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Global Mobile Communications

Devices, Networks & Digital Adoption

Pakistan in Global Perspective



Volume I

Historical Trends, Economic Relationships, Forecasting and Strategic Insights



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November 2026

Prologue - From Fixed-Line Telephony to the Two Pillars of Digital Connectivity

Telecommunications history is not simply a story of more telephones: It is a sequence of overlapping transitions: fixed-line voice networks enabled mass telephony; cellular systems extended mobility and personal access; digital generations brought messaging and mobile Internet; and broadband applications broadened communication into commerce, education, finance, healthcare and other services. Fixed networks have not disappeared: fibre, fixed broadband and backbone infrastructure remain essential to cellular access and data transmission.

This **Volume I** of the synthesis focuses deliberately on two measurable dimensions of that transformation. The first pillar is mobile-cellular subscriptions per 100 inhabitants, a measure of the intensity and reach of cellular connections. The second is individuals using the Internet (% of population), a measure of digital participation across access technologies. Together, they provide an empirically comparable framework for analysing historical diffusion, inequality, economic association, convergence and Pakistan's relative position. These measures underpin most of the country-level figures in this edition by design, not because they exhaust the economics of telecommunications.

Why quantitative evaluation is essential: Historical growth charts describe the expansion of connections and participation, but cannot determine whether the two indicators move together, whether digital disparities are converging, how associations with income change when country and global time effects are considered, or how sensitive future trajectories are to model choice. **Volume I**, therefore, applies descriptive distributions, correlations, panel econometrics, convergence diagnostics, principal component analysis, clustering and time-aware forecast comparisons as complementary tests of the evidence. Their purpose is to distinguish observed patterns from economic interpretation and to identify hypotheses and data requirements for **Volume II** and the Pakistan Strategy/Policy Paper, not to infer causal returns or commercially obtainable customers from country-level indicators alone.

Economic interpretation requires a further distinction: a model of real GDP per capita in levels does not directly test whether annual growth in Internet use or cellular subscriptions predicts annual real GDP growth. This **Volume I** evaluates the reported income-level associations; growth-on-growth relationships, geographic and income-group heterogeneity, and country-specific deviations are identified as explicit next-stage robustness tests.

The Two Pillars: What They Explain and What They Do Not

Table P-1. Interpretation and limitations of the two core connectivity indicators

Analytical pillar	What is observed	Not directly established
Cellular connection intensity	Mobile-cellular subscriptions per 100 inhabitants; multi-SIM activity can make the ratio exceed 100	Unique users, voice minutes, call-package prices, mobile-only Internet adoption or operator profit
Digital participation	Individuals using the Internet as a share of the population, regardless of access technology	Mobile-data volumes, mobile share of use, ARPU, paid-service packages or investment returns

One historical comparison demonstrates the scale of the transition. ITU's 'Measuring digital development: Facts and Figures 2024' reports approximately 33 mobile-cellular subscriptions per 100 inhabitants in 2005 and 112 in 2024. Fixed-telephone subscriptions declined from approximately 19 to 10 per 100, while fixed-broadband subscriptions increased from approximately 1 to 20. Active mobile-broadband subscriptions reached 95 per 100 in 2024; a comparable 2005 endpoint is not established in the cited ITU historical chart and is, therefore, not plotted. These are worldwide subscription intensities, not counts of unique individuals (ITU, 2024).

The mobile-cellular indicator is historically related to voice-capable cellular service; the Internet-use indicator captures an increasingly diverse set of activities. They therefore reflect related but non-identical aspects of communications development. Cellular evolution from 2G and SMS through 3G, 4G and 5G increased the feasibility and quality of mobile Internet access, but it would overstate the evidence to claim that these two statistical variables alone caused each technological advance.

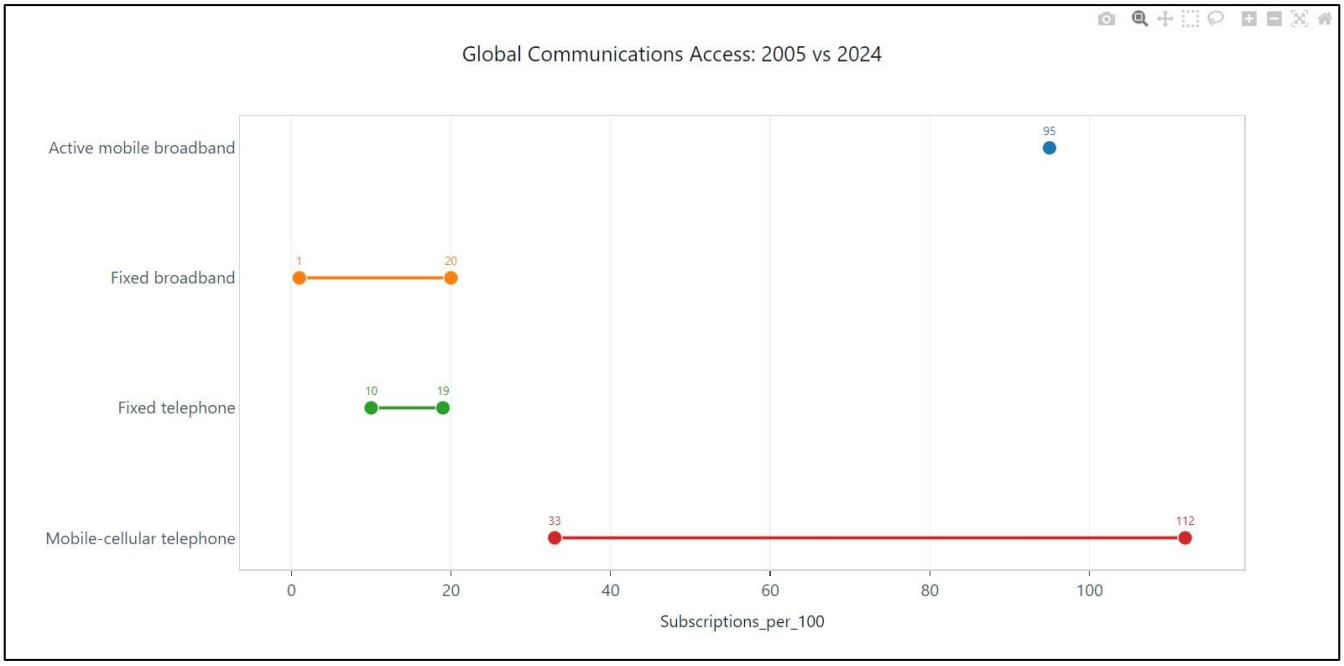


Figure P-1. Global communications access, 2005 versus 2024: selected subscription categories.

Source: International Telecommunication Union (2024), Measuring digital development: Facts and Figures 2024, pp. 9 and 12. Worldwide rounded subscriptions per 100 inhabitants; the 2005 active-mobile-broadband observation is unavailable in the cited figure and is not implied by the 2024-only marker. Lines join two endpoints for visual comparison; they do not represent estimated intervening annual trajectories.

What Volume I Does and What Volume II will Address

Volume I examines how widely cellular connectivity and Internet participation spread, how they differed across economies, their demographic and macroeconomic associations, and what the observed gaps imply for strategic screening. Voice calls, SMS, prepaid/postpaid calling packages, mobile-data consumption, tariff affordability, average revenue per user (ARPU), voice/data revenue mix and operator cash economics are essential commercial subjects, but they are not measured comprehensively in the present comparable country-year panel.

A planned **Volume II**, '**From Voice and SMS to Data Monetization: The Economics of Mobile Network Operators',** will investigate those service-level dimensions with appropriately matched ITU, regulatory and operator disclosures. Internet use in **Volume I** is a participation measure, not a substitute for data traffic, data-package subscriptions or service revenue in **Volume II**. This separation keeps the historical and statistical findings intact while avoiding claims the existing data cannot substantiate.

Reference: International Telecommunication Union. (2024). Measuring digital development: Facts and Figures 2024 (Subscriptions). https://www.itu.int/itu-d/reports/statistics/wp-content/uploads/sites/5/2024/11/2402588_1e_Measuring-digital-development-Facts-and-Figures-2024_v4.pdf

Executive Summary

This **Volume I** of an independent research on global telecommunication examines the expansion of mobile-cellular connectivity and Internet participation as two complementary analytical pillars of digital development. It also brings together device-manufacturer transformation, network expansion, demographic and economic context, exploratory statistics, global panel econometrics, convergence, forecasting diagnostics and a purposively selected 13-country comparison (Pakistan and twelve peers). The two pillars are intentionally the principal comparable country-level metrics, not exhaustive measures of calling-package demand, mobile-data traffic or operator revenue. The evidence is intended for strategic screening and reproducible research, not a revenue forecast or causal claim.

The economic modelling component reports 4,622 complete country-year observations across 196 economies during 2000–2024. It distinguishes observed cross-sectional associations from within-country fixed-effects relationships; results require source-vintage, specification and uncertainty qualifications. The digital-divide analyses use a stable 172-entity distributional cohort: median Internet use rose from 2.21% in 2000 to 82.10% in 2024. In a separate 2024 complete-case sample, the first two standardized PCA components explain 94.3% of the variance in the three selected indicators. Cluster solutions are exploratory: a two-member cluster in the k=3 partition limits its practical interpretation.

Economic-scope qualification: The dependent variable in the principal panel models is log real GDP per capita, not annual GDP growth. Accordingly, the estimates concern conditional associations with the level of income per person; they cannot be cited as estimated effects on GDP growth. This edition does not report dedicated annual connectivity-growth versus GDP-growth models or formal region- and income-group-specific coefficients. These are prioritized extensions, alongside investigation of countries whose adoption and subscription trajectories diverge.

Principal economic result and strategic meaning: In the reported two-way country-and-year fixed-effects model, mobile-cellular subscriptions per 100 inhabitants retain a positive conditional association with log real GDP per capita (coefficient +0.001705; 95% CI +0.000962 to +0.002447; $p < 0.001$), while the Internet-use coefficient is not statistically distinguishable from zero (+0.000074; 95% CI −0.001366 to +0.001514; $p = 0.920$). These estimates differ from the country-only fixed-effects results and demonstrate sensitivity to common time trends and specification. Strong residual serial correlation and outstanding robustness checks limit inferential confidence. Neither result establishes that subscriptions cause growth or that Internet participation lacks economic value. For strategy, the implication is to investigate the mechanisms, affordability, actual use, service quality, productive applications, and investment economics, rather than assuming rising connectivity metrics generate measurable economic returns.

Alignment with the ITU global benchmark: ITU (2024) estimates that 68% of the world population used the Internet in 2024. This does not contradict the 82.10% median reported here for a stable 172-economy cohort: the ITU measure is a world-population estimate, whereas the study median assigns one observation per country and is not a world usage rate. The ITU also distinguishes technical coverage from participation: 96% of the world population was covered by a 3G-or-better mobile-broadband network in 2024, while the Internet-use estimate remained 68% (ITU, 2024, Foreword). Differences in source vintage and revisions may further affect comparisons.

