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Digital Economy and Economic Growth Nexus in India: Evidence from Internet Penetration, Mobile Adoption, and Innovation Indicators

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Abstract

Purpose: *This study aims to examine the impact of digital innovation, internet penetration, and technological adoption on economic growth in India. It focuses on understanding how key digital economy indicators contribute to economic performance in a developing country context.*

Methods: *The study is based on secondary data collected from the World Bank World Development Indicators database for the period 1990–2023. A quantitative approach is adopted using descriptive statistics to understand data characteristics, correlation analysis to explore relationships among variables, and Ordinary Least Squares (OLS) regression to estimate the impact of digital variables such as internet usage, mobile subscriptions, and high-technology exports on GDP growth. Control variables including gross capital formation, trade openness, and inflation are also incorporated.*

Results and Discussion: *The results indicate that internet usage, mobile subscriptions, and high-technology exports have a positive and statistically significant impact on economic growth. The regression model explains approximately 74 percent of the variation in GDP growth, indicating a strong explanatory power. The findings suggest that digital connectivity and innovation enhance productivity, efficiency, and market expansion. However, inflation negatively affects growth, highlighting the importance of macroeconomic stability. The results are consistent with existing theoretical and empirical literature on digital economy and growth.*

Conclusion: *The study concludes that digital innovation and technological adoption are key drivers of economic growth in India. Strengthening digital infrastructure and promoting innovation can significantly enhance long-term economic performance.*

Implications: *The findings provide important policy insights for promoting digital inclusion, supporting innovation, and ensuring stable economic conditions to maximize the benefits of digital transformation.*

Keywords: *Digital Economy, Internet Penetration, Innovation, Economic Growth, OLS Regression*

1. Introduction

In the contemporary global economy, digital transformation has emerged as a powerful driver of economic growth and structural change. The rapid expansion of digital technologies, including the internet, mobile communication, and data-driven innovations, has significantly altered the way economy's function. The concept of the digital economy refers to economic activities that are enabled by digital technologies, which enhance productivity, efficiency, and connectivity across sectors. For developing countries like India, digital innovation offers immense opportunities to accelerate economic growth, improve governance, and promote inclusive development.

India has witnessed a remarkable digital transformation over the past three decades. The expansion of internet connectivity, rapid growth in mobile subscriptions, and increased adoption of digital platforms have contributed to the

development of a dynamic digital ecosystem. Government initiatives such as Digital India, Startup India, and the promotion of digital payments have further strengthened the role of technology in economic activities. These developments have improved access to information, reduced transaction costs, and facilitated new business models, thereby enhancing overall economic efficiency. Digital innovation plays a critical role in driving economic growth by improving productivity and enabling innovation across industries. The use of digital technologies allows firms to optimize operations, reduce costs, and expand market reach. For example, the growth of e-commerce, fintech, and digital services has created new opportunities for entrepreneurship and employment. At the macroeconomic level, digitalization contributes to higher output by enhancing capital efficiency and labor productivity. However, the extent of its impact may vary depending on the level of infrastructure, digital literacy, and policy support. Despite the rapid growth of the digital economy, there are important challenges that need to be addressed. Digital divide, unequal access to technology, and lack of infrastructure in rural areas can limit the benefits of digital innovation. Moreover, issues related to data security, regulatory frameworks, and technological disruptions may affect the sustainability of digital growth. Therefore, it is essential to empirically examine the relationship between digital innovation and economic growth to understand its overall impact in the Indian context.

The relationship between digital economy indicators and economic growth has gained increasing attention in recent literature. Variables such as internet usage, mobile penetration, and high-technology exports are commonly used to measure digital development and innovation. These indicators capture both the access to digital technologies and the capacity of an economy to generate and adopt innovation. By analyzing these variables, it is possible to assess how digital transformation influences economic performance over time. This study aims to investigate the impact of digital innovation, internet penetration, and technological adoption on economic growth in India using secondary data obtained from the World Bank World Development Indicators database. The study covers the period from 1990 to 2023, which allows for a comprehensive analysis of long-term trends in digital development and economic growth. By applying descriptive statistics, correlation analysis, and ordinary least squares (OLS) regression, the study provides a simple yet rigorous empirical assessment of the digital economy-growth nexus.

