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Digital Access Indicators and GDP per Capita Growth in Arab Countries: Panel Data Evidence, 2000–2023

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Abstract
This study examines the short-run association between digital access—measured by mobile subscriptions and Internet use—and GDP per capita growth across 21 Arab countries over the period 2000–2023. Utilizing World Development Indicators (WDI) data and a two-way fixed-effects panel model covering 428 complete-case observations, the empirical findings reveal that neither digital indicator nor aggregate investment exhibits a statistically significant contemporaneous relationship with economic growth. These results remain robust across various sensitivity checks, including alternative inference procedures and outlier controls. The study suggests that connectivity prevalence measures do not necessarily capture network quality, digital skills, or productive enterprise adoption. Consequently, policymakers should complement infrastructure expansion with targeted investments in digital skills and productive digital public and financial services.

Keywords: Digital Access, Economic Growth, Internet Use, Mobile Subscriptions, Panel Data, Arab Countries

1. Introduction

Telecommunications and Internet technologies have become part of modern productive infrastructure. They can reduce information and coordination costs, widen markets, support financial and public services, and facilitate innovation. Growth theory links these channels to capital accumulation, productivity improvement, and knowledge diffusion. Yet network expansion alone need not produce immediate aggregate growth: returns depend on service quality, user skills, complementary infrastructure, and firms' ability to integrate technology into production (World Bank, 2016; Organisation for Economic Co-operation and Development [OECD], 2019; International Monetary Fund [IMF], 2018; Vu *et al*., 2020; Vergara Cobos & Malásquez, 2023) [58, 42, 30, 55, 54].

Arab economies differ substantially in income, infrastructure, macroeconomic stability, and capacity to invest in digital systems. Conventional connectivity measures also have limitations. Mobile subscriptions measure subscriptions rather than unique users and may exceed population when individuals hold multiple SIM cards. Internet-use prevalence does not capture connection quality, intensity, or productive application. Estimated relationships can therefore vary with the indicator, sample, period, and econometric design (International Telecommunication Union [ITU], 2023; United Nations Conference on Trade and Development [UNCTAD], 2024; Belloumi & Touati, 2022) [31, 52, 8].

The empirical literature is mixed. Some cross-country studies report positive effects of Internet, broadband, or mobile access, while others find weak, insignificant, or horizon-dependent effects (Choi & Yi, 2009; Czernich *et al*., 2011; Niebel, 2018; Stanley *et al*., 2018; Harb, 2017; Belloumi & Touati, 2022; Abu Alfoul *et al*., 2024; Mohammed & Laib, 2025) [14, 15, 41, 50, 27, 8, 1, 39]. Reviews and meta-analyses generally report positive average associations but emphasize heterogeneity by technology, development level, period, and complementary inputs (Cardona *et al*., 2013; Vu *et al*., 2020; Vergara Cobos & Malásquez, 2023; Wang *et al*., 2024) [11, 55, 54, 56].

This paper estimates the within-country association between two widely available digital-access indicators and annual GDP per capita growth in Arab countries from 2000 to 2023. It separates country-specific time-invariant characteristics and common year shocks using two-way fixed effects, reports separate and joint indicator specifications, and checks sensitivity to alternative covariance estimation and extreme growth observations. The scope is deliberately narrower than the digital economy as a whole: the indicators do not measure e-commerce, digital skills, digital services, or digital capital directly.

Research questions and hypotheses

The study asks whether mobile subscriptions and Internet use are associated with GDP per capita growth after accounting for country and year effects and gross capital formation, and whether the estimates remain similar when both digital indicators are included together. The null hypotheses are that the mobile and Internet coefficients are each equal to zero. These are associational hypotheses, not causal claims.

2. Theoretical framework and literature review

2.1 Channels linking digital access to growth

Digital infrastructure may raise productivity by lowering search and communication costs, improving buyer–seller matching, expanding market reach, facilitating knowledge exchange, and enabling financial and administrative services. Network investment may also benefit sectors outside telecommunications through spillovers (Koutroumpis, 2009; Gruber & Koutroumpis, 2011; Qiang *et al*., 2009; Edquist *et al*., 2018; Gómez-Barroso & Marbán-Flores, 2020) [34, 23, 46, 20, 22].