The global and country figures show that mobile subscription intensity, Internet participation and unique-user penetration are not interchangeable. Subscriptions per 100 inhabitants can exceed 100 because multiple connections can be counted for one resident. The 2024 Pakistan comparison makes this distinction concrete: Bangladesh shows 31.22 more mobile subscriptions per 100 residents than Pakistan but 3.83 percentage points less Internet use. On Internet adoption, eleven of the twelve selected comparators exceed Pakistan, with the United Arab Emirates and Saudi Arabia each 42.75 percentage points higher. These are descriptive differences, not measures of unserved customers or bankable market size.

The 2024 GDP-per-capita scatter places Pakistan and Bangladesh toward the lower-income and lower-adoption end of the selected comparison. The dashed cross-sectional regression is descriptive; it does not demonstrate that Internet expansion causes income growth. ETS and ARIMA forecasting extends the comparisons to 2025–2030 and, separately, 2025–2034, but forecasts near full adoption are particularly sensitive to model form, data gaps and upper-bound clipping. A six-year backtest gives Pakistan ARIMA MAE 10.43 versus ETS 13.27 percentage points, based on only three matched observations; the 2020-cutoff validation does not establish a ranked Pakistan winner.

Selection and interpretation: The 13-country core sample combines Pakistan and its South Asian neighbours with China, Gulf and Türkiye comparators and six high-income benchmarks. The design is intentionally heterogeneous, intended to illuminate differences in digital adoption and market context, not to represent the world statistically. Cross-country gaps motivate further investigation; they do not identify the number of commercially obtainable subscribers.

The research contribution is an integrated evidence-to-decision architecture: differentiate connection counts from meaningful participation, examine affordable smartphones and network quality, use relevant peers to diagnose bottlenecks, and require operator-specific tariffs, active-user counts, unit economics and investment data before determining TAM, SAM, SOM or expected financial returns. Not all source figures and validation checks are independently certified: the manuscript identifies outstanding verification for Q04 cohort comparability, F-series naive/drift benchmarks, Pakistan data gaps and original source vintages. No fully calibrated F03c prediction-interval evaluation is claimed. A companion Pakistan sector strategy draft collates later public observations (2025 and selected 2026 developments), but these are complementary and are not blended into the historical 2000–2024 econometric or country-year results.

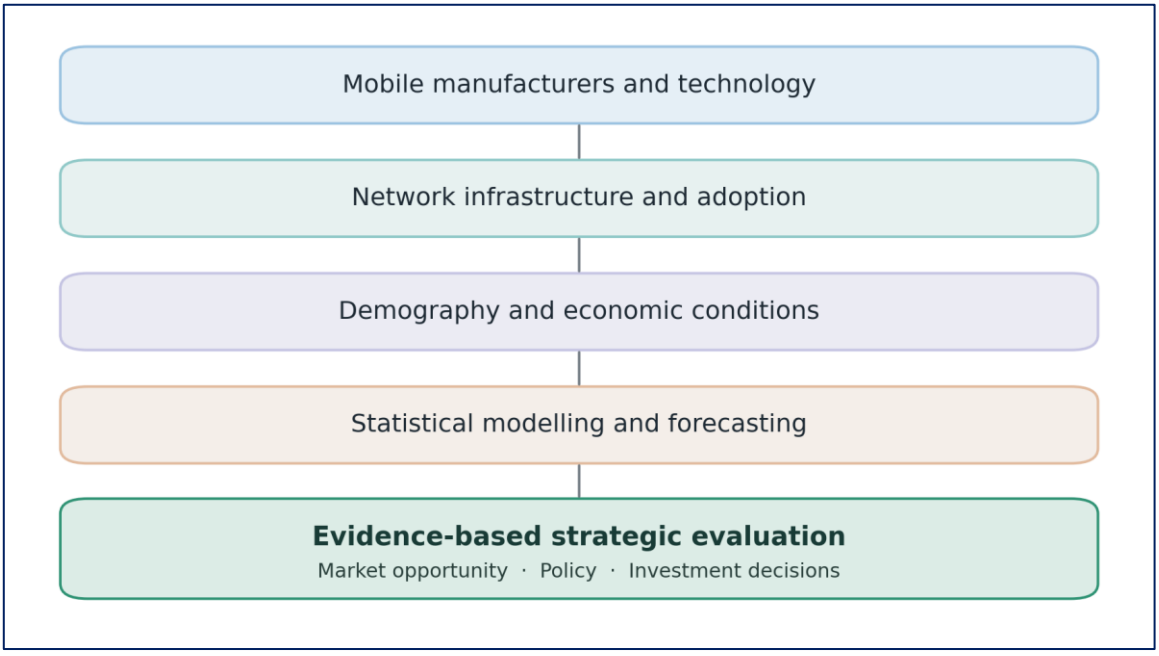


Figure ES-1. Integrated analytical framework linking technology, connectivity, economics and statistical evidence to strategic decisions.

Accordingly, the statistical component is central, not decorative to the synthesis. It tests whether apparent patterns survive more demanding comparisons, identifies where conclusions are sensitive to data and model choices, and makes the transition from historical description to falsifiable policy and commercial hypotheses explicit. The six-stage chain is:

> Statistical finding → economic interpretation → strategic implication → policy option → evidence required → measurable outcome (Sections 14.3–14.4 and Table 14-1).

Key Takeaways

- **Connectivity does not equal digital participation:** Mobile subscriptions count active cellular connections, whereas Internet-use percentages count people using the Internet through any access technology.
- **The external benchmark requires denominator discipline:** The ITU 2024 estimate of 68% worldwide Internet use is population-based; the 82.10% country median in our matched historical cohort is not directly comparable. Likewise, 96% 3G-or-better population coverage is not equivalent to 96% individual Internet use (ITU, 2024).
- **The two pillars are a defined analytical scope:** Mobile subscriptions and Internet-use percentages explain comparative access and participation, but they are not proxies for calling-package revenues, mobile-data consumption or operator profitability. The fixed-line-to-cellular transition is established in the Prologue; the service-economics extension is reserved for **Volume II** of this synthesis.
- **International diffusion was substantial but unequal:** The matched 172-entity cohort's median Internet-use share increased from 2.21% (2000) to 82.10% (2024), while country trajectories remained diverse.
- **Digital-development typologies are descriptive:** Two PCA components explain 94.3% of standardized three-indicator variation in the 2024 complete-case cohort; the small k=3 cluster argues against a definitive global ranking.
- **Pakistan's 2024 peer gaps are large but heterogeneous:** UAE and Saudi Arabia are 42.75 percentage points ahead on Internet use; India is 7.69 points ahead; Bangladesh is 3.83 points below.
- **The subscription–adoption discrepancy matters:** Bangladesh's subscription intensity exceeds Pakistan by 31.22 per 100 people while its Internet adoption is lower, demonstrating the risk of equating connections with unique participation.
- **Levels are not growth rates:** The two-way fixed-effects estimates concern log real GDP per capita, not annual real GDP growth. Testing changes in Internet participation and mobile-subscription intensity against real economic growth, with appropriate lags and controls, remains a separate research requirement.
- **Forecasts are conditional and validation-dependent:** ETS and ARIMA sometimes disagree sharply; Pakistan's six-year historical comparison uses just three matched observations and cannot establish high-confidence 2030 adoption.
- **Economic and commercial conclusions must respect evidence boundaries:** Cross-country GDP relationships are associations, while investment returns and serviceable markets require pricing, coverage, device, quality and operator-level financial evidence.
- **Econometric interpretation changes with model controls:** Once both country and year effects are included, the reported Internet-use coefficient is indistinguishable from zero, while the mobile-subscription coefficient remains positive in the evaluated specification. This is a reason to test mechanisms and robustness. not to proclaim a causal GDP benefit from additional SIMs or no value from Internet participation.
- **From evidence to action:** Correlation, econometrics, convergence, country typologies and forecasting identify distinct questions for Pakistan. Section 14.4 converts each finding into an economic interpretation, a strategic implication, a potential policy option, required validation evidence and a measurable pilot outcome, establishing a research agenda for **Volume II** and the Strategy/Policy Paper.
- **Industry relevance is conditional and testable:** Pakistan operators can investigate first-time access, device/data upgrading and deeper usage, subject to current market validation, customer trust, measurable retention and unit economics.
- **Peer selection has a defined purpose and a defined limit:** The 13-country cohort spans South Asian, large-market, regional and high-income contexts; it is a purposive benchmark rather than a statistically representative global sample.

Research Proposition and Commercial Significance

The central proposition of this synthesis is that future telecommunications growth should not be measured solely by the addition of cellular connections. An important source of potential growth may lie in converting demographic reach and existing connections into effective Internet participation, affordable smartphone access, appropriate service usage and commercially sustainable infrastructure investment. This proposition is a research question, not a demonstrated estimate of unserved customers, turnover or profit.

This distinction is especially pertinent to populous economies such as Pakistan, India, Bangladesh and China, which are included in the 13-country analytical comparison. A connection count below 100 per 100 residents can reflect age structure, device sharing, income, network availability or statistical definitions; a count above 100 may reflect multiple SIMs, enterprise connections and other arrangements. Neither statistic alone measures handset ownership or market saturation. Other populous economies may offer useful wider context but are not members of the study's core peer cohort.

The study contributes a transparent, reproducible, multi-level framework connecting manufacturer competition, network development, economic context, fixed-effects analysis, convergence diagnostics, forecast comparisons and Pakistan peer evidence. Completed results are reported in Parts IV–V with explicit observational and model limitations; unperformed sensitivity analyses are identified separately.

What This Review Offers

- A coherent international view linking handset competition, network development and socioeconomic demand context.
- Reproducible charts with documented data grain, units, sources, model limitations and figure interpretation.
- A company-neutral interpretation of strategic repositioning, consolidation and market withdrawal, recognizing operating achievements.
- A defensible opportunity-screening framework for service upgrades, affordable devices, broadband adoption and investment appraisal.
- Explicit boundaries between observed facts, exploratory associations, market scenarios and evidence still required.

Research Architecture

Table ES-1. Research architecture and principal analytical outputs

Part	Scope	Principal output
I. Manufacturers	Technology transition, shipments, revenue and corporate strategy	Selected manufacturer historical charts and case interpretations
II. Networks	Cellular subscriptions, Internet adoption and operator finance	Comparative connectivity and financial evidence
III. Market opportunity	Demography, GDP context, adoption disparities and Pakistan peers	International multipanels and cautious TAM/SAM/SOM framework

Pakistan focus: the core 13-country purposive comparison uses Pakistan and twelve peers across South Asia, China, Gulf and Türkiye, and high-income benchmarks. Separate context-only comparisons may cover other economies, but they are not part of the core peer sample. An operator-level customer and marketing study requires additional company-specific evidence.

Research extension (2026): Parts IV and V present the completed exploratory, econometric, convergence, forecast-comparison and Pakistan-peer figures. Outstanding validation tasks are limited to the audit items specifically identified in the publication-quality section; none of the reported associations is interpreted as a proven causal effect.

