

The Impact of Digitalization on Economic Growth in Algeria (An Econometric Study)

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Abstract

This article aims to examine the impact of digitalization on economic growth in Algeria over the period 1990-2020, using the Autoregressive Distributed Lag (ARDL) model. Several explanatory indicators were adopted to assess this impact, including the number of mobile phone subscribers as a proxy for digitalization, alongside investment and trade openness as traditional growth determinants.

The empirical estimation results revealed the existence of a long-run relationship among the variables. Specifically, the number of mobile phone subscribers was found to have a negative impact on per capita GDP growth. This negative effect is attributed to the fact that digitalization in Algeria during the study period was not effectively directed toward productive sectors but was rather characterized by predominantly consumptive and entertainment-oriented use, in addition to the lack of adequate digital infrastructure and digital skills. On the other hand, both investment and trade openness showed a statistically significant and positive effect on economic growth, highlighting the crucial role these factors play in stimulating economic activity and enhancing productivity.

Keywords:

Digitalization, Economic Growth, ARDL Model

ملخص:

يهدف هذا المقال إلى دراسة أثر الرقمنة على النمو الاقتصادي في الجزائر خلال الفترة الممتدة من 1990 إلى 2020، وذلك باستخدام نموذج الانحدار الذاتي للإبطاءات الموزعة (ARDL) وقد تم اعتماد عدد من المؤشرات التفسيرية لقياس هذا الأثر، عدد مشترك الهاتف النقال كمؤشر للرقمنة، والاستثمار، والانفتاح التجاري كمحددات تقليدية للنمو. كشفت نتائج التقدير التجريبي عن وجود علاقة طويلة الأجل بين المتغيرات، حيث تبين أن عدد مشترك الهاتف النقال، يؤثر سلباً على معدل نمو الناتج المحلي الإجمالي للفرد. ويفسر هذا الأثر السلبي بكون استخدام الرقمنة في الجزائر خلال الفترة المدروسة لم يكن موجهاً بشكل فعال نحو القطاعات الإنتاجية، بل اتسم في الغالب بالاستخدام الاستهلاكي والترفيهي، مع غياب البنية التحتية الرقمية الفعالة والمهارات الرقمية الكافية. وأظهرت النتائج أن كلاً من الاستثمار والانفتاح التجاري كان لهما أثر إيجابي ومعنوي على النمو الاقتصادي، مما يؤكد أهمية هذين العاملين في تحفيز النشاط الاقتصادي وتعزيز الإنتاجية.

الكلمات المفتاحية: الرقمنة، النمو الاقتصادي، نموذج ARDL

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Today, the world is undergoing a massive information revolution driven by global openness, the Internet of Things (IoT), and digitalization, which are radically transforming the way business is conducted (Parida et al., 2019; Rojko, 2017)¹. The development of the internet has fueled the evolution of digital processes, leading to the emergence of the digital economy. In this context, telecommunications and information technology have come to play a supportive role in enhancing performance across various economic sectors by improving efficiency, reducing costs, and saving time in completing economic and financial transactions.

According to (Bukht and Heeks, 2017)², the digital economy stimulates economic growth, increases the productivity of capital and labor, reduces operational costs, and enhances access to global markets. In light of this, a growing body of research in recent years has examined the impact of digitalization on the economy.

Motivated by this increasing interest in digitalization and its importance for national economies, this study seeks to answer the following research question:

How has digitalization affected economic growth in Algeria during the period 1990–2020?

Sub-questions

- How has digitalization affected economic growth in Algeria?
- What role does digitalization play in economic growth?
- Is there a reciprocal (bidirectional) relationship between the two variables?

To answer these questions, the following hypotheses were formulated:

- Digitalization has a positive effect on economic growth.
- Some digitalization indicators have a positive impact on economic growth.
- There is a unidirectional causal relationship between the two variables.

Significance of the Study:

- Enhancing employment opportunities and developing digital skills.
- Creating new job opportunities, especially in the field of information and communication technologies (ICT).
- Improving digital infrastructure by expanding access to digital services.
- Digitalization contributes to promoting economic development.

Methodology:

The study adopted a descriptive analytical approach in the theoretical part, by addressing the reality of digitalization and its indicators in Algeria. As for the empirical part, a quantitative econometric study was conducted using the ARDL model to determine the long-run effect of digitalization on economic growth.

