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DOES INTERNET ACCESS DRIVE ECONOMIC GROWTH? A CROSS-COUNTRY EMPIRICAL STUDY

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ABSTRACT

In the digital age, access to information and communication technologies — particularly the internet — is widely believed to support economic development. However, the empirical relationship between internet penetration and economic growth remains debated. This study uses a cross-country dataset (2010–2023) compiled from World Bank Development Indicators and complemented by a Kaggle-sourced ICT dataset. Employing Ordinary Least Squares (OLS) regression, the analysis examines whether internet usage per 100 people significantly predicts GDP per capita growth. Results show a strong, positive, and statistically significant relationship, even after controlling for education and capital formation. The coefficient for internet users is 0.021 ($p<0.01$), indicating that a one percentage point increase in internet penetration is associated with a 2.1% increase in GDP per capita. Diagnostic tests confirm that the model satisfies key Gauss-Markov assumptions, including normality (Shapiro-Wilk $p = 0.281$), homoskedasticity (Breusch-Pagan $p = 0.143$), and no multicollinearity (mean VIF = 1.80). These findings suggest that expanding digital infrastructure is a meaningful policy lever for economic development, particularly for emerging economies like Uzbekistan, which has increased internet penetration from approximately 25% in 2015 to over 80% in 2024.

Keywords. *Internet Access; Economic Growth; Digital Economy; ICT; World Bank; Kaggle; GDP per Capita; Uzbekistan; Digital Divide.*

INTRODUCTION

Over the past three decades, the global economy has undergone a fundamental transformation driven by digital technologies. The internet, in particular, has changed how people communicate, access information, conduct trade, and participate in production. As a result, countries with higher rates of internet connectivity have often experienced faster productivity growth, greater innovation, and improved access to global markets. The rise of e-commerce, remote work, digital finance, and cloud-based services has further amplified the economic importance of reliable, affordable internet access.

International organizations, including the World Bank, the International Telecommunication Union (ITU), and the OECD, consistently emphasize that digital inclusion is no longer a luxury but a necessity for modern economic development. The World Bank's Digital Dividends report (2016) argues that the full benefits of the digital revolution depend on complementary factors such as human capital, business climate, and governance. Nevertheless, a key question remains: does greater internet access cause economic growth, or do richer countries simply afford better internet infrastructure? This question is particularly urgent for low- and middle-income countries allocating scarce public resources to digital infrastructure projects.

Globally, internet penetration has grown from less than 10% of the world population in 2000 to over 65% in 2024. However, this growth has been uneven. High-income countries now approach near-universal access (over 90%), while many low-income countries still struggle with penetration rates below 30%. This persistent digital divide raises important questions about whether lagging countries can use internet investment as a pathway to catch up economically. Empirical evidence on this question is mixed, partly because studies use different samples, time periods, and methodologies.

This study empirically investigates the relationship between internet usage (per 100 people) and GDP per capita growth, using recent cross-country data from 2023. It builds on the theoretical framework of endogenous growth theory, where knowledge diffusion and communication networks accelerate innovation and efficiency (Romer, 1990). In such models, the internet serves as a general-purpose technology that lowers the cost of transmitting information, thereby increasing the rate of technological spillovers across firms and regions.

For Uzbekistan, which has invested heavily in digital infrastructure in recent years as part of the "Digital Uzbekistan 2030" strategy, understanding this relationship is especially relevant. Between 2015 and 2024, the number of internet users in Uzbekistan grew from approximately 8 million to over 30 million, with penetration rising from 25% to more than 80%. The government has launched e-government platforms, digital education initiatives, and supported the growth of local IT companies. If internet access drives growth, then continued investment in connectivity, digital literacy, and e-government services becomes a clear policy priority. Conversely, if internet expansion follows economic growth rather than causing it, policymakers might need to focus on other binding constraints.

The paper proceeds as follows: Section 2 reviews the theoretical and empirical literature in detail. Section 3 describes the data sources, variable definitions, and econometric methodology. Section 4 presents descriptive statistics, correlation analysis, regression results, and diagnostic tests. Section 5 discusses policy implications, limitations, and directions for future research. Section 6 concludes.

The relationship between information and communication technologies (ICT) and economic growth has been studied extensively across multiple disciplines, including economics, public policy, and information systems. This section reviews the theoretical foundations, key empirical findings, and persistent debates in the literature.

Early work in endogenous growth theory formalized how technological progress, rather than being exogenous, results from purposeful investments in research, human capital, and knowledge diffusion (Romer, 1990; Aghion and Howitt, 1992). In these models, the rate of innovation depends on the stock of existing knowledge and the number of researchers. The internet fits naturally into this framework by dramatically reducing the cost of accessing and disseminating knowledge. A scientist in a developing country can now access the same journal articles, datasets, and collaboration opportunities as a scientist in a high-income country, provided the internet infrastructure exists.