Research Identity: Strategy, Trust, Growth and Sustainable Leadership

This independent research examines the conditions under which telecommunications businesses can translate market scale, technological capability and capital investment into resilient customer relationships and durable economic value. Its strategic contribution is the integration of three evidence streams, manufacturer competition, operator/network development, and demographic-economic opportunity, rather than an unsupported claim to have discovered a previously unknown market gap.

Central proposition (for evaluation): sustainable competitive leadership requires continuous adaptation, affordable and meaningful access, customer-value creation and financial discipline. This is a testable proposition, not an inference that trust, loyalty or sustainability have already been quantified by the master dataset.

Executive Findings: What the Available Evidence Supports

The strongest directly observed cross-market pattern is the disconnect between cellular subscription intensity and Internet use. Subscription intensity can exceed 100 without universal individual ownership; conversely, large populations with lower Internet adoption warrant investigation without constituting mechanically calculable numbers of new customers. Historic vendor and operator records also demonstrate structural change, but cannot by themselves identify the causal drivers of success, failure or trust.

For commercial audiences, each observed pattern is translated into a diagnostic question, a potential response and a validation requirement. That makes the work useful as an independent opportunity-screening and strategic conversation tool, not a substitute for operators' internal pricing, customer-retention and network investment models.

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1. Study Design, Definitions and Evidence Standards

1.1 Objectives and Questions

Overarching research objective: To integrate historical, descriptive, statistical, econometric and predictive evidence into a transparent decision framework that evaluates global telecommunications development, Pakistan's relative position and the limits of what country-level indicators can establish. The resulting evidence is used to formulate testable operator and policy hypotheses with defined data requirements and measurable outcomes for **Volume II** and the companion Pakistan Strategy/Policy Paper.

- How have smartphone shipment leadership and firm strategies shifted over time?
- How do manufacturer revenue records and corporate exits or strategic pivots relate to technological change?
- What do subscriptions per 100 inhabitants measure, and how do they differ from Internet use?
- How do network-operator financial results differ by scope, currency and reporting period?
- Which demographic and economic combinations signal questions worth investigating about affordable devices, data packages and connectivity?
- How do connectivity measures correlate with GDP per capita in cross-country and within-country settings?
- Do Internet adoption rates converge over time, and how does Pakistan compare with matched peers?
- Which multivariate characteristics distinguish national digital-development profiles?
- Do time-aware forecasting models improve on transparent baseline projections?
- Which relationships remain robust to year effects, alternative controls, missing-data choices and sample restrictions?

1.2 Core Country Group: Rationale, Scope and Selection Limits

A purposive analytical cohort of 13 countries is used for consistent peer histories, 2024 cross-sections and Pakistan-relative comparisons: Australia, Bangladesh, China, Germany, India, Norway, Pakistan, Saudi Arabia, Singapore, Türkiye, the United Arab Emirates, the United Kingdom and the United States. Pakistan is the focal economy; the other twelve are comparators. The country-year values originate primarily from the World Bank WDI/ITU source histories documented in the References and Source Provenance section.

Selection follows four explicit considerations:

(1) geographic and development-stage contrast, including South Asian neighbours India and Bangladesh;

(2) large-scale device and connectivity markets, particularly China and India;

(3) Gulf and near-regional digital-development comparators, including Saudi Arabia, the United Arab Emirates and Türkiye; and

(4) high-income and high-adoption benchmarks: Australia, Germany, Norway, Singapore, the United Kingdom and the United States. Together, they span different subscription intensities, Internet participation levels and income contexts.

This is a purposive, heterogeneous comparison set, not a random or globally representative sample; the thirteen were not selected by a preregistered algorithm or a formal statistical matching procedure. The presence of countries with high adoption makes the cohort useful for identifying benchmark gaps but can also magnify apparent shortfalls. The sample is not suitable for estimating world averages, causal treatment effects or Pakistan's commercially addressable market.

Selection is conditional on the historical availability of relevant country-year observations and does not imply that all 13 countries report every indicator in all 25 years. The much larger global analytical populations used for econometrics

and convergence remain separate: the manuscript reports 196 economies for one panel model, a stable 172-entity adoption cohort, and a smaller complete-case multivariate sample. These sample sizes are not interchangeable.

1.3 Research Novelty: Integration Rather Than Claims of Discovery

Mobile connectivity, the digital usage gap, device affordability and market segmentation are established research topics. This study does not claim to have discovered them or to be the first to compare subscription and Internet penetration. Its potential distinction is a transparent synthesis across three industry layers: handset supply and corporate adaptation; network connectivity and operator economics; and demographic-economic conditions affecting viable service demand.

A defensible original contribution would be demonstrated through disciplined cross-country diagnostics, documented indicator definitions, reproducible figures and business-relevant hypotheses. A formal claim of academic originality would require a targeted literature comparison, which is beyond the present public-data synthesis.

1.4 Evidence Hierarchy and Comparability

Table 1-1. Evidence categories and permitted interpretations

Evidence category	Appropriate interpretation
International country indicators	Observed country-year subscriptions per 100, Internet users (%), or absolute connections; missing values not zero
Corporate financial disclosures	Reported metrics within specified segment, year, fiscal basis and currency
Industry smartphone trackers	Shipment estimates with device category, tracker vintage and calendar period stated
Demographic/economic context	Population and age estimates from stated year; GDP “latest available” is not necessarily same year
Calculated or scenario measures	Explicit formulas, inputs and data availability; no implied source observation

Subscriptions per 100 inhabitants may exceed 100 through multiple-SIM use, devices and other connections; they do not indicate individual ownership. Internet use (%) is a population measure rather than a count of mobile-broadband connections. Handset sell-in shipments are not equivalent to retail sell-through or national purchases. Group financial results cannot substitute for mobile-only operating results without clear disclosure. Fiscal/calendar differences, currencies, ownership overlaps and changing reporting boundaries are not silently harmonized.

1.5 Figure Reproduction and Source Transparency

Map note. Publication maps use a generalized world-boundary layer to display international indicators. Unmapped territories and missing country values must not be interpreted as zero.

Each visual exhibit reports its subject, period, indicator units and interpretation limits. The reproducibility appendix describes the statistical settings and remaining source-verification requirements.

1.6 Integrated Strategic Decision Architecture

The analytical sequence is: (1) determine the market and evidence boundary; (2) observe technology, demographic and financial conditions; (3) separate measured results from interpretations; (4) identify alternative causes and commercial pathways; (5) test investment and customer-value implications with company data; and (6) monitor outcomes and revisit assumptions. Growth, trust, competition and financial resilience are treated as interacting strategic domains, not interchangeable metrics.

Table 1-2. Strategic research domains and additional validation needs

Strategic domain	Observed in present evidence	Additional validation required
Market access and adoption	Population, cellular subscriptions and Internet use	Unique users, coverage, affordability, customer segments
Customer trust and value	Indirect context only	Churn, complaints, quality, transparency, loyalty surveys
Competitive adaptation	Vendor shipments, financial snapshots, corporate events	Comparable product-mix, channel, R&D and platform data
Economic resilience	Selected revenue, margin and CAPEX series	Same-scope cash flow, spectrum, financing and risk scenarios

Part I: Mobile Devices and Manufacturers

2. From Handset Engineering to Device Ecosystems

Mobile-phone competition evolved from hardware design, distribution reach and reliability toward integrated operating systems, application ecosystems, chip technologies, imaging, manufacturing efficiency, branding and complementary digital services. The resulting competitive history includes sustained large-scale participation, rapid market-share changes, alliances, acquisitions and exits. These distinct outcomes should not be collapsed into a single “success versus failure” narrative.

2.1 Smartphone Shipments and Market Positions

The selected shipment chart shows successive market positions but is not a complete manufacturer-by-year census. Apple and Samsung have longer records in the selected data, while several competitors appear for shorter periods. Unreported years must remain absent, and vendor-level “Others” and global totals must not be interpreted as independent handset brands. Source provenance for the underlying manufacturer records is listed in the references section.

2.2 Financial Performance, Competitive Disruption and Corporate Transformation

The evolution of the global mobile communications industry has been characterized not only by rising smartphone adoption and expanding digital connectivity, but also by substantial differences in the commercial performance and strategic trajectories of individual manufacturers. While some companies successfully sustained large-scale device businesses, others experienced declining revenues, prolonged operating losses, loss of market position, or fundamental changes in their business models.

The contrasting experiences of Apple and LG Electronics illustrate the importance of distinguishing market expansion from individual corporate success. Growth in the global market for mobile devices and Internet services does not guarantee that every participating manufacturer will achieve sustainable revenues, profitability, or competitive advantage.

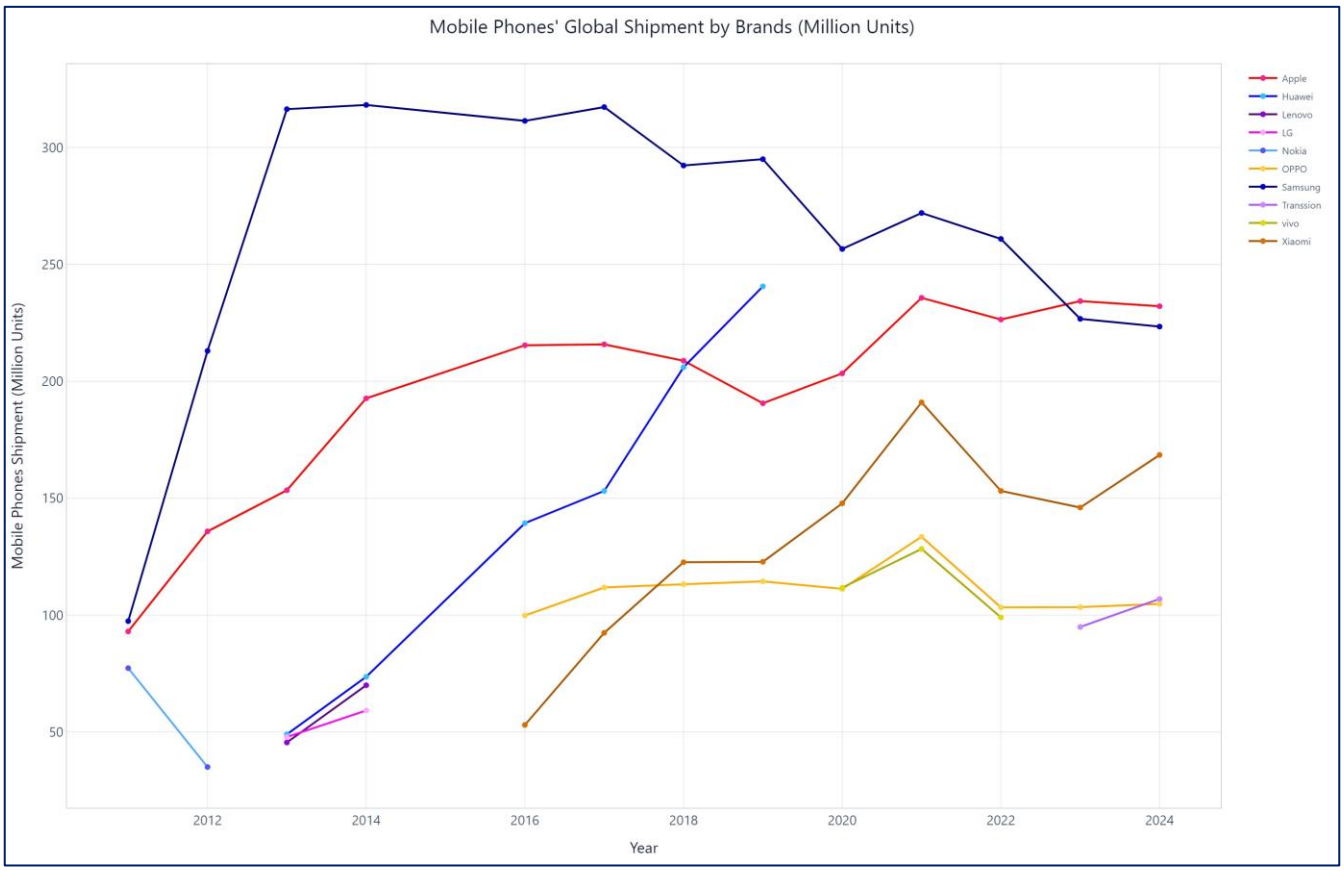


Figure 2-1. Selected smartphone manufacturers: observed global shipment values and available years.