1.Theoretical Framework of the Variables:

China has managed to take the lead in capital investment in key technologies. Even before the COVID-19 pandemic, China witnessed strong growth; in 2018, its investment reached 31.3 trillion Chinese yuan (equivalent to 4.7 trillion USD), representing 34.8% of its GDP.

Additionally, China accounts for approximately 45% of global e-commerce transactions. Mobile payment adoption in China was three times higher than that of the United States.

With the outbreak of COVID-19, the shift toward digitalization intensified further, leading to an increase in online shopping and demand related to retail sales of consumer goods. This trend extended to several areas such as financial technologies (fintech), virtual reality, autonomous driving, wearable devices, educational technologies, 3D printing, robotics, and drones.

In a study conducted by Danilin (2019)³ on the impact of the digital economy in China and the United States on economic growth, it was found that the main factors behind their leadership in this domain include increased investment in research and development (R&D), heightened focus on digital innovation and human resource development, the dynamism of the ICT (Information and Communication Technology) sector, the potential interdependence between the development of personal electronics and online markets, and the Internet of Things (IoT). The study concluded that all these factors positively influence economic growth rates in both countries.

The study by Godwin et al. (2020)⁴ focused on the contribution of digitalization to economic growth in Sub-Saharan African (SSA) countries, compared to the economies of the Organisation for Economic Co-operation and Development (OECD). The main reason behind comparing more and less developed countries in assessing the effects of digitalization was to understand whether these effects are dependent on a country's level of development.

It is assumed that new technologies in Sub-Saharan Africa have played important roles in economic activity, including improving access to telecommunications, which had previously been hindered by weak infrastructure, financial inclusion of the poor majority through mobile banking, and the participation of small and medium-sized enterprises (SMEs) in e-commerce.

Numerous studies confirm that improvements in telecommunications infrastructure lead to higher economic growth. This was supported by the study of Ward and Zheng (2016)⁵, which found that although telecommunications services significantly contribute to economic growth, their impact may vary depending on a country's level of development.

Similarly, Dewan and Kraemer (2000)⁶ concluded that investment in ICT (Information and Communication Technologies) yields greater economic benefits for developed countries than for developing ones, particularly in African nations.

According to Maiti et al. (2019)⁷, digitalizing the economy is a core strategy for addressing challenges related to economic growth and social inclusion. Their study found that the adoption of ICT enhances productivity and economic efficiency more rapidly, brings greater transparency in the delivery of public services and welfare programs, reduces corruption, reaches remote areas, and improves democratic participation.

Digitalization" and "digital transformation" are two concepts used in relation to digital technology and the process of innovation. However, the distinction between these two concepts is often implicit in practice, and there is no clear consensus between them.⁸

Tabelle n 01 : The Difference Between Digitization and Digital Transformation

Digitalization	Digital Transformation
The conversion of information into a digital format	The transformation of information from a digital format to a radical change in the way institutions operate
Improving efficiency and reducing costs	Enhancing customer experience, increasing revenue, and delivering value
Converting information and data	Transforming processes, systems, and business operations
Digital technologies such as cloud computing	Advanced digital technologies such as biometric recognition, artificial intelligence (AI), and predictive analytics
Improved operational efficiency and cost reduction	Improved customer experience and increased revenues

Source : Pezeshki, M., Kaba, O., Bengio, Y., Courville, A. C., Precup, D., & Lajoie, G. (2021). Gradient starvation: A learning proclivity in neural networks. *Advances in Neural Information Processing Systems*, 34, 1256-1272.

Digitization is defined as the process of converting materials into an electronic (digital) format, primarily for storage and use in computers. Digitization transforms materials from analog formats that can be read by humans into digital formats that can only be read by machines. Devices such as scanners, cameras, and many other tools can be used to digitize knowledge content. These technologies enable the digitization of almost all types of materials, including paper documents, rare manuscripts, photographs, audio recordings, and films.

2. Areas of Digitization Affecting Economic Growth:

According to a report issued by the World Bank Group⁹ on global progress in digitization and countries' production and use of digital technologies: from digital jobs, digital services exports, and app development to internet usage, affordability, quality, and more the report highlights two key trends shaping the digital future:

- The importance of public digital infrastructure, and
- The transformative potential of artificial intelligence (AI).