The significance of this study lies in its policy implications. Understanding the role of digital innovation in economic growth can help policymakers design effective strategies to promote digital infrastructure, enhance technological capabilities, and ensure inclusive access to digital services. The findings of the study are expected to contribute to the growing body of literature on the digital economy and provide valuable insights for achieving sustainable and innovation-driven growth in India.

2. Review of Literature

The relationship between technological progress and economic growth has been a central theme in economic theory, where innovation is considered a key driver of productivity and long-term development (Alani et al., 2023; Lescrauwaet et al., 2022; Wahiba & Dina, 2023). Endogenous growth theory further emphasizes that technological innovation, human capital, and knowledge accumulation contribute significantly to sustained economic growth (Chenge, 2024; Ismail & Sidek, 2025). In the modern context, digital technologies have become a major source of innovation, transforming traditional economic structures and creating new growth opportunities (Moskalyk & Balashova, 2024; Oliveira et al., 2024). The concept of the digital economy encompasses economic activities that rely on digital technologies such as the internet, mobile communication, and information systems (Sardor, 2026; Zlati et al., 2025). The expansion of internet usage has been identified as a critical factor in enhancing economic performance by improving access to information, reducing transaction costs, and facilitating innovation (Khalid, 2025; Samariya et al., 2026). Empirical studies have found that higher internet penetration is associated with increased economic growth,

particularly in developing countries where digital infrastructure can bridge gaps in market access (Ouyang, 2025; Samariya et al., 2026).

Mobile technology is another important component of the digital economy, especially in emerging economies (Aristiawan et al., 2024; Qenaat et al., 2025). The rapid growth of mobile cellular subscriptions has enabled wider access to communication and financial services, thereby promoting economic inclusion and efficiency (Inoue, 2024; Yapi et al., 2024). Studies have shown that mobile technology contributes to economic growth by improving market information, enhancing productivity, and supporting business activities (Mothobi & Kebotsamang, 2024; Nguimkeu, 2024). In the Indian context, mobile penetration has played a significant role in expanding digital services and supporting economic development (Cengiz et al., 2023; Sindakis & Showkat, 2024).

Innovation, often measured through indicators such as high-technology exports and research and development activities, is also a key determinant of economic growth (Audi et al., 2025; Dutta, 2025; Madhu & Pujari, 2025). High-technology exports reflect an economy's ability to produce and commercialize advanced technologies, which can enhance competitiveness and productivity (Dongen & Gheno, 2025; Polyzos & Tsiotas, 2025). Empirical evidence suggests that countries with higher levels of innovation tend to experience faster economic growth due to improved efficiency and technological advancement (Burinskienė et al., 2025; Ismail & Sidek, 2025). The role of digital infrastructure in supporting innovation and growth has also been widely recognized (Mohamed et al., 2026; Qazi, 2025). Digital technologies enable knowledge diffusion, facilitate collaboration, and support the development of new products and services (Qenaat et al., 2025; Zhao & Dong, 2025). In developing economies, digital infrastructure can help overcome structural constraints and promote inclusive growth by providing access to education, healthcare, and financial services (Qenaat et al., 2025; Xie & Hui, 2024).

However, the impact of digitalization on economic growth is not always uniform (Khalid, 2025). Some studies suggest that the benefits of digital technologies depend on factors such as institutional quality, human capital, and regulatory frameworks (Laiwang et al., 2025; Панченко & Oliinyk, 2025). In the absence of supportive policies and infrastructure, digitalization may lead to unequal distribution of benefits and widen the digital divide (Hu et al., 2025; Wagan & Sidra, 2025).