The payoff may be delayed by learning and organizational adjustment, or limited by gaps in skills, reliable electricity, network quality, and institutions. Measuring access rather than productive use can attenuate estimated effects. This is related to the productivity paradox in which technology adoption expands before its contribution is visible in aggregate productivity and growth statistics (Cardona *et al*., 2013; Niebel, 2018; Vu *et al*., 2020; World Bank, 2016; Vergara Cobos & Malásquez, 2023) [11, 41, 55, 58, 54].

2.2 International evidence

Early studies linked Internet, broadband, and mobile diffusion to economic growth, with broadband effects sometimes increasing as coverage and adoption expand (Choi & Yi, 2009; Czernich *et al*., 2011; Arvin & Pradhan, 2014; Castaldo *et al*., 2018; Toader *et al*., 2018) [14, 15, 3, 12, 51]. Subsequent cross-country research has reported positive average relationships while documenting variation across income groups and technologies (Farhadi *et al*., 2012; Das *et al*., 2018; Bahrini & Qaffas, 2019; Appiah-Otoo & Song, 2021; Cheng *et al*., 2021; Kim *et al*., 2021; Haldar *et al*., 2023; Saba & Ngepah, 2022; Nabi *et al*., 2023) [21, 17, 6, 2, 13, 33, 26, 47, 40]. Other studies emphasize investment, finance, institutions, and heterogeneity among developing economies (Asongu & Odhiambo, 2020; David, 2019; Haftu, 2019; Awad & Albaity, 2022; Latif *et al*., 2018; Pradhan *et al*., 2018) [4, 18, 25, 5, 36, 45].

Evidence is not uniform. Estimated effects can depend on the technology and development context; some studies report no robust Internet effect or different short- and long-run results (Maurseth, 2018; Niebel, 2018; Ishida, 2015; Maneejuk & Yamaka, 2020; Hussain *et al*., 2021; Papaioannou, 2023) [38, 41, 32, 37, 29, 43]. A meta-analysis of 65 studies finds a positive average ICT-growth effect but also substantial variation and possible publication bias, while a World Bank review of 112 studies discusses channels at macro, firm, and individual levels (Stanley *et al*., 2018; Wang *et al*., 2024; Vergara Cobos & Malásquez, 2023) [50, 56, 54].

2.3 Middle East and Arab-country evidence

For the Middle East, Habibi and Zabardast (2020) [24] report a more limited Internet-use association than in OECD economies, while mobile subscriptions have a relatively larger association in their Middle Eastern sample. MENA studies also point to the roles of financial development, energy, and investment, with varying results (Sassi & Goaied, 2013; Saidi *et al*., 2018) [49, 48]. Harb (2017) [27] finds that telecommunications investment is not significant for economic performance in parts of Arab and Middle Eastern samples; this is related context, although the control in the present study is gross capital formation rather than telecommunications investment.

Belloumi and Touati (2022) [8], analyzing 15 Arab countries from 1995 to 2019 with a panel ARDL model, find that ICT indicators are insignificant in the short run while some positive effects emerge in the long run. This is consistent with the absence of a detectable short-run association in the present estimates, despite differences in coefficient signs and model design. Dahmani *et al*. (2023) [16] report positive telecommunications effects in MENA using a dynamic long-run framework. More recent evidence remains heterogeneous: Abu Alfoul *et al*. (2024) [1] report a negative ICT-adoption effect with education-related conditioning, whereas Mohammed and Laib (2025) [39] report a positive significant digitalization-growth relationship for MENA using broader measures and fixed-effects/System GMM models.

2.4 Research gap and contribution

This study contributes a recent, reproducible panel analysis using annual GDP per capita growth, two separate access indicators, two-way fixed effects, and sensitivity checks. It complements studies using composite digitization or firm-level digitalization measures (Brodny & Tutak, 2022; Kurniawati, 2021) [9, 35]. It does not claim that the indicators represent the full digital economy or identify causal effects; its contribution is a conditional short-run association for a relatively broad Arab-country sample with available data.