Interpretation limit: Different tracking series and omitted years weaken perfect side-by-side comparison.

2.2.1 Apple: Sustained Revenue Generation and Ecosystem Positioning

Apple's reported iPhone net sales, presented in Figure 2-2, demonstrate the scale of revenue generated by an established smartphone product line during fiscal years 2017–2025. The series illustrates both fluctuations and subsequent recovery, with iPhone revenue increasing substantially after fiscal 2020 and remaining at a high level through the latest reported year.

Apple's experience provides an example of the commercial significance of product differentiation, integrated hardware and software, brand positioning, and ecosystem participation. However, the revenue trajectory alone cannot establish the relative contributions of these factors, nor can it be interpreted as a direct measure of handset profitability or market share.

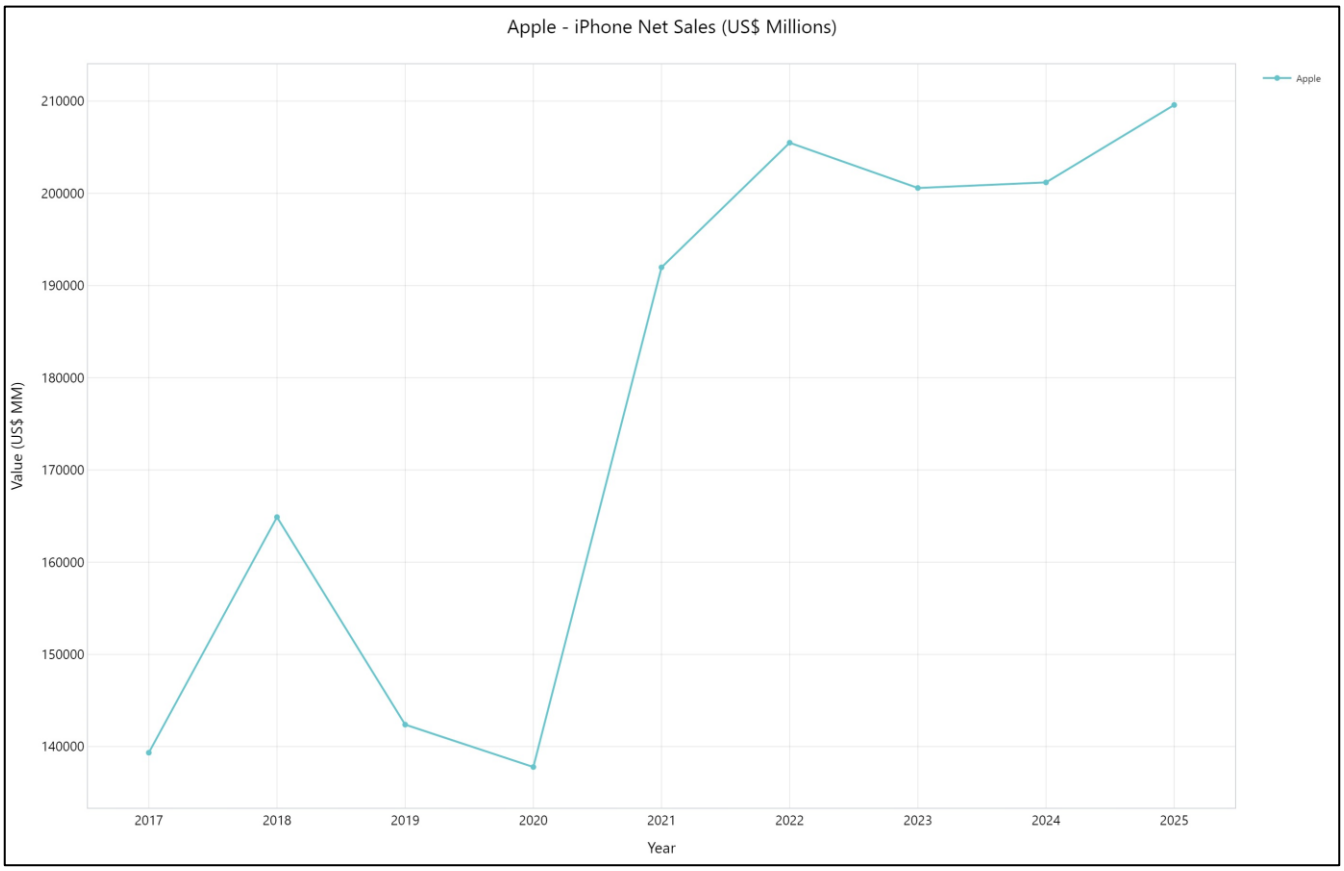


Figure 2-2. Apple: reported iPhone net sales for available fiscal years.

Source / basis: Apple iPhone product revenue, USD million, fiscal-year reporting.

Interpretation: The figure demonstrates the scale and evolution of iPhone product revenues. It does not represent Apple's total corporate revenue, handset operating profit, or smartphone unit shipments.

2.2.2 LG Electronics: Revenue Decline, Financial Losses and Market Withdrawal

LG Electronics provides a contrasting case of competitive pressure and strategic withdrawal from mobile handset manufacturing.

As illustrated in Figure 2-3, LG's Mobile Communications revenue declined from approximately KRW 15.06 trillion in 2014 to KRW 5.22 trillion in 2020, representing a reduction of approximately 65.3% in nominal Korean won over the period.

The deterioration was not limited to revenue. In its official 2019 financial results, LG reported Mobile Communications revenue of **KRW 5.97 trillion (approximately US$5.12 billion)** and a full-year operating loss of **KRW 1.01 trillion (approximately US$866.75 million)**. The company identified increased marketing expenditure supporting flagship devices, while also reporting weak sales of mass-market smartphones in overseas markets.

These results demonstrate that the segment was experiencing considerable financial pressure even as global smartphone usage and digital connectivity continued expanding.

On **5 April 2021**, LG Electronics announced its decision to close its mobile-phone business, with the wind-down expected to be completed by 31 July 2021. The company explained that withdrawal from the highly competitive handset sector would allow it to redirect resources toward businesses including electric-vehicle components, connected devices, smart homes, robotics, artificial intelligence, and business-to-business solutions.

The LG case illustrates two important strategic considerations. First, participation in a growing telecommunications ecosystem does not ensure sustained competitiveness or profitability. Second, withdrawal from one product market may represent a deliberate reallocation of capital and technological resources rather than the disappearance of the parent company or its broader technological capabilities.

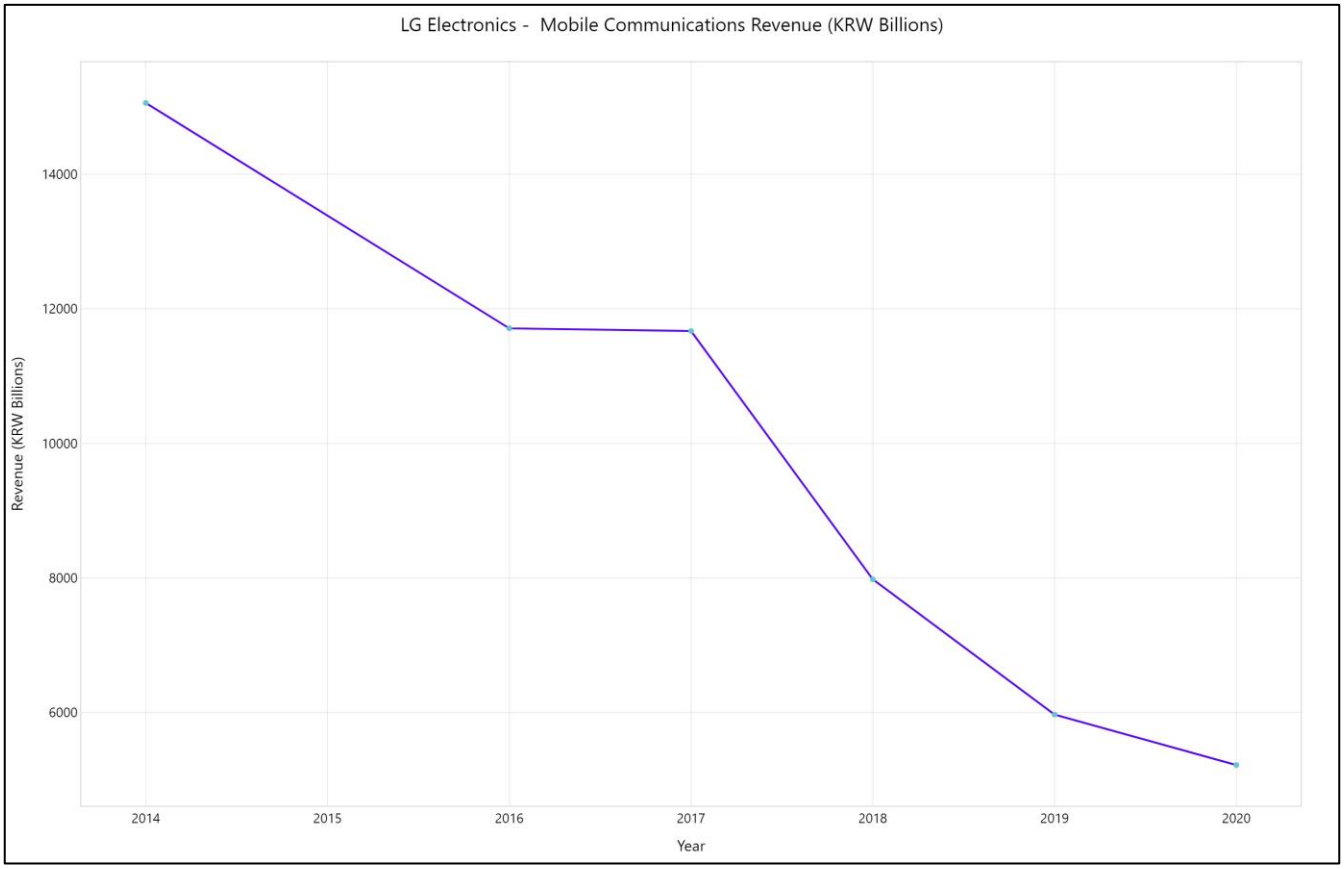


Figure 2-3. LG: Mobile Communications revenue in observed reporting years.