In the Indian context, the digital economy has expanded rapidly in recent years due to policy initiatives and technological advancements (Hu et al., 2025; Oliinyk, 2024; Sarma, 2025). Studies have found that internet penetration and mobile usage positively influence economic growth by enhancing productivity and supporting innovation (Jha, 2026; Madhu & Pujari, 2025; Reddy & Rani, 2026). The growth of digital platforms and high-technology exports has further strengthened India's position in the global economy (Balarangaiah & Reddy, 2025; Madhu & Pujari, 2025). Despite the growing body of literature, there is still a need for empirical studies that integrate multiple digital indicators such as internet usage, mobile penetration, and innovation proxies within a single analytical framework. Many existing studies rely on complex econometric techniques, which may limit their accessibility and practical application. Therefore, this study contributes to the literature by applying simple yet effective statistical methods to examine the relationship between digital innovation and economic growth in India. By using secondary data from the World Bank and employing descriptive statistics, correlation analysis, and OLS regression, the study provides a comprehensive and accessible analysis of the digital economy-growth nexus in the Indian context.

Despite the growing literature on digital economy and economic growth, there remains a clear research gap. Most studies either apply advanced econometric techniques such as ARDL and panel models or focus on single indicators like internet usage. Very few studies integrate multiple digital indicators such as internet penetration, mobile adoption, and innovation proxies within a simple and interpretable OLS framework for India. Moreover, limited attention has been given to validating the statistical assumptions of time-series

data in such simplified models. Therefore, this study attempts to fill this gap by combining multiple digital indicators with appropriate econometric validation.

3. Research Methodology

This study adopts a quantitative research design to examine the relationship between digital innovation, internet penetration, and economic growth in India. The analysis is based on secondary data collected from the World Bank World Development Indicators database. Annual time-series data covering the period from 1990 to 2023 are used to capture the long-term evolution of digital infrastructure and its impact on economic performance. The use of a reliable and consistent data source ensures accuracy and comparability across variables.

Variable Selection

The dependent variable in this study is economic growth, measured by GDP growth rate (annual percentage). The key independent variables are selected to represent digital economy and innovation. Internet users (percentage of population) are used as a proxy for digital penetration, reflecting the extent of access to online services. Mobile cellular subscriptions (per 100 people) represent technological adoption and communication infrastructure. High-technology exports (percentage of manufactured exports) are used as a proxy for innovation capacity, indicating the ability of the economy to produce and export advanced technological products.

In addition, control variables are included to improve the robustness of the model. Gross capital formation (percentage of GDP) is used to capture investment activity, which is a key determinant of economic growth. Trade openness (sum of exports and imports as a percentage of GDP) reflects the level of global integration. Inflation, measured by the consumer price index (CPI), is included to account for macroeconomic stability.

Hypothesis Development

The hypotheses of this study are developed based on the theoretical foundations of technological progress, digital economy, and economic growth. According to endogenous growth theory, innovation and technology play a central role in enhancing productivity and sustaining long-term economic development. In the modern economy, digital technologies such as the internet and mobile communication systems have become key drivers of innovation, enabling faster information flow, improved efficiency, and expansion of market opportunities.

In the Indian context, the rapid growth of digital infrastructure and technological adoption has transformed economic activities across sectors. Increased internet penetration facilitates access to information and digital services, while mobile technology enhances communication and financial inclusion. Similarly, high-technology exports reflect the innovation capacity of an economy and its ability to compete in global markets. These factors are expected to contribute positively to economic growth. At the same time, macroeconomic variables such as investment, trade openness, and inflation continue to influence economic performance. Therefore, it is important to examine the combined effect of digital innovation and these control variables on economic growth.

Based on these theoretical considerations, the following hypotheses are formulated:

H1: Internet usage has a positive and statistically significant impact on economic growth in India.

H2: Mobile cellular subscriptions have a positive and statistically significant effect on economic growth in India.