3. Data and Methodology

3.1 Data source and sample

Annual observations for 2000–2023 are obtained from the World Bank's World Development Indicators (WDI) (World Bank, 2026) [59]. The extraction list contains 22 Arab countries. The potential panel comprises 528 country-year observations (22 countries × 24 years). Complete-case deletion leaves 428 observations for 21 countries; Syria contributes no complete observation for all four model variables. Available observations per country range from 8 to 24, so the panel is unbalanced. Before estimation, the Djibouti gross-capital-formation observation for 2021 was cross-checked against the United Nations Statistics Division (UNSD) National Accounts Main Aggregates database. UNSD reports gross capital formation of 247,259,057,429 Djiboutian francs and GDP of 602,971,000,000 francs for that year (United Nations Statistics Division, 2026) [53]. Their ratio is 41.0068% of GDP. This independently sourced estimate replaces the WDI value of −15.6784% in the corrected baseline; the unadjusted WDI series is retained for sensitivity analysis. The UNSD database is based on official country submissions and may supplement missing or inconsistent observations with estimates; accordingly, the adjustment is explicitly treated as a cross-source replacement rather than a directly observed WDI value.

3.2 Variables and measurement

Table 1: Variables and operational definitions

Role	Variable	WDI indicator	Operational definition
Dependent	GDP per capita growth	NY.GDP.PCAP.KD.ZG	Annual growth rate of GDP per capita at constant prices (%)
Digital predictor	Mobile subscriptions	IT.CEL.SETS.P2	Mobile-cellular subscriptions per 100 people; not unique users
Digital predictor	Internet use	IT.NET.USER.ZS	Individuals using the Internet as a share of population (%)
Control	Gross capital formation	NE.GDI.TOTL.ZS	Gross capital formation as a share of GDP (%)

Gross capital formation is a measure of aggregate investment, not ICT-specific investment, and is treated as a control. The 2021 Djibouti value in the corrected analysis is a transparent cross-source estimate: 247,259,057,429 ÷ 602,971,000,000 × 100 = 41.0068%. Mobile subscriptions and Internet use proxy access and prevalence; neither captures network quality, digital skills, or productive use.

3.3 Econometric specification

Three two-way fixed-effects specifications are estimated: (1) mobile subscriptions and investment; (2) Internet use and investment; and (3) both digital indicators and investment. The general model is:

$$Growth_{it} = \beta_1 Digital_{it} + \beta_2 Investment_{it} + \alpha_i + \lambda_t + \varepsilon_{it}$$

Where i denotes country and t denotes year; α_i represents country fixed effects and λ_t represents year fixed effects. Coefficients are interpreted as within-country associations after absorbing these effects. Baseline standard errors are clustered by country. Driscoll–Kraay standard errors with bandwidth 2 are used as an alternative inference procedure to allow for possible cross-sectional and serial dependence. The panel framework follows standard references in panel-data econometrics (Wooldridge, 2010; Hsiao, 2014; Baltagi, 2021) [57, 28, 7], while clustered and Driscoll–Kraay inference follows Cameron and Miller (2015) [10], Driscoll and Kraay (1998) [19], and Pesaran (2006) [44].

3.4 Sensitivity checks and data quality

The joint specification is re-estimated using Driscoll–Kraay standard errors and after winsorizing GDP per capita growth at the 1st and 99th percentiles. As further checks, the model is re-estimated with the unadjusted WDI gross-capital-formation value and with WDI gross fixed capital formation (% of GDP; NE.GDI.FTOT.ZS) for every country-year with complete data (World Bank, 2026) [59]. Extreme growth observations are retained in the baseline because they may reflect genuine country experiences.

3.5 Ethics and data availability

The study uses published country-year macroeconomic data and contains no individual-level records or human-subject intervention. The extracted data and reproducible code accompany the working materials.

4. Results

4.1 Coverage and missing observations

Table 2: Missing data and analytical sample

Indicator	Missing of 528	Missing (%)
GDP per capita growth	20	3.8
Mobile subscriptions	4	0.8
Internet use	34	6.4
Gross capital formation	72	13.6
Complete-case sample	100 excluded	428 observations retained

Gross capital formation has the largest amount of missing data. Complete-case deletion removes 100 of 528 possible observations and results in uneven coverage across countries. This may constrain generalizability and should be considered when interpreting estimates.

