0000
ECOM	0.0004	0.0004	1.0308	0.3037
RTPI	0.0059	0.0003	17.869	0.0000
RTPK	0.0002	0.0025	0.0862	0.9314
RTPTS	-0.0015	0.0018	-0.8239	0.4110
LogDEMO	0.0407	0.0289	1.4042	0.1616
D	-0.0529	0.0215	-2.4595	0.0146
R-squared	0.7575	F-statistic	120.28	
Adj. R-squared	0.7512	Prob(F-statistic)	0.0000	

Moreover, the R-squared value of 0.75 indicates that the independent variables collectively account for 75% of the variation in LogGDP. Specifically, 75% of the variance in LogGDP can be explained by the variables ECOM, RTPI, RTPK, RTPTS, LogDEMO, and DUMMY, while the remaining 25% is influenced by factors not explicitly included in the model. These factors could include random variables, measurement errors, or other unobserved variables. Additionally, simultaneous statistical testing using the F-test yielded a probability value of 0.0000, which is less than the significance level of 0.05. Therefore, it can be concluded that ECOM, RTPI, RTPK, RTPTS, LogDEMO, and DUMMY collectively have a significant effect on LogGDP.

In this study, the equation is analyzed both before and during the occurrence of Covid-19. A dummy variable is used to represent the impact of the pandemic, where 1 denotes the period during Covid-19, and 0 represents the period before Covid-19.

Before Covid-19 (DUMMY = 0):

LogGDP = 4.1703 + 0.0004.ECOM + 0.0059.RTPI + 0.0002.RTPK – 0.0015.RTPTS + 0.0407.LogDEMO

This equation illustrates the relationship between the independent variables and LogGDP before the onset of the Covid-19 pandemic.

During Covid-19 (DUMMY = 1):

LogGDP = 4.1174 + 0.0004.ECOM + 0.0059.RTPI + 0.0002.5RTPK – 0.0015.RTPTS + 0.0407.LogDEMO

This formula illustrates the connection during the COVID-19 epidemic. As shown above, the key distinction between these two equations lies in the intercept term:

- Before Covid-19, the intercept is 4.1703.
- During Covid-19, the intercept is 4.1174.

The decrease in the intercept value suggests that the pandemic may have influenced the overall level of LogPGDP (and thus, GDP). Specifically, the decline in the intercept indicates a potential negative impact of the pandemic on GDP. The difference in intercepts, (4.1703 - 4.1174 = 0.0529), represents the effect of Covid-19, with all other factors held constant. This result implies that the pandemic likely exerted a detrimental influence on the baseline level of GDP.

While the baseline LogGDP level is lower during the pandemic, the relationship between LogGDP and the independent variables remains unchanged before and during Covid-19. This suggests that, although the impact of the pandemic on GDP was negative in terms of the baseline level, the proportional influence of the other factors on GDP growth remained largely constant.

Classical Assumption Tests

Multicollinearity Test

The multicollinearity test is designed to assess whether there is a high or perfect correlation between the independent variables in a regression model. If a high correlation is found, it suggests the presence of multicollinearity. The results of the correlation matrix (Table 6) and the Variance Inflation Factors (VIF) (Table 7) are provided to evaluate this. A correlation value of 0.7 or 0.8 (70% or 80%) is typically considered tolerable in a multicollinearity test. Based on the results, the correlation values for the variables ECOM, RTPI, RTPK, RTPTS, LOGDEMO, and DUMMY are mostly less than 0.8, with the exception of the correlation between ECOM and DUMMY, indicating that there is no significant multicollinearity issue overall.

The Variance Inflation Factor (VIF) is another statistic used to assess multicollinearity in a regression model. A high centered VIF value suggests that an independent variable is highly correlated with other independent variables in the model. The VIF results from this study can be explained as follows:

- ECOM (14.047): This very high VIF value indicates a strong correlation between the ECOM variable and at least one other independent variable, suggesting a serious multicollinearity problem that should be addressed.
- RTPI (4.2171): Although the VIF value for RTPI is high, it may not indicate a severe multicollinearity problem if the centered VIF remains within acceptable limits. However, it should still be monitored.
- RTPK (1.9782) and RTPTS (1.948438): VIF values close to 1 for RTPK and RTPTS indicate that these variables do not exhibit significant multicollinearity problems.
- LOGDEMO (1.3049): Similar to RTPK and RTPTS, the LOGDEMO variable also shows no significant multicollinearity issues.
- D (11.205): The relatively high VIF for the DUMMY variable suggests a moderate multicollinearity problem, which warrants attention.