Source / basis: LG segment disclosures and underlying source notes, KRW billion.

Interpretation limit: Annual and quarterly figures must not be silently combined; annual history and reporting vintage require review.

Interpretation: The figure illustrates the segment's substantial revenue contraction before the company's 2021 withdrawal from mobile-phone manufacturing.

2.2.3 Other Manufacturer Transitions and Strategic Implications

The experiences of Nokia, BlackBerry, Motorola, Sony Ericsson, Huawei, Xiaomi, Samsung, and other manufacturers further demonstrate the changing competitive structure of the smartphone industry.

Nokia transferred substantially all of its Devices & Services business to Microsoft in April 2014 while continuing as a significant telecommunications network and technology company. BlackBerry transitioned away from its historical handset-centered business model toward software, security, and related enterprise technologies. Other manufacturers experienced ownership changes, shifting market positions, or evolving product and regional strategies.

These developments are not interpreted simply as evidence of successful or unsuccessful management. Competitive outcomes reflect multiple interacting factors, including platform ecosystems, technological innovation, distribution capabilities, product positioning, capital requirements, regulatory conditions, and changing consumer preferences.

Table 2-1. Strategic transformation of selected mobile manufacturers

Strategic domain	Observed in present evidence	Additional validation required
Nokia	Devices & Services business transferred to Microsoft in 2014; telecommunications network operations continued.	Strategic redeployment, platform competition, and business transformation.
BlackBerry	Transition from handset manufacturing toward enterprise software and cybersecurity services.	Business-model adaptation, enterprise positioning, and technological restructuring.
LG Electronics	Mobile Communications revenue declined approximately 65.3% during 2014–2020; reported an operating loss of approximately US$867 million in 2019; withdrew from handset manufacturing in 2021.	Competitive pressure, declining financial sustainability, and strategic capital reallocation.
Apple and Samsung	Continued as major smartphone manufacturers, supported by differentiated product portfolios and technology ecosystems.	Product differentiation, ecosystem competitiveness, manufacturing scale, and commercial resilience.
Huawei, Xiaomi, OPPO and peers	Changing global and regional market positions, reflecting competitive expansion, technological advances, and market restrictions.	Innovation, affordability, distribution strategies, geopolitics, and market access.
Motorola and Sony Ericsson	Ownership and organizational transformations	Industry consolidation and restructuring of technology assets

Note: The table documents selected strategic transitions rather than ranking overall company performance; LG's reported 2019 loss pertains to its Mobile Communications segment.

2.2.4 Relevance to Digital Adoption and Market Opportunities

These manufacturer experiences are relevant to the broader objectives of this research because the commercial consequences of telecommunications growth extend beyond network expansion and subscription counts.

Rising Internet adoption can create opportunities for smartphone purchases, device replacement, mobile-data services, applications, and connected technologies. However, the ability of individual companies to capture these opportunities depends on their competitive positioning, customer value, cost structures, pricing, and capacity to adapt.

For emerging markets, including Pakistan, the historical lessons suggest that affordable device availability, meaningful Internet participation, technological adaptability, and commercially sustainable business models must be evaluated together.

The experiences of Apple and LG therefore reinforce a central proposition of this study: growth in mobile connectivity and digital adoption creates potential economic value, but the capture of that value is neither automatic nor equally distributed among participating companies.

The figures provide descriptive corporate evidence rather than causal estimates of competitive success or failure. A more definitive evaluation would require comparable information on operating margins, research and development expenditure, product mix, market shares, pricing, and customer behavior.

2.3 From Handset Volumes to Commercially Viable Device Demand

A populous market with comparatively low mobile-subscription intensity is not necessarily an unserved handset market: one device may contain multiple SIMs, a user may share a handset, and older cohorts may have different access patterns. For manufacturers, the useful question is whether potential demand is concentrated in first-time purchases, replacement cycles, lower-priced smartphones, financing arrangements or devices suited to data-intensive applications.

Our shipment histories document global manufacturer positions, not annual handset sell-through by country. Accordingly, national market prospects are treated as screening hypotheses that would need device ownership, prices, replacement intervals and distribution evidence before they could support revenue forecasts.

2.4 What Manufacturers Can Gain from This Analysis

The evidence framework helps distinguish shipment volume from revenue capture, encourages attention to compatible fiscal and device definitions, and suggests deeper questions about replacement demand, affordability, premium positioning and ecosystem strategy. It does not rank firms by undisclosed handset profit margins or assume market-share shifts directly reveal managerial competence.

2.5 What Manufacturer History Can and Cannot Teach Future Leaders

The commercial significance of Nokia, BlackBerry, LG, Apple, Samsung and newer device competitors is not a simplistic ranking of management quality. Their trajectories invite disciplined comparison of ecosystem participation, portfolio positioning, supply-chain exposure, product innovation and capital redeployment. A market exit may reflect strategic reallocation; a high shipment volume does not ensure attractive segment profits. Decisions for a device business should be evaluated against compatible revenue, cost, device mix and customer evidence rather than headline units alone.

Actionable manufacturer hypotheses include affordable smartphone access for price-sensitive markets, replacement and upgrading demand, software-supported customer value, and differentiation beyond initial device sales. Country-level vendor sell-through and observed replacement cycles are not available comprehensively in the present master, so these remain priority questions for commercial validation.

Part II: Mobile Networks and Operators

3. The International Expansion of Cellular Connectivity

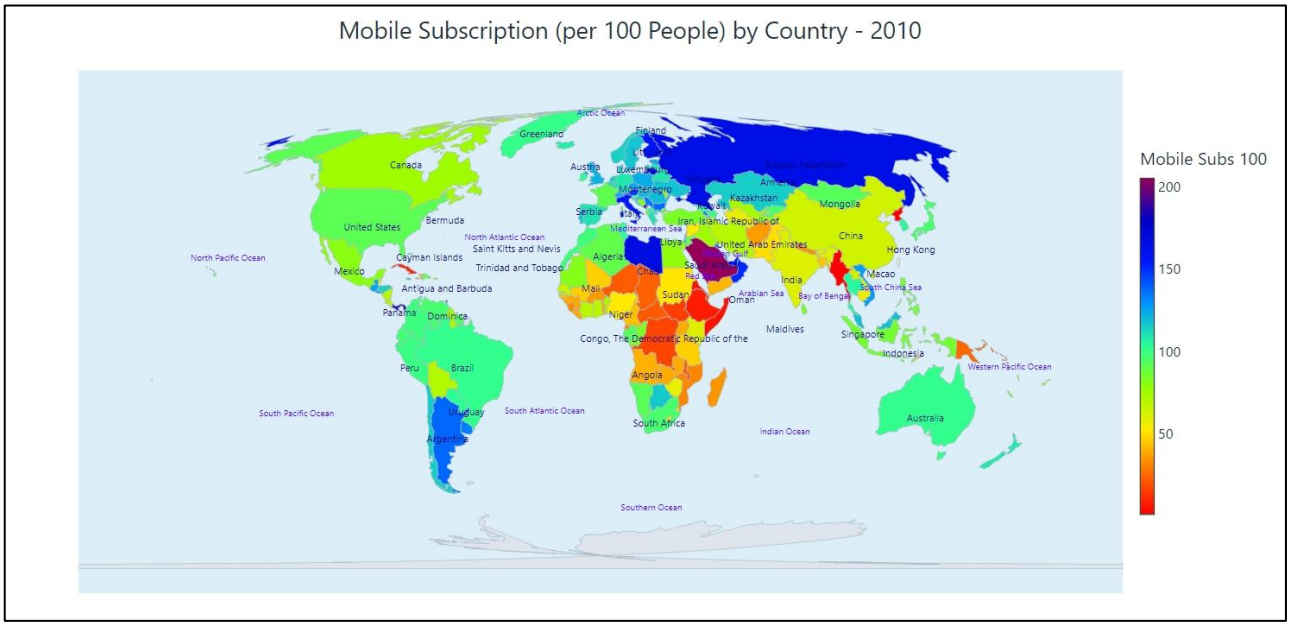


Figure 3-1. Global mobile-cellular subscription intensity, 2010.

Source: World Bank/ITU country-level mobile-cellular subscription series, 2010. Unmapped areas do not imply zero values.

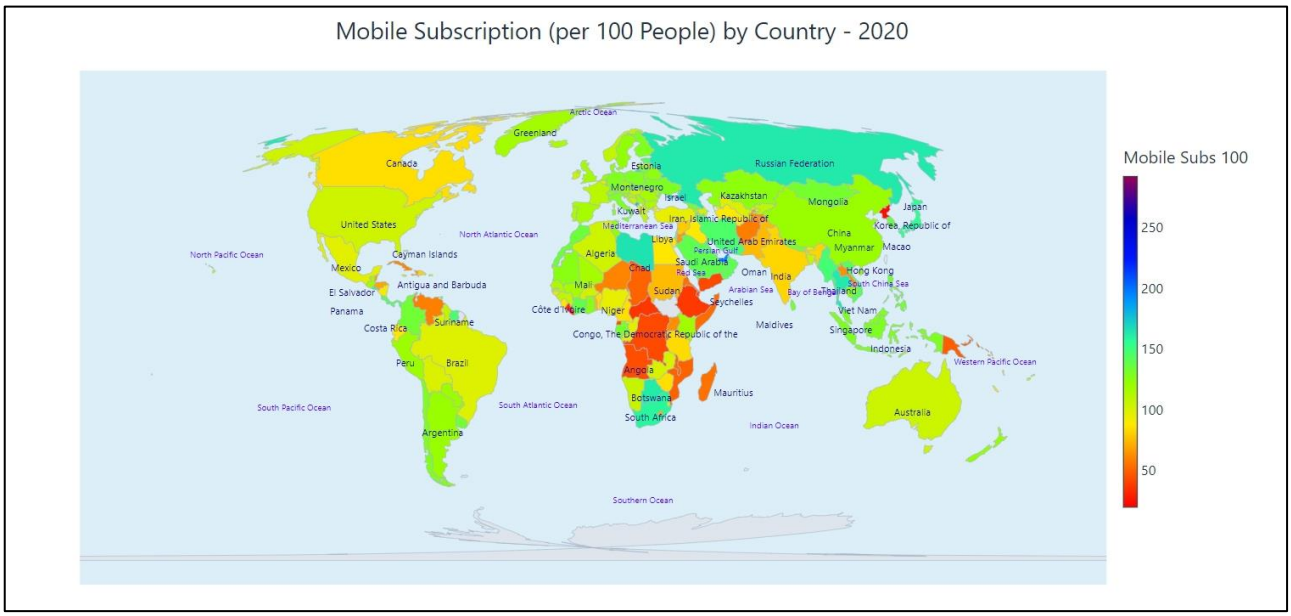


Figure 3-2. Global mobile-cellular subscription intensity, 2020.