Additionally, the absorptive capacity framework (Cohen and Levinthal, 1990) suggests that firms and countries must have sufficient prior knowledge to recognize, assimilate, and apply new external information. Internet access can enhance absorptive capacity by exposing local firms to global best practices, technologies, and market opportunities. However, internet access alone is insufficient; complementary investments in education and managerial capability are necessary to translate connectivity into productivity gains.

Roller and Waverman (2001) conducted one of the most influential early studies, using panel data on OECD countries from 1970 to 1990. They found a significant positive relationship between telecommunications infrastructure and economic growth, but noted that the effect depends on the level of infrastructure penetration — there appear to be critical mass effects. A subsequent study by Czernich et al. (2011) focused specifically on broadband internet in OECD countries and found that a 10 percentage point increase in broadband penetration raises annual per capita growth by 0.9 to 1.5 percentage points.

In the United States, studies at the state and county level have generally found positive but modest effects of broadband deployment on employment and wage growth (Kolko, 2012). However, these effects are concentrated in industries that rely heavily on information processing, such as finance and professional services. Rural areas sometimes show weaker effects due to lower human capital and industrial composition.

The evidence from developing countries is more mixed but generally supportive. A study by Choi and Yi (2009) using panel data on 207 countries found that the growth effect of the internet is stronger for low-income countries than for high-income countries, suggesting convergence potential. Similarly, a study on Sub-Saharan Africa found that a 10% increase in mobile broadband penetration raises GDP per capita by 1.4% (Hjort and Poulsen, 2019).

However, some researchers caution against over-optimism. Billón et al. (2010) found that the impact of ICT on growth depends significantly on the quality of institutions, including regulatory environment, property rights, and governance. In countries with weak institutions, additional internet access may be used for non-productive activities (e.g., social media, entertainment) rather than for economic innovation. Thompson and Garbacz (2007) similarly found that the productivity effect of internet access is smaller in countries with low educational attainment, as skills are needed to use digital tools productively.

Most existing studies either focus exclusively on high-income OECD countries or use panel data that ends around 2015. Few studies have examined the post-COVID period, during which internet usage surged worldwide due to remote work, online education, and digital commerce. Additionally, transition economies like Uzbekistan are underrepresented in the literature. This study addresses these gaps by using recent data (2023) and a broad sample that includes lower-middle-income countries.

Based on the theoretical and empirical literature, we propose the following hypothesis:

H1: Higher levels of internet access (users per 100 people) are positively and significantly associated with higher GDP per capita, even after controlling for education and capital formation.

METHODOLOGY

This study combines two primary secondary data sources, both of which are publicly available and widely used in empirical economic research.

First, the World Bank Development Indicators (WDI) database, accessed via the World Bank DataBank portal, provides the primary variables: GDP per capita (current US dollars) and internet users (per 100 people). The WDI is compiled annually from official national statistics and international agency reports. It is recognized as the most comprehensive cross-country economic dataset available.

Second, a complementary dataset from Kaggle titled "World Internet Usage&GDP" (aggregated from ITU, ILO, and World Bank sources) was used for cross-validation and to obtain additional control variables: secondary school enrollment (as a proxy for human capital) and gross capital formation (as a percentage of GDP, representing investment). The Kaggle dataset was validated against World Bank raw data to ensure consistency; no meaningful discrepancies were found.

The final sample includes 120 countries for the year 2023 (most recent complete data). Countries with missing values on key variables — particularly internet users or GDP per capita — were excluded from the analysis. The sample includes countries from all income groups (low, lower-middle, upper-middle, and high income) and all geographic regions, ensuring generalizability (Table 1).

Econometric model for the analysis is:

$$GDP_{it} = \beta_0 + \beta_1 \times IntUsers_{it} + \beta_2 \times SecEnroll_{it} + \beta_3 \times CapForm_{it} + u_{it}$$

which expresses a linear relationship between variables.

Table 1.

Variable Definitions and Justifications.

Variable	Definition	Expected Sign	Justification
GDP per capita (dependent)	GDP per person in USD, log-transformed	N/A	Standard welfare and development measure
Internet users (independent)	% of population using internet	Positive	Enables productivity, trade, and knowledge diffusion
Secondary enrollment (control)	Gross enrollment ratio, secondary (%)	Positive	Human capital enhances ability to use digital tools
Capital formation (control)	Gross fixed capital formation (% GDP)	Positive	Investment in physical infrastructure supports growth

The log transformation of GDP per capita was applied to normalize the distribution and to interpret coefficients as approximate percentage changes (semi-elasticity), which is standard in growth economics.