4.2 Descriptive statistics

Table 3: Descriptive statistics for the estimation sample

Variable	Mean	Std. dev.	Minimum	Median	Maximum
GDP per capita growth (%)	0.748	8.121	−49.128	1.175	91.781
Mobile subscriptions per 100 people	83.686	56.804	0.000	79.424	220.412
Internet users (%)	37.868	33.329	0.026	26.600	100.000
Gross capital formation (% GDP; corrected baseline)	23.918	9.709	−10.596	23.035	51.780

Annual growth varies widely. Mobile subscriptions exceed 100 per 100 people in some country-years, consistent with subscriptions rather than unique users. The minimum and maximum growth observations are Libya in 2011 (−49.13%) and Libya in 2012 (91.78%). Following the source reconciliation described above, the lowest investment value in the corrected estimation sample is −10.60% in Djibouti in 2022; the 2021 observation is 41.01% using the UNSD national-accounts ratio. The unadjusted WDI series is examined separately below.

4.3 Two-way fixed-effects estimates

Table 4: Baseline two-way fixed-effects estimates

Variable	Model 1: Mobile	Model 2: Internet	Model 3: Both
Mobile subscriptions	−0.0162 (0.0178); p=0.364	—	−0.0147 (0.0181); p=0.417
Internet use	—	−0.0203 (0.0260); p=0.434	−0.0164 (0.0264); p=0.535
Gross capital formation	0.0580 (0.0616); p=0.347	0.0516 (0.0648); p=0.426	0.0593 (0.0617); p=0.337
Observations	428	428	428
Countries	21	21	21
Within R^2	0.0122	0.0132	0.0149
Robust model F-test, p-value	0.2215	0.4632	0.3105

Notes: Coefficients are reported with standard errors in parentheses and p-values after semicolons. All models include country and year fixed effects. Standard errors are clustered by country. The Djibouti 2021 investment value uses the UNSD-based estimate described in Section 3.1. None of the mobile, Internet, or investment coefficients is statistically significant at the 5% level.

The mobile coefficient is negative in the specifications that include it but statistically insignificant. The Internet coefficient is likewise negative and insignificant. The estimates therefore provide insufficient evidence of a contemporaneous short-run association between either access indicator and GDP per capita growth. Gross capital formation is also not significant at 5%. Within R^2 values range from 0.012 to 0.015, and none of the robust overall F-tests is significant at 5%.

4.4 Robustness checks

Table 5: Sensitivity analysis for the joint specification

Check	N / countries	Mobile coefficient (p)	Internet coefficient (p)	Investment coefficient (p)
Driscoll–Kraay SE; bandwidth 2; corrected baseline	428 / 21	−0.0147 (0.455)	−0.0164 (0.572)	0.0593 (0.131)
Growth winsorized at 1st/99th percentiles; clustered SE	428 / 21	−0.0187 (0.364)	−0.0022 (0.949)	0.0457 (0.452)
Unadjusted WDI GCF value for DJI 2021	428 / 21	−0.0162 (0.366)	−0.0169 (0.525)	0.0868 (0.140)
WDI gross fixed capital formation proxy	381 / 20	−0.0224 (0.201)	−0.0096 (0.758)	0.0728 (0.498)

The digital-access coefficients remain statistically insignificant in every sensitivity specification. The fixed-capital-formation check uses the World Bank indicator NE.GDI.FTOT.ZS for all observations with available data and therefore has a smaller sample (381 observations from 20 countries). The cross-source replacement changes the estimated investment coefficient but does not change the substantive finding for mobile or Internet access.