Source: World Bank/ITU country-level mobile-cellular subscription series, 2020. Colour range is comparable with the other historical maps.

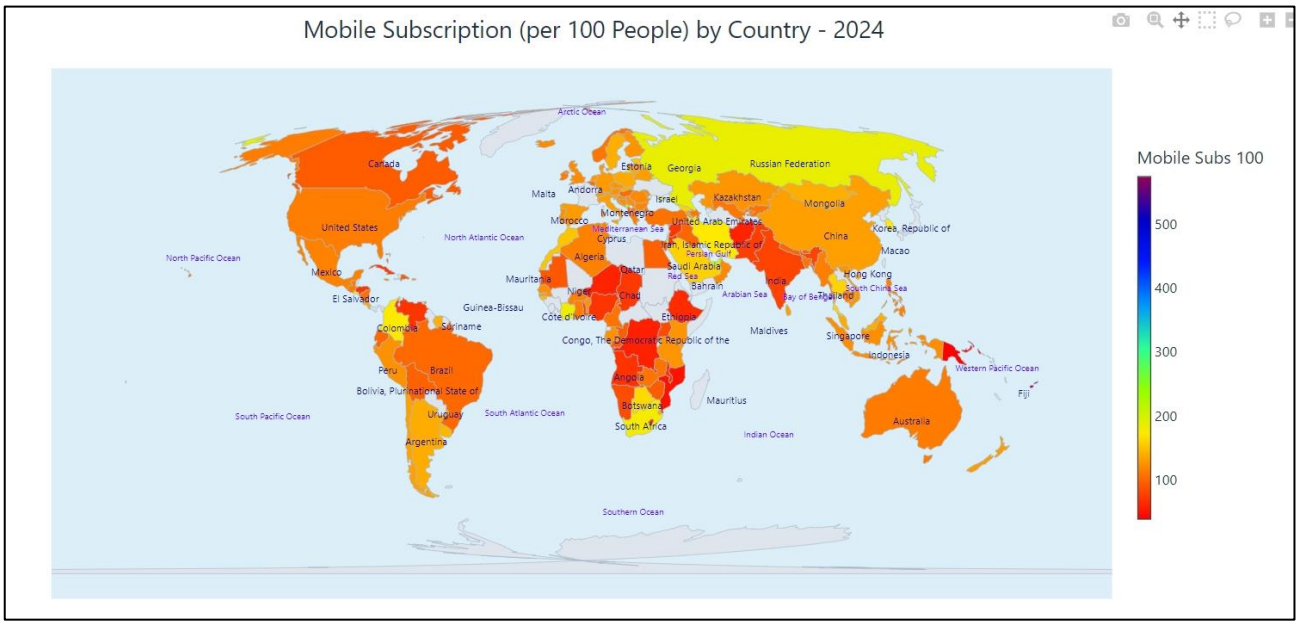


Figure 3-3. Global mobile-cellular subscription intensity, 2024.

Source: World Bank/ITU country-level mobile-cellular subscription series, 2024. Country coverage is incomplete; grey is not zero.

Historical map interpretation: Figures 3-1–3-3 provide a visual comparison of mobile-cellular subscription intensity in 2010, 2020 and 2024. Geographic contrasts should be read as differences in reported connections per 100 inhabitants, not unique mobile-phone ownership or Internet participation. Changes in the apparent map coverage may also reflect reporting gaps; therefore, country-level comparisons and missing-value checks are necessary before inferring national growth or decline.

Network operators invest continually in spectrum, radio access infrastructure, core networks, distribution and service systems. The rise of cellular subscriptions and the diffusion of Internet use broadly accompanied the shift from voice and SMS to mobile data, yet the indicators describe different units. Subscription intensity is a connection-based intensity ratio; Internet use refers to individuals using the Internet, potentially through fixed or mobile access. The historical migration from fixed-line telephony to cellular voice and subsequently mobile broadband is introduced in the Prologue (Figure P-1). The two country-level indicators used here remain analytically distinct from voice traffic, SMS volumes, data packages and service income.

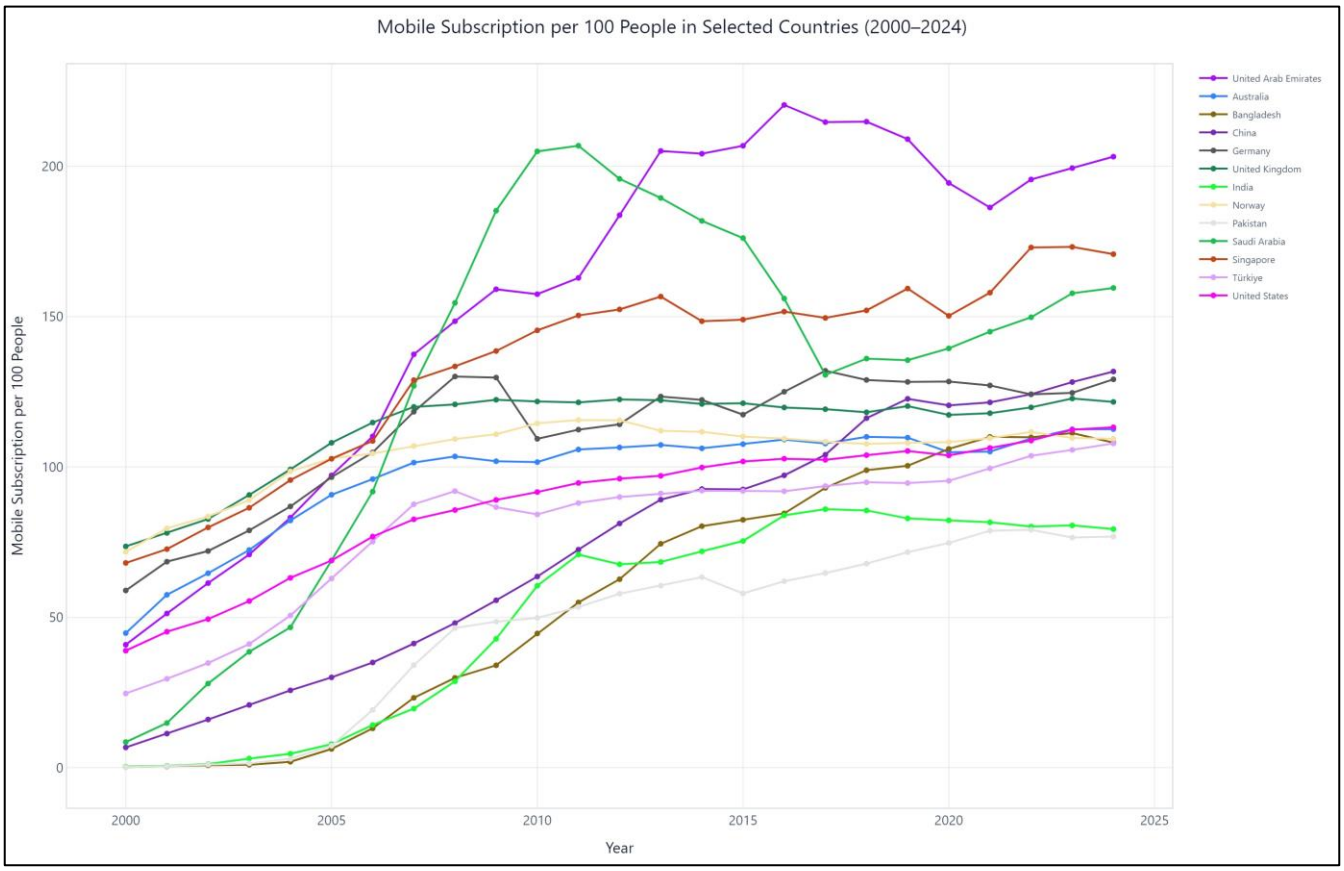


Figure 3-4. Mobile-cellular subscriptions per 100 inhabitants across the 13-country analytical cohort, 2000–2024.

Interpretation limit: Values above 100 do not mean more unique phone users than inhabitants.

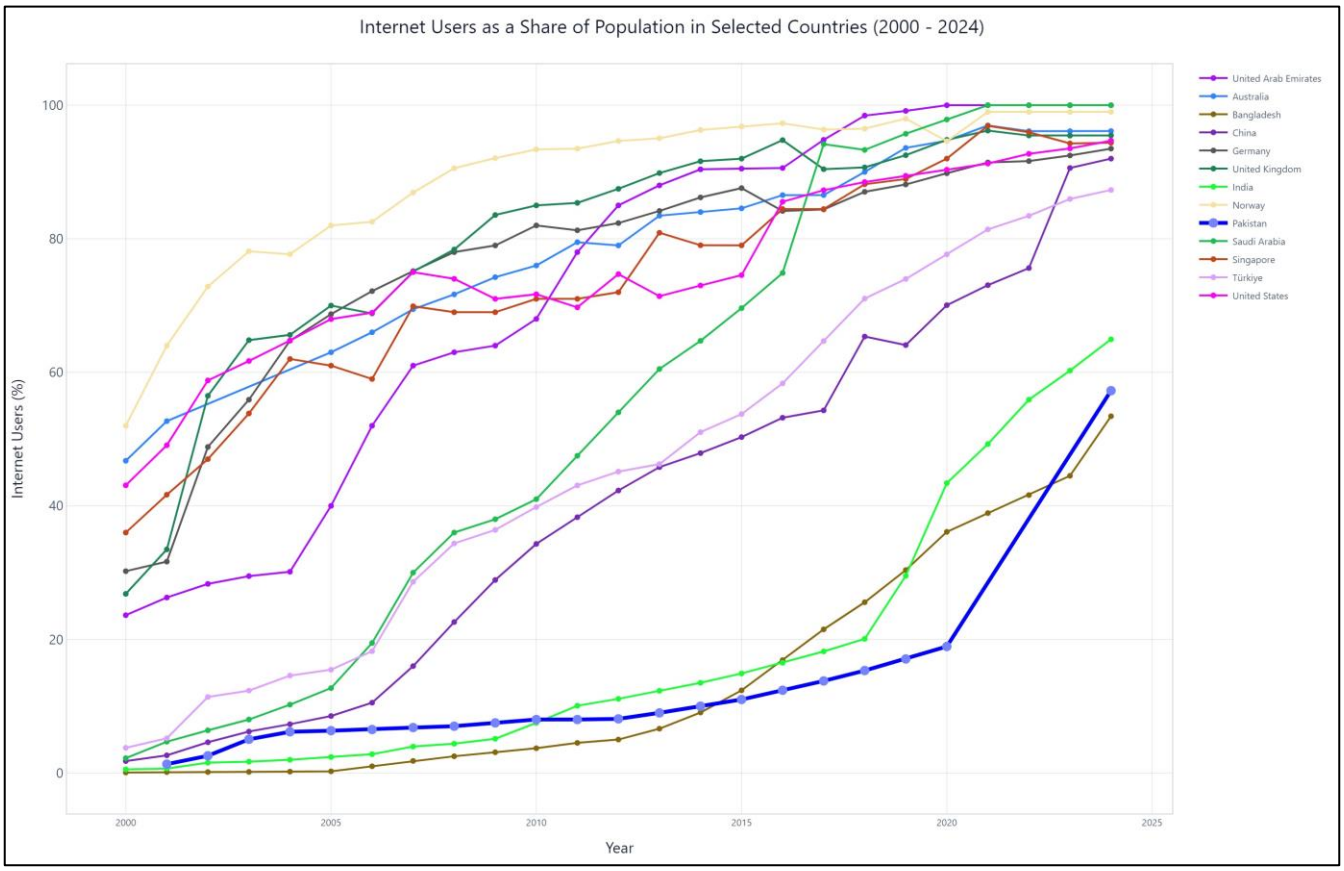


Figure 3-5. Individuals using the Internet (% of population) across the 13-country analytical cohort, 2000–2024.