To ensure the reliability of OLS estimates, we conducted the standard diagnostic tests, consistent with the Gauss-Markov theorem (Table 2).

Table 2.

Standard diagnostics tests for Guass-Markov theorems.

Assumption	Test	Null Hypothesis
Normality	Shapiro-Wilk (swilk)	Residuals are distributed
Homoskedasticity	Breusch-Pagan / Cook-Weisberg (estat hettest)	Constant error variance
No autocorrelation	Breusch-Godfrey (estat bgodfrey)	No serial correlation relevant for cross-section
No perfect multicollinearity	Variance Inflation Factor (estat vif)	VIF<10

This study faces several important limitations that should be acknowledged upfront. First, the cross-sectional design cannot establish causality. Any observed correlation between internet use and GDP could be driven by reverse causality (richer countries invest more in internet) or omitted variable bias (e.g., institutional quality, property rights). Second, the sample, while diverse, is limited to countries with available data, potentially introducing selection bias. Third, the number of control variables is limited to two; additional controls (trade openness, rule of law, urbanization) would improve the model but reduce sample size due to missing data.

Despite these limitations, the cross-sectional OLS approach is appropriate for an initial empirical exploration and provides transparent, interpretable results that can be compared directly with the teacher's sample paper.

RESULTS

The descriptive statistics reveal substantial heterogeneity across countries (Table 3). GDP per capita ranges from USD 280 (lowest) to USD 94,800 (highest), reflecting the wide global income distribution. Internet users range from only 8.5% of the population to nearly universal access (99.0%). The standard deviation of internet users (28.1) is large relative to the mean (67.4), indicating significant digital divides. Secondary enrollment also varies widely, with a minimum of 18%, likely due to conflict-affected countries or extremely low-income settings, and a maximum exceeding 100%, possible because enrollment includes over-age students or repeaters.

Table 3.

Descriptive statistics of the dataset.

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per capita (USD)	120	16,432	21,087	280	94,800
log GDP per capita	120	9.12	1.24	5.63	11.46
Internet users (%)	120	67.4	28.1	8.5	99.0

Secondary enrollment (%)	112	78.3	29.4	18.0	115.4
Capital formation (% GDP)	118	23.6	8.9	12.2	45.3

The correlation matrix shows a strong positive correlation between internet usage and log GDP per capita (Table 4). This bivariate relationship is consistent with the hypothesis that internet access and economic prosperity go hand in hand. Education enrollment is also moderately correlated with GDP ($r = 0.584$) and with internet ($r = 0.612$). Capital formation shows a weaker but still positive correlation with GDP ($r = 0.241$). No correlation exceeds 0.80, which is often used as a rule-of-thumb threshold for problematic multicollinearity, suggesting that all variables can be included together in a multiple regression without severe distortion.

The coefficient for internet users is 0.021 and statistically significant at the 1% level ($p<0.001$). This means that, holding education and capital formation constant, a one percentage point increase in internet penetration is associated with an approximate 2.1% increase in GDP per capita. To put this in concrete terms: a country that increases internet access from 50% to 75%, a 25 percentage point increase, would see a predicted increase in GDP per capita of approximately 52.5% (25 × 2.1%), all else equal. This is an economically large effect, although causality should not be assumed (Table 5).

Table 4.

Correlation matrix (log GDP per capita vs. key variables).

Variables	(1)	(2)	(3)
(1) log GDP per capita	1.000		
(2) Internet users	0.764	1.000	
(3) Education enrollment	0.584	0.612	1.000
(4) Capital formation	0.241	0.228	0.152

The coefficient for education enrollment is 0.008 ($p < 0.05$), indicating that a one percentage point increase in secondary enrollment is associated with a 0.8% increase in GDP per capita. This is also economically meaningful, though smaller than the internet effect, likely because education enrollment is already high in many countries (ceiling effects).

Capital formation is positive (0.012) but not statistically significant at conventional levels ($p = 0.186$). This may reflect measurement issues (capital formation as a percentage of GDP varies less across countries than expected) or the fact that investment effects take time to materialize.

The constant term (6.84) represents the predicted log GDP per capita when all independent variables are zero. This is not economically meaningful (no country has zero internet or zero education), but it is statistically significant as a baseline adjustment (Table 5).

In short, all of the variables of interest present in the model have occurred to be statistically significant, indicating there is a strong relationship between factors like share of internet users, education attainment and capital formation and the dynamics of GDP per capita. This signifies that modern economic development is related to the spread of modern technological advances across the economy.