5. Discussion

The central result is that neither mobile subscriptions nor Internet use has a statistically significant short-run association with GDP per capita growth after controlling for country and year effects. This aligns in significance, though not necessarily in coefficient signs or specification, with Belloumi and Touati (2022) [8], who find no short-run significance for ICT indicators in an Arab-country sample but report some positive long-run relationships. The result is also consistent with research emphasizing that macroeconomic effects may lag firm-level gains while skills and organizational changes accumulate (Cardona *et al*., 2013; Niebel, 2018; Vu *et al*., 2020; Vergara Cobos & Malásquez, 2023) [11, 41, 55, 54].

The negative point estimates do not show that mobile or Internet access reduces growth: the estimates are imprecise and their confidence intervals include zero. The appropriate conclusion is insufficient evidence of an association in these models, rather than evidence of a negative effect. This differs from studies reporting significant long-run or positive effects, including Dahmani *et al*. (2023) [16] and Mohammed and Laib (2025) [39], and from international evidence with a positive average relationship (Stanley *et al*., 2018; Wang *et al*., 2024) [50, 56]. Abu Alfoul *et al*. (2024) [1], however, report negative effects in a MENA setting, underlining that a single universal coefficient should not be presumed.

Several mechanisms may explain differences across studies. First, the present indicators measure connectivity prevalence rather than quality or productive use in firms and digital commerce. Second, digital investment may affect output with a lag, while the current model relates access to contemporaneous annual growth and includes no lags. Third, returns may depend on income, skills, governance, and complementary infrastructure. Finally, country effects remove time-invariant cross-country differences and year effects absorb common shocks; identification therefore comes from within-country changes around common trends, not from cross-country differences in average digitalization. These interpretations are consistent with reviews and comparative Middle East evidence (Habibi & Zabardast, 2020; World Bank, 2016; OECD, 2019; ITU, 2023; UNCTAD, 2024) [24, 58, 42, 31, 52].

The unbalanced sample and unusual observations warrant caution. Syria contributes no complete cases, and some countries have only eight observations. Libya's extreme growth values widen the outcome distribution. The 2021 Djibouti WDI value is not silently treated as valid or deleted: it is replaced by a clearly documented UNSD-based ratio in the corrected baseline, while the raw WDI series and an alternative gross-fixed-capital-formation measure are separately estimated. Winsorizing growth does not change the inference for either digital indicator. Missing-data selection and subgroup heterogeneity remain possible limitations.

Alternative standard errors matter because the baseline has only 21 country clusters. The mobile and Internet coefficients remain insignificant under Driscoll–Kraay inference, reducing concern that the main conclusion is solely an artifact of the baseline covariance estimator. This does not remove the limits created by the number of countries or the possibility of reverse causation: economic

growth may enable greater digital access, just as access may support productivity. Separating these directions requires a suitable dynamic or quasi-experimental research design.

6. Conclusion and policy implications

Using annual data for 2000–2023, this paper analyzes digital access and economic growth in Arab countries. In a complete-case sample of 21 countries and 428 observations, mobile subscriptions and Internet use are not statistically significant predictors of GDP per capita growth in two-way fixed-effects models. This finding persists with alternative standard errors, after winsorizing extreme growth values, under the unadjusted WDI investment value, and when using gross fixed capital formation as an alternative investment measure. It does not establish that digitalization is unimportant or harmful; it indicates that the access measures used here do not significantly explain annual within-country growth in the estimated specifications. The Djibouti investment correction is explicitly derived from the UNSD-reported national-accounts numerator and GDP and should be described as a cross-source estimate.

For policy, network expansion should be assessed alongside digital skills, productive adoption by firms, digital public and financial services, and reliable electricity and connectivity, rather than by subscription counts alone. These are implications of mechanisms discussed in the literature, not causal effects tested by this model. Future research could test lagged effects, interactions with education or human capital, country groups by income or stability, and measures of network quality and digital capital. Researchers should verify the flagged source observation and consider dynamic or causal methods where data permit.

7. Limitations

The study measures two dimensions of access rather than the full digital economy, digital skills, or service quality. The panel is unbalanced and complete-case deletion excludes Syria. The specification contains no lags and does not identify causal effects. The investment correction relies on an alternative official international data source for one country-year, while the original WDI and a fixed-capital proxy are reported as sensitivity checks. The estimates should therefore be treated as reproducible associational evidence rather than causal effects.

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