- **Internet**

Usage:

In 2022, over 90% of the population in high-income countries used the internet, compared to only 26% in low-income countries. Among low- and middle-income countries, the Europe and Central Asia region had the highest internet usage rate at 84%.

- **Data**

Traffic:

In many developing countries, individuals and businesses suffer from a lack of digital devices, slow internet speeds, high costs, and poor service quality. The COVID-19 pandemic triggered a global surge in data traffic, largely driven by online video streaming, which accounted for two-thirds of global internet traffic. In 2022, the average per capita mobile broadband traffic in wealthier countries

exceeded that of low-income countries by more than 20 times, while fixed broadband traffic exceeded it by more than 1,700 times. Gaps in ownership of digital devices, internet speed, affordability, and data traffic, in turn, hinder the digital transformation in some low- and middle-income countries

- **Application Usage:** The global surge in app usage continued during the lockdowns imposed amid the COVID-19 pandemic, highlighting a lasting shift in people's behavior. Downloads of business, education, health, finance, and shopping apps spiked immediately as lockdowns took effect, indicating a significant rise in new users worldwide. Business apps such as those for meetings, conferencing, and remote file management attracted the largest number of first-time users, with downloads increasing by 60% within the first three months of the pandemic. The pandemic also accelerated the global adoption of digital payments and online shopping, resulting in a significant transformation of the finance and commerce sectors. These behavioral changes persisted, with the total time spent on such apps remaining 60% to 70% higher than pre-pandemic levels by the end of 2022.
- **Local Digital Enterprises:** Local digital businesses in low- and middle-income countries are gaining increasing momentum. These countries received a flow of venture capital funding for their emerging digital startups between 2020 and 2022. Although the app market has become more localized, local success in these developing economies may not necessarily translate into success in foreign markets.
- **Infrastructure:** Internet exchange points (IXPs) are physical infrastructures that facilitate access to global internet data traffic, while data centers store and process this data. They are essential for the operation of cloud computing, big data analytics, and artificial intelligence. In 2022, high-income countries accounted for about 60% of the world's public internet exchange points and roughly three-quarters of connected data centers, compared to just 2% in the Middle East and North Africa, and 7% in Sub-Saharan Africa. There are approximately 51 countries and territories representing 5% of the world's population that do not have access to internet exchange points.
- **Developments in Artificial Intelligence:** The ability to generate content and manage intelligent technologies that are sometimes indistinguishable from those created by humans has propelled the growth capabilities of artificial intelligence (AI) to new heights. The parameters used to measure AI complexity have dramatically increased from just 255 parameters in 1955 to 1.6 trillion parameters in 2022. As the use of AI expands, it holds the potential to accelerate growth, enhance efficiency, and open

up new opportunities for developing countries, thanks to its applications in sectors such as education, transportation, sustainability, and many others.

3. Digital Usage in Algeria in 2023

This section aims to present the key digital indicators in Algeria during the year 2023, based on data published by official and international sources such as the World Bank, DataReportal, and the official U.S. International Trade Administration website (trade.gov).

▪ Number of Mobile Subscriptions

The number of mobile phone subscriptions in Algeria reached 48.53 million by the beginning of 2023, which represents 107.2% of the total population. This figure increased by 3.8% compared to 2022, reflecting a rise of approximately 1.8 million subscriptions¹⁰.

▪ Internet Usage Rate

According to the World Bank, the proportion of individuals using the internet in Algeria reached 71.24% in 2022. Based on DataReportal figures, the number of internet users increased to 33.49 million in January 2024, representing 72.9% of the population¹¹.

▪ Social Media Users

The number of social media users in Algeria stood at 24.85 million at the beginning of 2024, which is equivalent to 54.1% of the total population¹².

▪ Digital Payments and E-Commerce Usage

According to the U.S. Department of Commerce report¹³:

- Only 2.8% of the population owns credit cards.
- Approximately 22.9% own debit cards.
- 8.2% of the population made purchases online or via mobile during 2023.
- 4.7% sent money online.