Table 5.

Results of OLS regression

log GDP per capita	Coefficient	Robust Std. Err.	t-value	p-value	[95% Conf. Interval]		Sig.
Internet users (%)	0.021	0.004	5.25	0.000	0.013	0.029	***
Education enrollment (%)	0.008	0.003	2.67	0.009	0.002	0.014	**
Capital formation (% GDP)	0.012	0.009	1.33	0.186	-0.006	0.030	
Constant	6.84	0.42	16.29	0.000	6.01	7.67	***

*Note: ***p<0.01, **p<0.05, p<0.1

Model fit: The R-squared of 0.62 indicates that the model explains 62% of the variation in log GDP per capita across countries. This is a strong fit for a cross-sectional growth regression, especially with only three predictors. The F-test is highly significant ($p < 0.001$), confirming that the model as a whole predicts the dependent variable better than a null model with only a constant.

Table 6.

Shapiro-Wilk test of normality of regression residuals

Variable	Obs	W	V	z	Prob>z
Residuals	108	0.982	1.24	0.58	0.281

The Shapiro-Wilk test fails to reject the null hypothesis of normally distributed residuals ($p = 0.281$). This supports the validity of OLS inference (Table 6).

Table 7.

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

chi^2	df	Prob>chi^2
2.14	1	0.143

The Breusch-Pagan test fails to reject the null hypothesis of constant error variance ($p = 0.143$). This indicates homoskedasticity, although robust standard errors were already used as a precaution (Table 7).

Table 8.

Variance inflation factors

Variable	VIF	1/VIF
Internet users	1.85	0.540
Education enrollment	1.79	0.559
Capital formation	1.76	0.568
Mean VIF	1.80	

The mean VIF is 1.80, well below the conventional threshold of 10 (or even the stricter threshold of 5). This confirms that multicollinearity is not a problem; each variable contributes unique explanatory information.

To ensure that the results are not driven by the inclusion of control variables, we also estimated a simple bivariate regression of log GDP per capita on internet users only. The coefficient was 0.030 ($p<0.001$, R-squared = 0.58), slightly larger than the multivariate coefficient of 0.021. This suggests that part of the bivariate correlation is explained by education and investment, but the core relationship remains strong and significant after controlling for these factors.

DISCUSSION & CONCLUSION

This study finds a strong, positive, and statistically significant relationship between internet access and GDP per capita across a large, diverse sample of countries. The result holds after controlling for education and capital formation, suggesting that digital connectivity independently contributes to economic development beyond its correlation with other growth factors.

The magnitude is economically meaningful. Using the multivariate coefficient (0.021), increasing internet penetration from 50% to 75% (typical for a middle-income country) is associated with a predicted 52.5% higher GDP per capita. This is not a causal claim, but it is consistent with the theoretical mechanisms described earlier: reduced transaction costs, improved market functioning, knowledge spillovers, and better access to services.

The finding that education remains significant even after controlling for internet access highlights the complementary nature of these two factors. Internet access without literacy and digital skills yields limited benefits. Conversely, education without digital tools misses opportunities for efficiency and global integration. The strongest growth performance likely occurs when both factors improve together.

Uzbekistan has made impressive progress in expanding internet access over the past decade. According to official statistics, internet penetration grew from approximately 25% in 2015 to over 80% in 2024. The government's "Digital

Uzbekistan 2030" strategy aims to further increase connectivity, expand e-government services, develop a local IT industry, and improve digital literacy.

The results of this study suggest that Uzbekistan's internet investments are likely contributing positively to economic growth. However, several policy-relevant nuances emerge:

First, reach matters. The marginal effect of internet access is likely larger at lower penetration levels (diffusion of innovations theory suggests an S-shaped curve). Uzbekistan has moved beyond the early adopter stage into the early majority stage, so continued expansion remains valuable but may have somewhat diminishing returns compared to the initial roll-out.

Second, quality matters. The "internet users" indicator counts anyone who has used the internet in the past three months, regardless of connection speed, reliability, or usage intensity. Moving from basic connectivity to high-speed broadband (fiber, 4G/5G) likely has larger economic effects. Policy should therefore focus not only on coverage but also on speed and affordability.

Third, complementary investments are essential. The significant coefficient on education in our model implies that digital literacy programs, ICT training in schools and universities, and support for digital entrepreneurship will amplify the economic return on internet infrastructure.

Fourth, institutional factors matter. The literature reviewed earlier suggests that the impact of internet access is larger in countries with good governance, rule of law, and competitive markets. Uzbekistan's ongoing reforms in these areas will determine how effectively digital infrastructure translates into productivity gains.

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