Interpretation limit: Internet users include non-mobile means of access; this is not smartphone penetration.

Interpretation: Internet participation rises considerably across the peer group, yet a single metric reveals different adoption pathways. Mature and high-income economies tend to occupy the upper end of the display, while the South Asian trajectories differ substantially. Pakistan's recorded Internet-use path requires careful attention to reported-year gaps and discontinuities; the graph alone does not establish the causes of the differences.

3.1 Selected-Country Comparison and Changes in Adoption over Time

The two 13-country historical exhibits introduced in this chapter show mobile subscription intensity and Internet participation over 2000–2024. They supersede the former four-country charts. Their purpose is to compare the timing and scale of digital diffusion across the selected cohort, not to assert that these countries constitute a statistically representative global sample. Subsequent sections refer back to these figures rather than repeating the same trajectories.

3.2 Subscription Intensity is Not Internet Use

Comparing subscriptions per 100 with Internet use provides a useful screening device. Markets with multiple cellular connections may still have relatively low Internet participation; conversely, individuals may access the Internet without maintaining their own mobile subscriptions. The numerical difference is not an estimate of 'unserved customers', because the measures have different denominators and concepts.

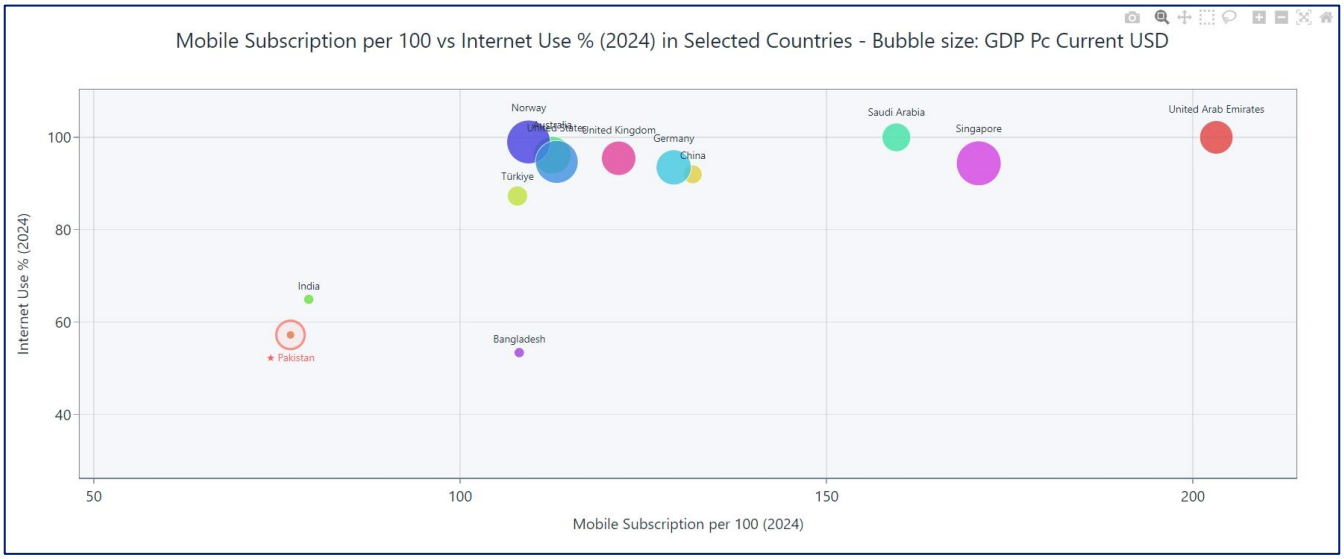


Figure 3-6. Mobile-cellular subscription intensity versus Internet use: selected-country comparison, 2024.

Interpretation limit: Exploratory association across the selected 13-country sample; not causal.

Interpretation*:* The 2024 cross-sectional bubble plot adds economic context to the subscription–usage relationship, but marker sizes are not a causal explanation of digital participation. Use matched observed values for each country; missing values are omitted rather than assigned zero. The corresponding 2020 exhibit provides a historic comparison, not another independent conclusion.

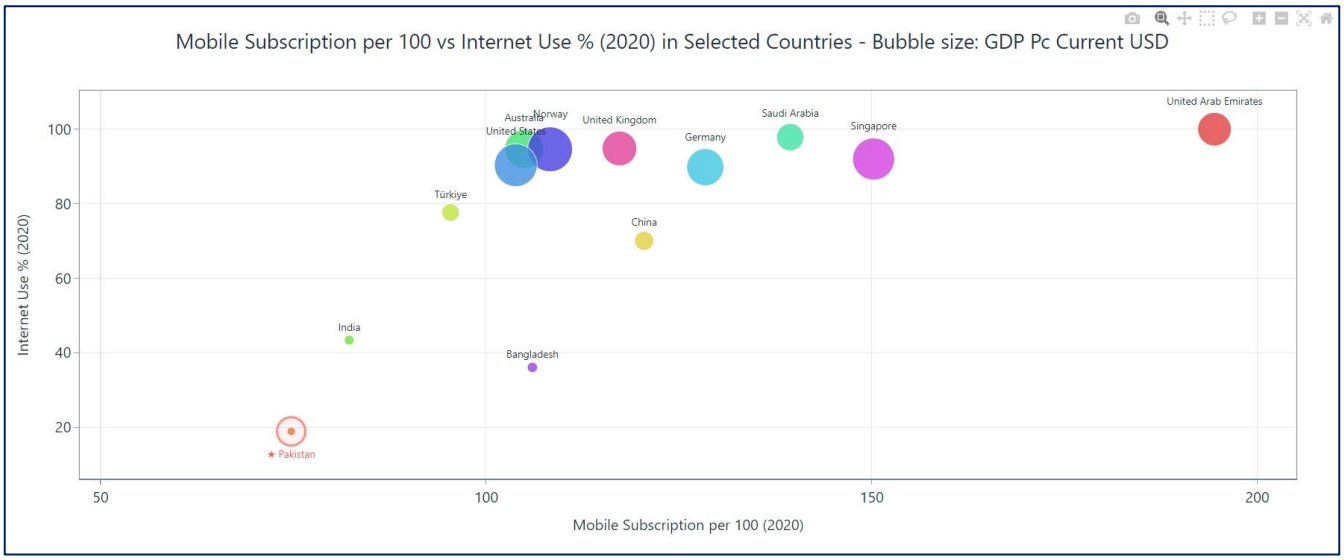


Figure 3-7. Mobile-cellular subscription intensity versus Internet use: population-weighted country comparison, 2024.

Interpretation limit: Cross-sectional associations are affected by income, infrastructure, governance and other confounders.

3.3 Data Completeness and Technology Scope

The international master panel provides broad historical coverage but is not complete for every country and year; recent reported values are particularly uneven. Its available 4G/5G indicators are too sparse to quantify comparable global investment returns. Therefore, the main network analysis concentrates on cellular connections and Internet

use, with modern technology deployment treated as contextual rather than a fully harmonized quantitative model. The World Bank WDI extraction vintage and recorded indicator codes are specified in the source-provenance register.

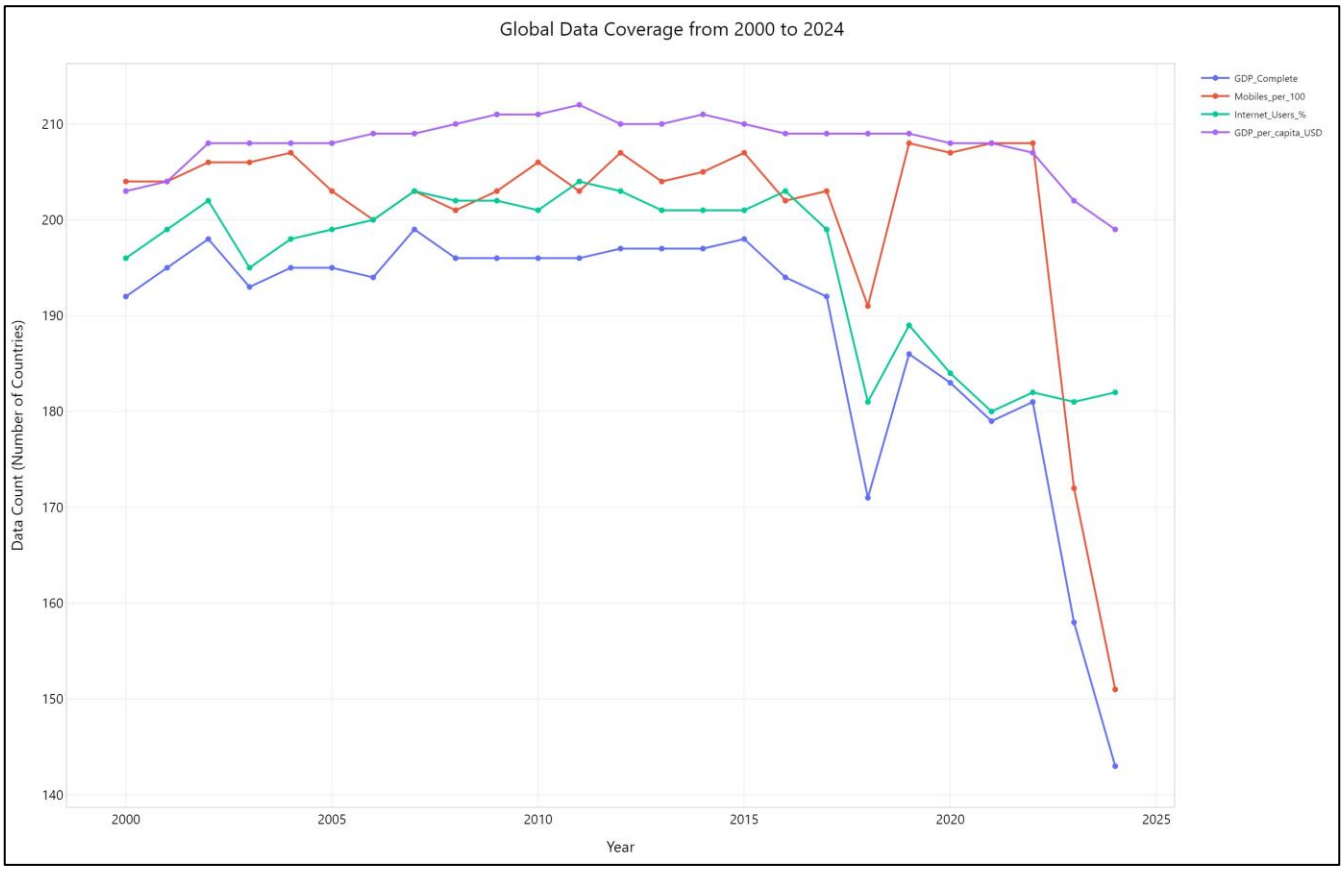


Figure 3-8. Number of reported national observations by year and indicator.