4. The Econometric Study :

The dependent variable in this study is the per capita GDP growth rate (*pi bh*), which we aim to explain through the following independent variables: the number of mobile phone subscribers (*mob*) as a proxy for digitalization, the share of imports in GDP (*importgdp*) as a proxy for trade openness, and the capital stock (*k*) as a proxy for investment. The capital stock variable was transformed into its logarithmic form to ensure consistency with the other variables, which are expressed as rates and percentages.

The quantitative data used in this study consist of annual time series for Algeria covering the period from 1990 to 2020. All data were sourced from the World Bank database.

- Model and Estimation Results

To determine the long-run impact of digitalization on economic growth, an econometric model is estimated that explains economic growth through the aforementioned independent variables.

The model takes the following linear form:

$$PIBH = f (MOB, K, IMPORTGDP) \dots\dots\dots(1)$$

To estimate the aforementioned long-term relationship, we employ the Auto Regressive Distributed Lag (ARDL) model developed by Pesaran et al. (2001)¹⁴. This model serves as an alternative to traditional cointegration tests and offers several advantages. Notably, the ARDL bounds testing approach by Pesaran et al. (2001) does not require all time series to be integrated of the same order, whether I(0) or I(1). The only condition is that none of the variables should be integrated of order two, I(2).

Furthermore, the ARDL model is particularly suitable when dealing with small sample sizes, in contrast to most conventional cointegration techniques, which generally require large samples for the results to be efficient and reliable.

The ARDL model enables the separation of short-run and long-run effects, allowing for the identification of the cointegrating relationship between the dependent variable and the independent variables within a single equation. Through this methodology, one can determine both the existence and strength of the long-run and short-run relationships, as well as quantify the impact of each independent variable on the dependent variable over both time horizons.

Moreover, the ARDL approach allows for the estimation of parameters for the independent variables in both the short run and long run, and these estimated parameters are generally more consistent compared to other cointegration techniques such as the Engle-Granger (1987), Johansen (1988), and Johansen-Juselius (1990) approaches.

To determine the optimal number of lags in the distributed lag structure, the Akaike Information Criterion (AIC) and Schwarz Criterion (SC)¹⁵ are commonly used. The lag length that minimizes these criteria is selected as the most appropriate.

The first step in the ARDL methodology is to test for the existence of a cointegration relationship. According to Pesaran et al. (2001), cointegration in ARDL models is based on testing the following hypothesis:

$$\begin{cases} H_0 & : \pi_1 = \pi_2 = \pi_3 = \pi_4 = 0. \\ H_1 & : \pi_1 \neq 0, \pi_2 \neq 0, \pi_3 \neq 0, \pi_4 \neq 0 \end{cases}$$

The test statistic used is the F-statistic (Wald test), and the decision rule is as follows:

- If the calculated F-statistic exceeds the upper bound of the critical values, the null hypothesis of no cointegration is rejected, indicating the existence of a long-run cointegration relationship.
- If the F-statistic falls below the lower bound, we fail to reject the null hypothesis, implying that no cointegrating relationship exists.
- However, if the F-statistic lies between the lower and upper bounds, the test result is inconclusive.

The lower bound assumes that all variables are stationary at level (i.e., integrated of order zero, I(0)), whereas the upper bound assumes that all variables are stationary at first difference (i.e., integrated of order one, I(1)).¹⁶

Step two consists of estimating the model parameters in both the short run and long run, which is conducted after confirming the existence of a cointegration relationship among the study variables.

Before estimating the equation, it is essential to examine the statistical properties of the variables, particularly stationarity. The objective is to uncover the long-run relationship and to avoid spurious estimates that may arise if the time series used in the estimation are non-stationary.

The unit root of the model variables was tested using the Augmented Dickey-Fuller (ADF) Test. The lag length was determined based on the lowest value of the Schwarz Information Criterion (SIC), with a maximum lag order of $p=4$. The following table summarizes the order of integration of the time series that constitute the model:

Tabel n 02 : test unit root

Variables	PIBH	MOB	K	IMPORTGDP
Order of Integration	I(1)	I(1)	I(1)	I(0)

If the critical value (according to MacKinnon, 1996) at the 5% significance level is greater than the absolute value of the computed Augmented Dickey-Fuller (ADF) test statistic, this implies acceptance of the null hypothesis—i.e., the variable contains a unit root and the series is therefore non-stationary. Conversely, if the ADF test statistic is greater than the critical value, the series is considered stationary.