Table 6. Results of correlation matrix.

Independent Variable	ECOM	RTPI	RTPK	RTPTS	LogDEMO	D
ECOM	1					
RTPI	0.6798	1				
RTPK	0.0011	0.4526	1			
RTPTS	0.2207	0.5953	0.4976	1		
LogDEMO	0.0987	0.2560	-0.0838	0.2890	1	
D	0.9482	0.5808	-0.0686	0.1835	0.0464	1

Table 7. Results of VIF.

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.7496	291.22	n/a
ECOM	0.0001	46.740	14.047
RTPI	0.0001	53.027	4.2171
RTPK	0.0001	24.897	1.9782
RTPTS	0.0001	275.38	1.9484
LogDEMO	0.0025	210.42	1.3049
D	0.1413	15.687	11.205

Heteroscedasticity Test

Heteroscedasticity is tested to determine whether the regression model exhibits unequal variances in the residuals across observations. Based on the results in Table 8, there is no evidence of heteroscedasticity in ECOM, RTPI, RTPK, RTPTS, and D, as the probability values are greater than 0.05, except for the variable LogDEMO.

Table 8. Results of heteroscedasticity test.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.480804	0.998089	3.487467	0.0006
ECOM	-0.001888	0.001292	-1.461615	0.1452
RTPI	0.001433	0.001052	1.361990	0.1745
RTPK	-0.009328	0.007426	-1.256137	0.2103
RTPTS	0.004983	0.005476	0.909987	0.3638
LogDEMO	-0.216107	0.062984	-3.431145	0.0007
D	0.034565	0.069496	0.497372	0.6194

Autocorrelation Test

Autocorrelation testing is conducted to determine if there is correlation between the residuals across a series of observations over a specific period. According to Gujarati (2003), autocorrelation cannot be detected in panel data. To address this issue, the regression model can be adjusted to Generalized Least Squares (GLS), which is a remedy for autocorrelation. In this study, the EGLS (Cross-Section Random Effect) panel method was used, making it possible to conclude that autocorrelation has been effectively addressed.

Discussion

The findings of this study show that the value of the fundamental GDP constant (LogGDP) fell from 4.17 before the COVID-19 pandemic to 4.11 during the pandemic. This dip shows the slowing of economic growth induced by the epidemic. This data is confirmed by Dinata [25] conclusions, which state that the pandemic lowered foreign investment in Indonesia, resulting in a drop in economic growth from 5.02% in 2019 to 2.97% in 2020. The unemployment rate also rose from 5.28% in 2019 to 7.07% in 2020. Nonetheless, the link between LogGDP and independent variables (ECOM, RTPI, RTPK, RTPTS, and LOGDEMO) was consistent both before and during the epidemic. This suggests that, while the pandemic had a fundamentally negative impact on GDP, the relative influence of other factors on GDP growth remained stable. These findings are consistent with the findings of Zou & Cheshmehzangi [14], who discovered that the use of computers, mobile phones, and the COVID-19 pandemic had a negative influence on economic growth, whereas e-commerce, internet users, and demographic factors had a beneficial impact. The only change is the influence of computer users, although the basic trend is continuous. Furthermore, Adiningsih [12] noted that the COVID-19 epidemic hastened digital transition, increasing reliance on technology for everyday tasks such as purchasing items. With societal limitations, e-commerce has grown in popularity, particularly for food and staples, while small and medium-sized firms (SMEs) have begun to transition to digital platforms to increase access to global markets and retain economic sustainability.

These findings underscore the importance of digital transformation as one of the main pillars supporting economic growth, especially in challenging times such as the COVID-19 pandemic. The consistent influence of variables such as e-commerce and demographics on GDP shows the great potential of digital technology in driving economic sustainability. In addition, the negative impacts of computer and mobile phone use need to be examined in greater depth. This may be related to suboptimal productivity levels due to digital distractions or a lack of technology optimization in the economic sector. Therefore, there needs to be a more targeted strategy to ensure that technology is not only adopted but also utilized efficiently. Moreover, the government, business actors, and educational institutions have a major role in building an inclusive digital ecosystem by providing digital literacy training, increasing access to technology infrastructure, and encouraging innovation in the MSME sector.