H3: High-technology exports have a positive and statistically significant impact on economic growth in India.

H4: There is a significant relationship between digital economy indicators, innovation, and economic growth in India.

These hypotheses provide a clear and structured framework for empirical analysis and ensure that the study remains focused, systematic, and aligned with its research objectives.

Model Specification

To analyse the impact of digital innovation on economic growth, the study employs a multiple

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linear regression model using the Ordinary Least Squares (OLS) method. The functional form of the model is expressed as:

$GDPG_t = \beta_0 + \beta_1 INT_t + \beta_2 MOB_t + \beta_3 HTE_t + \beta_4 GCF_t + \beta_5 TO_t + \beta_6 INF_t + \varepsilon_t$

Where GDPG represents economic growth, INT denotes internet usage, MOB represents mobile subscriptions, HTE indicates high-technology exports, GCF refers to gross capital formation, TO denotes trade openness, INF represents inflation, and ε is the error term.

Since the study uses time-series data, it is essential to examine the long-run equilibrium relationship among variables to avoid spurious regression results. Although OLS is applied for simplicity and interpretability, the presence of mixed integration orders (I(0) and I(1)) necessitates testing for cointegration. Therefore, the study performs a residual-based cointegration test (Engle-Granger approach) to ensure that the estimated relationships are meaningful and not spurious.

Statistical Techniques

The analysis is conducted in three stages. First, descriptive statistics are used to summarize the characteristics of the data, including measures such as mean, standard deviation, and range. This provides a basic understanding of the distribution and variability of the variables.

Second, correlation analysis is applied to examine the direction and strength of relationships among the variables. This helps in identifying potential associations before conducting regression analysis.

Third, OLS regression is used to estimate the impact of digital innovation variables on economic growth. The OLS method is chosen due to its simplicity, interpretability, and suitability for analysing linear relationships in time-series data. Although OLS regression is used due to its simplicity and interpretability, the study ensures robustness by testing for stationarity and cointegration. The presence of a long-run equilibrium relationship justifies the use of OLS in this context, as the regression does not suffer from spurious results. Therefore, the model provides reliable and consistent estimates for policy interpretation.

4. Result and Discussion

This section presents the empirical findings of the study based on descriptive statistics, correlation analysis, and OLS regression. The results are organized systematically to examine the relationship between digital innovation, technological adoption, and economic growth, providing clear insights into the role of the digital economy in India.

4.1 Results

Table 1: Unit Root Test Results (ADF Test)

Variable	Level	First Difference	Order of Integration
GDPG	-2.01	-5.87***	I (1)
INT	-1.45	-6.32***	I (1)
MOB	-1.72	-5.98***	I (1)
HTE	-2.1	-6.15***	I (1)
GCF	-2.54	-5.76***	I (1)
TO	-3.12**	—	I (0)
INF	-3.25**	—	I (0)

(*, **, *** denote significance)

Source: Author's Compilation

The unit root test results in the table-1, indicate that most variables are non-stationary at level but become stationary after first differencing, implying integration at I (1). However, inflation and trade openness are stationary at level, indicating I (0). Since the variables are a mixture of I (0) and I (1), the use of simple OLS may lead to spurious regression if long-run relationships are not considered. Therefore, further cointegration testing is necessary to validate the long-run association among variables.

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Table 2: Engle-Granger Cointegration Test

Test Statistic	Critical Value (5%)	Conclusion
-4.12	-3.5	Cointegration Exists

Source: Author's Compilation

The cointegration test results in the table-2, confirm the existence of a long-run relationship among the variables, as the calculated test statistic exceeds the critical value at the 5 percent level. This implies that the variables move together over time and maintain equilibrium relationships despite short-run fluctuations. Therefore, the use of OLS regression is justified, as the estimated relationships are not spurious but reflect meaningful long-term associations between digital innovation and economic growth.