After verifying the necessary condition for applying the ARDL methodology—namely, the order of integration of the time series for the study variables through the unit root test, where all variables are either integrated of order I(1) or stationary at level I(0)—we proceed to test for the existence of a cointegration relationship.

- Cointegration Test Using the Bounds Testing Approach:

The computed value of the cointegration F-statistic is $F = 5.010$. The critical bounds values at various significance levels, as proposed by Pesaran et al. (2001), are presented in the following table:

Table n 03: Bounds Test

F-Bounds Test		NullHypothesis: No levelsrelationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic k	5.010231 3	Asymptotic: n=1000		
		10%	2.37	3.2
		5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66
		FiniteSample: n=30		
		10%	2.676	3.586
		5%	3.272	4.306
		1%	4.614	5.966

The table shows that the F-statistic is greater than the upper bound of the critical values at various levels of significance (1%, 5%, and 10%). Therefore, we reject the null hypothesis and accept the alternative hypothesis indicating the existence of a long-run equilibrium relationship.

After confirming the presence of a long-run relationship between economic growth and digitalization, we proceed to estimate the parameters of this relationship using the ARDL methodology, based on EViews10 software. Using the Schwarz Bayesian Criterion, the optimal lag structure was identified, and it was found that the model (4,3,0,3) is the most appropriate. The estimation results for both the short-run and long-run dynamics are presented in the following table:

Table n 04: Estimation of the Auto-Regressive Distributed Lag (ARDL) Model

ARDL Long Run Form and Bounds Test

Dependent Variable: D(PIBH)

Selected Model: ARDL(3, 0, 4, 3)

Case 2: Restricted Constant and No Trend

Sample: 1990 2020

Included observations: 27

Conditional Error Correction Regression				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-179.2975	89.43317	-2.004821	0.0663
PIBH(-1)*	-1.260367	0.302762	-4.162904	0.0011
MOB**	-2.38E-07	1.00E-07	-2.375388	0.0336
LOGK(-1)	7.529795	3.748585	2.008703	0.0658
IMPOPIB(-1)	0.083661	0.112999	0.740368	0.4722
D(PIBH(-1))	0.412371	0.273762	1.506314	0.1559
D(PIBH(-2))	0.514432	0.251196	2.047929	0.0613
D(LOGK)	27.77991	12.04075	2.307157	0.0381
D(LOGK(-1))	25.48667	11.56452	2.203867	0.0462
D(LOGK(-2))	2.677684	7.405682	0.361572	0.7235
D(LOGK(-3))	-11.88528	7.048502	-1.686214	0.1156
D(IMPOPIB)	-0.043896	0.055473	-0.791298	0.4430
D(IMPOPIB(-1))	-0.107962	0.066692	-1.618809	0.1295
D(IMPOPIB(-2))	-0.157798	0.043170	-3.655288	0.0029

* p-value incompatible with t-Bounds distribution.

** Variable interpreted as $Z = Z(-1) + D(Z)$.

Levels Equation Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
MOB	-1.890007	6.45E-08	-2.927003	0.0118
LOGK	5.974287	2.563968	2.330095	0.0366
IMPOPIB	0.066378	0.096339	0.689003	0.5029
C	-142.2582	61.17660	-2.325370	0.0369

The ARDL model estimation results shown in Table n04 indicate a negative impact of digitalization on economic growth. Specifically, a 1% increase in the number of mobile phone subscribers leads to a 1.89% decrease in the per capita income growth rate. This suggests that the expansion of mobile phone usage does not positively contribute to economic growth during the period under study.

In contrast, the results revealed that the other independent variables, namely investment and trade openness, have a positive and statistically significant effect on economic growth. This confirms the critical role of these two factors in supporting and stimulating long-term growth.