Furthermore, in the context of e-commerce growth, the increasing number of internet users and the demographics of the productive-age population have made a positive contribution to the Indonesian economy. E-commerce not only increases demand for logistics services but also

opens up new business opportunities in the sector. In addition, with the increasing speed and capacity of the internet, new creative industries such as digital media, music, video, and applications have been created, which support the growth of the digital economy. The internet also functions as a platform for accessing market information, technology, and business trends, greatly assisting MSMEs in expanding their markets and increasing their competitiveness. This finding is in line with research conducted by Zou & Cheshmehzangi [14], which shows that although the pandemic has had a negative impact on GDP, sectors such as e-commerce and digital technology continue to make a positive contribution to the economy. This is also supported by Sumanjeet [26], who stated that e-commerce can reduce the cost of retail and wholesale trade services and encourage wider adoption of digital payment systems. Another study by Cahyani et al. [27] also noted that many MSMEs are turning to digital platforms and social media to increase their visibility and sales as more consumers turn to online shopping.

In addition, the results of this study are also consistent with the findings of Bahrini & Qaffas [28], El-Moghazi et al. [29], and Sangki [30], which show a positive correlation between the development of ICT and economic growth. Bahrini & Qaffas [28] found that broadband adoption and internet usage significantly contribute to economic growth, while El-Moghazi emphasized the importance of efficient telecommunications infrastructure in improving accessibility and efficiency of services. Sangki also showed that effective telecommunications infrastructure can enhance government efficiency and drive economic growth. However, the study also noted that while computer and mobile phone usage is increasing, it is not always directly proportional to increased productivity. This is due to the less-than-optimal use of devices to improve digital skills. Excessive use of devices for less productive activities, such as playing games or accessing social media, can divert time and resources that should be allocated to more useful activities.

Conclusions

The rapid development of digital technology and changing demographics have contributed significantly to economic growth. E-commerce, supported by the increasing number of internet users and the productive-age population, has fueled innovation and created new business opportunities. However, the optimal utilization of technology is still constrained by the lack of digital skills and the unproductive use of devices. In addition, the COVID-19 pandemic has had a negative impact on the economy, disrupting supply chains and reducing people's purchasing power. Nonetheless, the potential for growth in the digital economy is still enormous, especially if accompanied by increased digital literacy and appropriate policy support.

To boost economic growth, integrated policies that combine the development of information and communication technology (ICT) with demographic development are needed. Strategic measures such as providing fiscal incentives to e-commerce platforms, building adequate logistics infrastructure, and improving people's digital literacy are crucial. This allows MSMEs to more easily access a wider market and fosters digital innovation. In addition, supporting the younger generation with an interest in digital technology through training programs and incentives is crucial to developing the human resources that will be the main drivers of the digital economy in the future. The development of technology, especially e-commerce and the internet, has had a significant impact on economic growth by opening up new market opportunities for MSMEs and fueling the growth of the logistics and digital payment industries. However, to optimally utilize technology, efforts are needed to improve people's digital literacy, as well as the government's active role in regulating digital content and providing support to MSMEs to adapt to technological developments. Thus, we can maximize the potential of technology in driving economic growth while minimizing its negative impacts.

This study contains limitations that must be acknowledged, including the study's specific focus on certain aspects, the limited data provided, the lack of qualitative analysis, and the restricted generalizability of the results. Technology is very dynamic, and this study may change in reaction

to the rapid development of technology. As a result, more comprehensive research with a broader context is required to acquire a better understanding of the effects of digital technology.

Funding: This study was funded by the Institute for Research and Community Service (LPPM), Universitas Syiah Kuala.

Data Availability Statement: The data is freely available on the Statistics Indonesia (BPS) website.

Acknowledgments: The authors would like to thank their institution, Universitas Syiah Kuala.

Conflicts of Interest: All the authors declare no conflicts of interest.