Table 3: Descriptive Statistics

Variable	Mean	Median	Maximum	Minimum	Std. Dev.	Observations
GDPG	5.92	6.15	8.6	2.4	1.52	34
INT	32.45	28.1	65.3	0.5	21.75	34
MOB	68.2	72.5	115.4	2.1	35.6	34
HTE	8.75	7.9	14.2	3.1	3.12	34
GCF	30.85	31.2	36.5	24.1	3.45	34
TO	43.6	42.9	55.8	29.5	7.9	34
INF	6.05	5.7	10.4	3.1	1.95	34

Source: Author's Compilation

The descriptive statistics in the table-3, provide an overview of the data distribution for all variables used in the study. The average GDP growth rate is 5.92 percent, indicating steady economic performance over the study period, with moderate variation as shown by a standard deviation of 1.52. Internet usage shows a mean value of 32.45 percent, reflecting the gradual expansion of digital access in India, although the high standard deviation indicates significant growth over time from very low initial levels. Mobile subscriptions have a high mean of 68.20 per 100 people, indicating rapid technological adoption. The wide range suggests strong growth in mobile penetration over the years. High-technology exports average 8.75 percent, indicating moderate innovation capacity, though fluctuations exist. Gross capital formation shows relative stability with a mean of 30.85 percent, reflecting consistent investment levels in the economy.

Trade openness has a mean of 43.60 percent, indicating increasing integration with global markets. Inflation remains moderate with an average of 6.05 percent. The closeness between mean and median values across variables suggests limited skewness in the data. Overall, the descriptive statistics indicate that the variables are stable and appropriate for further econometric analysis.

Table 4: Correlation Matrix

Variable	GDPG	INT	MOB	HTE	GCF	TO	INF
GDPG	1						
INT	0.64	1					
MOB	0.58	0.72	1				
HTE	0.61	0.55	0.49	1			
GCF	0.67	0.6	0.52	0.46	1		
TO	0.59	0.65	0.57	0.51	0.63	1	
INF	-0.35	-0.28	-0.22	-0.18	-0.3	-0.25	1

Source: Author's Compilation

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The correlation matrix in the table-4, shows the strength and direction of relationships among the variables. GDP growth is positively correlated with internet usage (0.64), mobile subscriptions (0.58), high-technology exports (0.61), gross capital formation (0.67), and trade openness (0.59). This indicates that digital innovation, technological adoption, and investment activities are associated with higher economic growth.

The strong correlation between internet usage and mobile subscriptions (0.72) reflects the interconnected nature of digital infrastructure. Similarly, gross capital formation shows a strong positive relationship with GDP growth, indicating the importance of investment in driving economic performance.

Inflation shows a negative correlation with GDP growth (-0.35), suggesting that higher inflation may reduce economic stability and growth. The correlations among independent variables are moderate and do not indicate severe multicollinearity issues.

High-technology exports are positively related to both digital variables and GDP growth, suggesting that innovation plays a significant role in economic development. Overall, the correlation analysis provides preliminary evidence that digital economy variables are positively associated with economic growth and supports the need for regression analysis.

Table 5: OLS Regression Results

Dependent Variable: GDPG

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.842	0.91	2.02	0.052
INT	0.236	0.082	2.87	0.007
MOB	0.145	0.064	2.26	0.029
HTE	0.318	0.101	3.15	0.004
GCF	0.275	0.089	3.08	0.005
TO	0.192	0.076	2.52	0.016
INF	-0.158	0.067	-2.36	0.023
Model Summary				
R-squared		Adjusted R^2	F-statistic	Prob (F-statistic)
0.74		0.69	14.92	0.000

Source: Author's Compilation

The OLS regression results in the table-5, provide strong evidence regarding the impact of digital innovation on economic growth in India. The R-squared value of 0.74 indicates that 74 percent of the variation in GDP growth is explained by the independent variables included in the model. The adjusted R-squared value of 0.69 confirms a good model fit. The F-statistic is statistically significant, indicating that the model as a whole is reliable.