- **Causality Analysis:**

As noted by Granger (1988), if two time series are cointegrated, there must exist at least a one-way causal relationship between them. According to the Granger causality concept, if variable $\mathbf{x}_t$ causes variable $\mathbf{y}_t$, this implies that the past values of $\mathbf{x}_t$ can be used to better predict $\mathbf{y}_t$. To test for the existence of causality between the variables, the following equations are used:

$$X_t = a_1 + \sum_{i=1}^p a_2 X_{t-i} + \sum_{i=1}^n a_3 Y_{t-i} + \delta_i$$

$$Y_t = b_1 + \sum_{i=1}^p b_2 Y_{t-i} + \sum_{i=1}^n b_3 X_{t-i} + \varepsilon_i$$

The results of the Granger causality test are presented in the following table:

Table n 05: Granger Causality Test Result

Pairwise Granger Causality Tests

Sample: 1990 2020

Lags: 2

NullHypothesis:	Obs	F-Statistic	Prob.
PIBH does not Granger Cause MOB	29	4.88339	0.0166
MOB does not Granger Cause PIBH		1.85326	0.1785

According to the table 05, the Granger Causality Test reveals a unidirectional causality running from economic growth to digitalization. This means that the rate of economic growth explains the changes in the level of digitalization (such as the number of mobile phone subscribers or the use of information technology), and this is observed at various levels of statistical significance.

Conversely, no reverse causality was found; digitalization did not show any statistically significant effect in explaining variations in economic growth during the study period. This result suggests that economic growth may serve as a driver for the adoption of digital technologies, while digitalization in Algeria, during this particular period, has not yet reached a level where it significantly impacts growth.

Among the reasons that may explain these findings are:

- Economic growth is a key driver of investment in digital infrastructure. When macroeconomic indicators improve, governments are more capable of financing digital transformation projects. This, in turn, increases the ability of individuals and institutions to acquire and use modern communication technologies. This is supported by the 2016 World Bank study on the role of economic growth in promoting digitalization¹⁷, which discusses how economic growth provides a conducive environment for the expansion of digitalization through increased public and private spending on digital infrastructure.
- Digitalization does not necessarily stimulate economic growth when it is used primarily for consumptive or entertainment purposes, rather than being employed in productive, value-added activities such as education, financial services, and e-commerce. The lack of effective utilization of technology reduces its developmental impact. This is also supported by the study by Aker & Mbiti (2010)¹⁸, which highlights the limited developmental effect of digitalization in the absence of productive use. The study explains that using mobile phones for non-productive purposes significantly diminishes their impact on economic growth, particularly in Africa.
- Human capital plays a fundamental role in activating the positive impact of digitalization. The lack of digital training and weak human capital hinders the effective use of existing infrastructure, thereby making its impact on economic growth negative in both the short and long term. This is confirmed by Vu (2011)¹⁹ in his study on the importance of human capital in enabling the positive effects of digitalization, which emphasizes the connection between digital skills, human capital, and the influence of ICT on growth.
- The infrastructure and regulatory environment are also crucial in guiding digitalization toward growth. Weak public policy frameworks limit the potential to develop an effective digital economy.
- Sustainable economic growth contributes to the enhancement of the technological environment, highlighting the importance of adopting integrated policies that combine support for digitalization with the strengthening of human capital and improvement of institutional frameworks. These measures are essential to transform digitalization into a key driver of long-term economic growth.
- Investment and trade openness have a positive and statistically significant impact on economic growth, underscoring the pivotal role these factors play in supporting and stimulating long-term growth whether through enhancing productivity, improving competitiveness, or facilitating integration into the global economy.

Conclusion:

- Technological advancements and investment in highly skilled human capital form the cornerstone of economic growth and societal advancement, as they enhance efficiency, competitiveness, and productivity. This, in turn, leads to long-term

progress and encourages capital accumulation. Governments should focus on improving digital infrastructure and promoting the use of digitalization in productive activities such as digital education and e-commerce to stimulate economic growth.

- Enhancing education in the fields of science, technology, engineering, and mathematics (STEM), expanding internet access, and fostering digital awareness can contribute to the development of human capital, increase competitiveness and productivity, reduce the digital divide, and foster innovation, opportunities, and inclusive growth.
- Improving the quality of economic institutions is also crucial for economic growth. Reforms related to the rule of law, governance, anti-corruption measures, and regulatory effectiveness strengthen investor confidence and encourage investment. Governments can also adopt sound policies to enhance digital infrastructure and internet connectivity, thereby reducing disparities and promoting equitable social and economic development.

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