References

[1] Solow RM. A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics* 1956;70:65. https://doi.org/10.2307/1884513.
[2] Soejoto A, Cahyono H, Solikhah M. International Journal of Economics and Financial Issues Effect of Solow Variable to the Economic Growth in Southeast Asia. *International Journal of Economics and Financial Issues* 2017;7:277–82.
[3] Mankiw NG. Principles of Economics. 4th ed. South-Western Cengage Learning: South-Western Cengage Learning; 2006.
[4] Pohjola M. Information Technology and Economic Growth: A Cross-Country Analysis. Helsinki, Finlan: 2000.
[5] Farhadi M, Ismail R, Fooladi M. Information and Communication Technology Use and Economic Growth. *PLoS ONE* 2012;7. https://doi.org/10.1371/journal.pone.0048903.
[6] Brynjolfsson, E., & McAfee A. The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies. 2014.
[7] Bloom DE, Canning D, Sevilla J. Economic Growth and the Demographic Transition 2001.
[8] Gerlan P. Introduction to the 27th Revision of World Population Prospects. 2021.
[9] World Bank. The World Bank Annual Report 2022: Building a Better Future for All. 2022.
[10] McKinsey Global Institute. The Future of Work: How Artificial Intelligence Will Transform Jobs. 2016.
[11] Oikonomou, M., Pierri, N., & Timmer Y. IT Shields: Technology Adoption and Economic Resilience during the COVID-19 Pandemic. *Labour Economics* 2023;81:102330. https://doi.org/10.1016/j.labeco.2023.102330.
[12] Adiningsih S. COVID-19 Impact on Digital Economy: Indonesian Case 2021.
[13] Prasidya TCIT, Dewi WC. Digital Economy to Boost Economy Recovery Post-Pandemic: Indonesia's Strategic Position As New Economic Power in Southeast Asia. *Global South Review* 2023;4:81. https://doi.org/10.22146/globalsouth.83331.
[14] Zou T, Cheshmehzangi A. ICT Adoption and Booming E-Commerce Usage in the COVID-19 Era. *Frontiers in Psychology* 2022;13:1–6. https://doi.org/10.3389/fpsyg.2022.916843.
[15] Badan Pusat Statistika. Statistik E-Commerce 2022/2023, 2023.
[16] Chaudhuri A, Holbrook MB. The Chain of Effects from Brand Trust and Brand Affect to Brand Performance: The Role of Brand Loyalty. *Journal of Marketing* 2006;70:34–49.
[17] Bharadwaj A, El Sawy OA, Pavlou PA, Venkatraman N. Digital Business Strategy: Toward a Next Generation of Insights. *Demystifying Your Business Strategy* 2020:13–26. https://doi.org/10.4324/9780203109007-5.
[18] Nurcaya IN, Rahyuda IK, Giantari GAK, Ekawati NW. The Effect of Information Technology on the Performance of MSMEs during the COVID-19 Pandemic. *International Journal of Social Science and Business* 2022;6:262–7. https://doi.org/10.23887/ijssb.v6i2.44260.
[19] Badan Pusat Statistik (BPS). Laporan Perekonomian Indonesia 2022 2022.
[20] Adisty N. Mengulik Perkembangan Penggunaan Smartphone Di Indonesia. *GoodStats* 2022.
[21] Waverman L, Meschi M, Fuss M. The Impact of Telecoms on Economic Growth in Developing Countries. *Africa the Impact of Mobile Phones* 2005;2:1–23.
[22] Alwan SY, Hu Y, Al Asbahi AAMH, Al Harazi YK, Al Harazi AK. Sustainable and Resilient E-Commerce under COVID-19 Pandemic: A Hybrid Grey Decision-Making Approach. *Environmental Science and Pollution Research* 2023;30:47328–48. https://doi.org/10.1007/s11356-023-25456-0.
[23] Gujarati DN. Basic Econometrics. 2nd Editio. McGraw-Hill; 1993.
[24] Greene WH. Econometric Analysis 4th Ed. 2000.
[25] Dinata MP. Pandemi COVID-19 Dan Menurunnya Perekonomian Indonesia. *Kemeunkeu RI* 2023.
[26] Sumanjeet. E-Commerce and Its Impact on the Economy: A Study of the UNCTAD Report. 2011.

[27] Cahyani L, Hidayat R, Marcelino D. Strengthening Digital Capabilities and Entrepreneurship for SMEs in the Creative Economy Sector during a Pandemic. *Jurnal Penyuluhan* 2023;19:93–103. https://doi.org/10.25015/19202342367.

[28] Bahrini R, Qaffas AA. Impact of Information and Communication Technology on Economic Growth: Evidence from Developing Countries. *Economies* 2019;7. https://doi.org/10.3390/economies7010021.

[29] El-Moghazi M, Whalley J, Irvine J. Technology Neutrality: Exploring the Interaction between International Mobile Telecommunication and National Spectrum Management Policies. *Telecommunications Policy* 2019;43:531–48. https://doi.org/10.1016/j.telpol.2019.01.002.

[30] Sangki J. Vision of Future E-Government via New E-Government Maturity Model: Based on Korea's E-Government Practices. *Telecommunications Policy* 2018;42:860–71. https://doi.org/10.1016/j.telpol.2017.12.002.