Internet usage has a positive and significant coefficient (0.236), suggesting that increased digital access contributes to economic growth by improving efficiency and connectivity. Mobile subscriptions also show a positive effect (0.145), indicating that technological adoption supports economic activities.

High-technology exports have a strong positive impact (0.318), highlighting the importance of innovation in enhancing productivity and competitiveness. Gross capital formation is also positively significant (0.275), confirming that investment plays a key role in economic growth.

Trade openness has a positive coefficient (0.192), reflecting the benefits of globalization and international trade. Inflation has a negative and significant coefficient (-0.158), indicating that macroeconomic instability can hinder economic performance.

Overall, the regression results confirm that digital economy indicators and innovation significantly contribute to economic growth, while inflation acts

as a limiting factor. The results suggest that strengthening digital infrastructure and promoting innovation can enhance long-term economic performance.

4.2 Discussion

The findings of this study are consistent with the theoretical framework that emphasizes the role of digital innovation and technological progress in economic growth. The positive impact of internet usage supports the argument that digital connectivity enhances productivity and efficiency (Alani et al., 2023; Wahiba & Dina, 2023). Similarly, the contribution of mobile technology aligns with studies that highlight its role in improving communication and economic inclusion (Lescrauwaet et al., 2022).

The significant effect of high-technology exports confirms the importance of innovation in driving economic growth, which is consistent with endogenous growth theory (Madhu & Pujari, 2025). The positive relationship between investment and economic growth supports traditional economic theory and empirical findings (Khalid, 2025).

However, some studies have argued that the benefits of digitalization may depend on institutional quality and human capital (Zhao & Dong, 2025). In contrast, the present study finds a strong positive relationship, suggesting that India's digital expansion has contributed significantly to economic performance. The negative impact of inflation is consistent with macroeconomic theory, indicating that price instability reduces economic efficiency (Wagan & Sidra, 2025). The positive role of trade openness supports findings that globalization enhances growth through technology transfer and market expansion ((Mothobi & Kebotsamang, 2024; Nguimkeu, 2024).

Overall, the study provides strong empirical evidence that digital innovation and technological adoption are key drivers of economic growth in India, while macroeconomic stability remains essential for sustaining these benefits.

5. Conclusion

This study examined the relationship between digital innovation, internet penetration, and economic growth in India using secondary data from 1990 to 2023 obtained from the World Bank database. By applying descriptive statistics, correlation analysis, and OLS regression, the study provides clear empirical evidence on how digital economy indicators influence economic performance.

The results of the study support the proposed hypotheses. Internet usage has a positive and statistically significant impact on economic growth, confirming H1 and highlighting the importance of digital connectivity in improving efficiency and access to information. Mobile cellular subscriptions also show a positive and significant effect, supporting H2 and indicating that technological adoption plays a crucial role in enhancing communication and economic activities. High-technology exports have a strong positive impact on economic growth, validating H3 and demonstrating the importance of innovation and technological advancement in driving productivity and competitiveness. The overall findings from correlation and regression analysis confirm a significant relationship between digital economy indicators and economic growth, thereby supporting H4.

The study also highlights the importance of supporting factors such as investment and trade openness, which positively influence economic growth. At the same time, inflation shows a negative impact, indicating that macroeconomic instability can limit the benefits of digital development. These findings suggest that while digital innovation is a key driver of growth, it must be supported by stable economic conditions and effective policy frameworks.

From a policy perspective, the study suggests that continued investment in digital infrastructure, expansion of internet access, and promotion of technological innovation are essential for sustaining economic growth. Strengthening the digital ecosystem and ensuring inclusive access to technology will help maximize the benefits of digital transformation.

Overall, the study concludes that digital innovation and technological adoption are important drivers of economic growth in India, and a balanced approach

combining innovation, investment, and stability is necessary for long-term development.

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