Interpretation limit: A fall in observed locations reflects source coverage, not a verified collapse in telecommunications.

4. Operator Financial Performance and Investment Economics

Mobile-network operators face continuing capital expenditure, customer-service costs, depreciation, licence obligations and changing service demand. Their reported results may be consolidated across fixed lines, global subsidiaries, enterprise services and device sales. A defensible comparison must use the exact revenue/profit boundary and reporting period before calculating margin or CAPEX intensity.

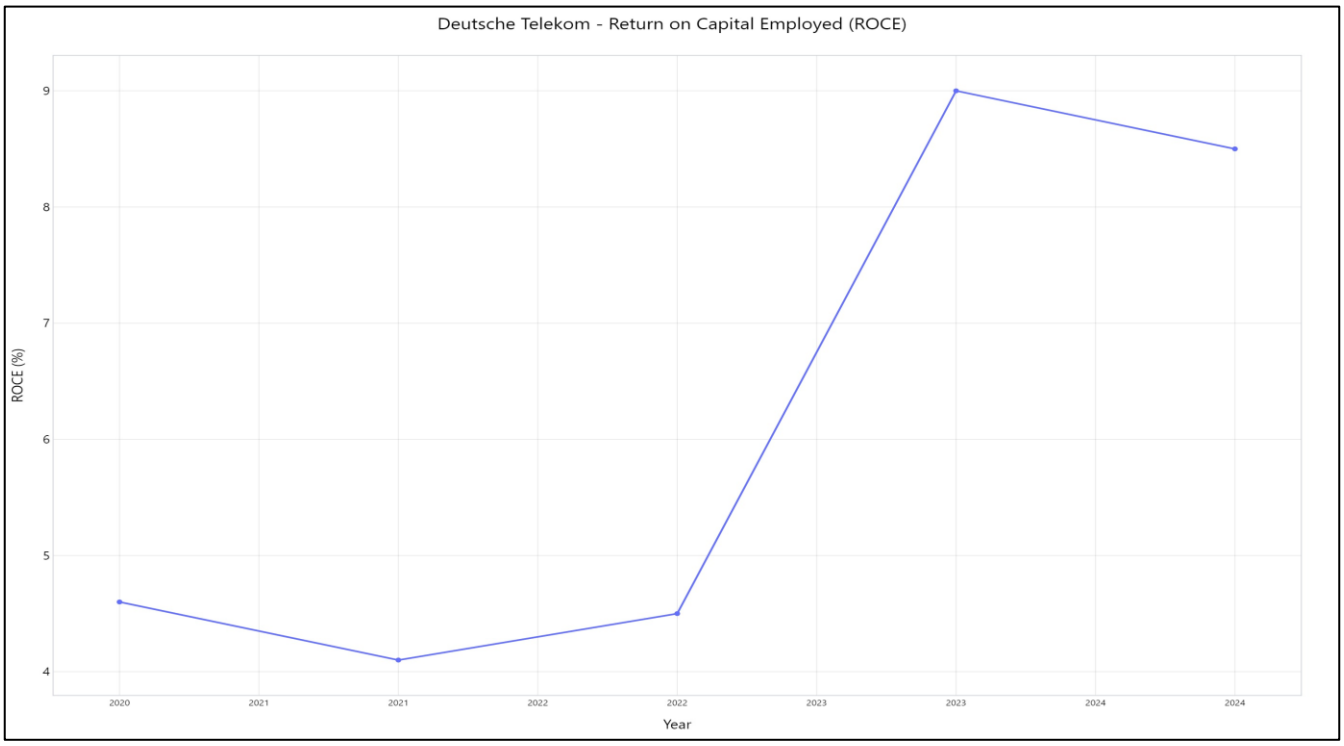


Figure 4-1. Deutsche Telekom: reported return on capital employed in available periods.

Source / basis: Deutsche Telekom group ROCE (%) as labelled in disclosure.

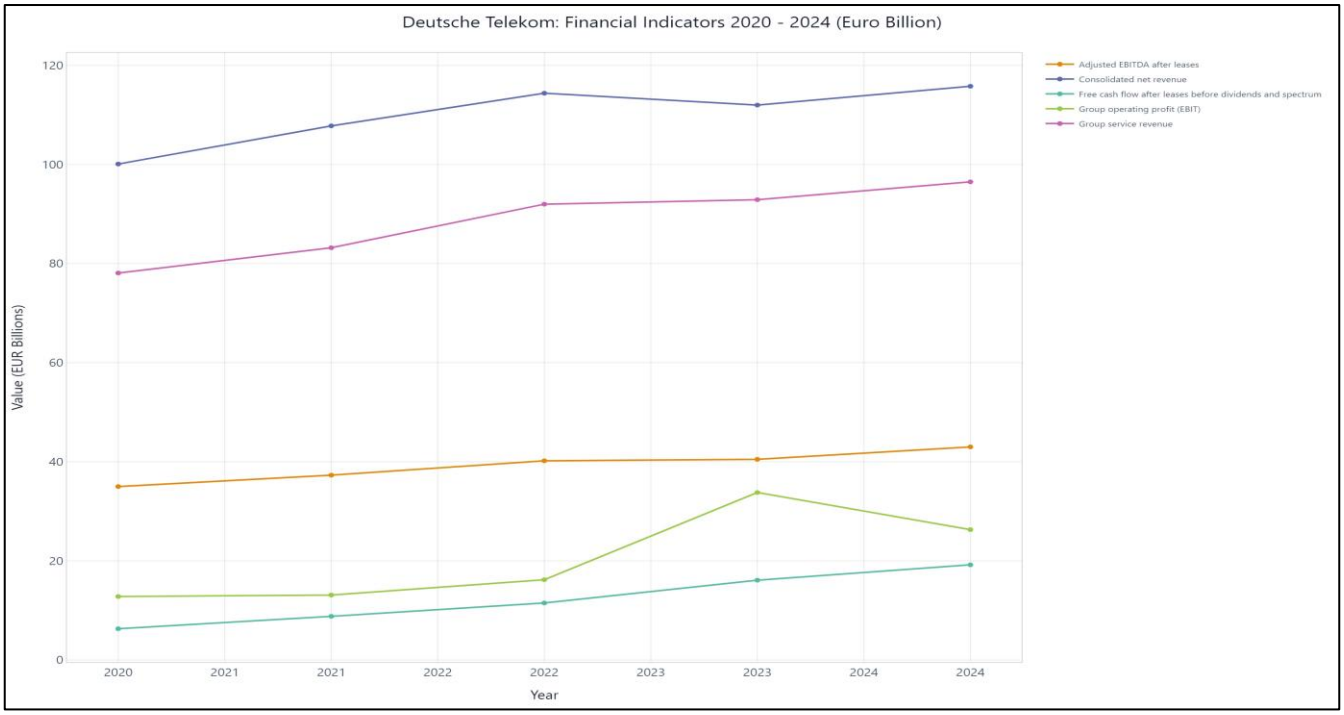


Figure 4-2. Deutsche Telekom: reported group service financial indicators in available periods.

Source / basis: Deutsche Telekom group service revenue, EUR billion, disclosed reporting series.

These are selected group-level benchmarks rather than a claim about mobile-only profitability or universal operator performance. Subscriber growth, average revenue per account, service revenue, EBITDA, CAPEX and network quality

would need to be assembled on compatible, company-specific bases before stronger investment-return comparisons are made.

4.1 Three Commercially Distinct Pathways for Operators

First-time connectivity: improve access among eligible people not actively connected, conditional on coverage and affordability.

Digital upgrading: support the move from basic connectivity to Internet-capable devices and meaningful broadband use.

Usage deepening: improve the value and quality of services for existing users, subject to willingness to pay, reliability and competitive market conditions.

These pathways have different revenue and cost models. Customer acquisition, migration between technologies and growth in usage cannot be inferred simply by subtracting national percentages from one another. Subscriber denominators, traffic, tariffs, network costs and retained revenue are needed to distinguish their commercial feasibility.

4.2 Practical Operator Implications

The comparative approach can support market monitoring, source-aligned peer analysis, investigation of Internet-use gaps, and questions about service accessibility, affordability and network upgrade timing. Any resulting action requires validation against operator-specific customer economics and internal performance records.

4.3 Customer Trust, the Economics of Service Quality and Business Sustainability

Trust is treated as a strategic performance driver to investigate, not as a measured finding of this database. Operators may benefit from reliable network experience, predictable billing, clear package conditions, effective grievance resolution and data privacy practices. Those mechanisms can plausibly influence retention, willingness to use data services and reputation. Establishing these relationships requires operator-specific complaint, churn, quality, ARPU and pricing records, ideally tracked by cohort over time.

An evidence-responsible scorecard should separate customer outcome indicators (complaints per 10,000 accounts, network-availability percent, unresolved billing disputes, data service usage) from business performance (churn, net adds, ARPU, contribution margin, CAPEX intensity). No trust score is assigned in this paper because these underlying measures have not been harmonized for the comparator countries.

4.4 Sustainable Operator Growth: Three Distinct Pathways

First-time access expands the base of people and enterprises served; technology upgrades improve device and broadband capability; deeper digital engagement increases the usefulness and potentially the economic yield of existing access. Each pathway needs a different investment logic. A high SIM-to-population ratio is not proof that first-time adoption is complete; a low Internet-use rate is not proof that a data bundle will be profitable. Pricing, service experience and unit economics must be tested before implementation.

Part III: Demography, Economics and International Market Opportunity

5. Why Population Size Alone Does Not Define Telecom Demand

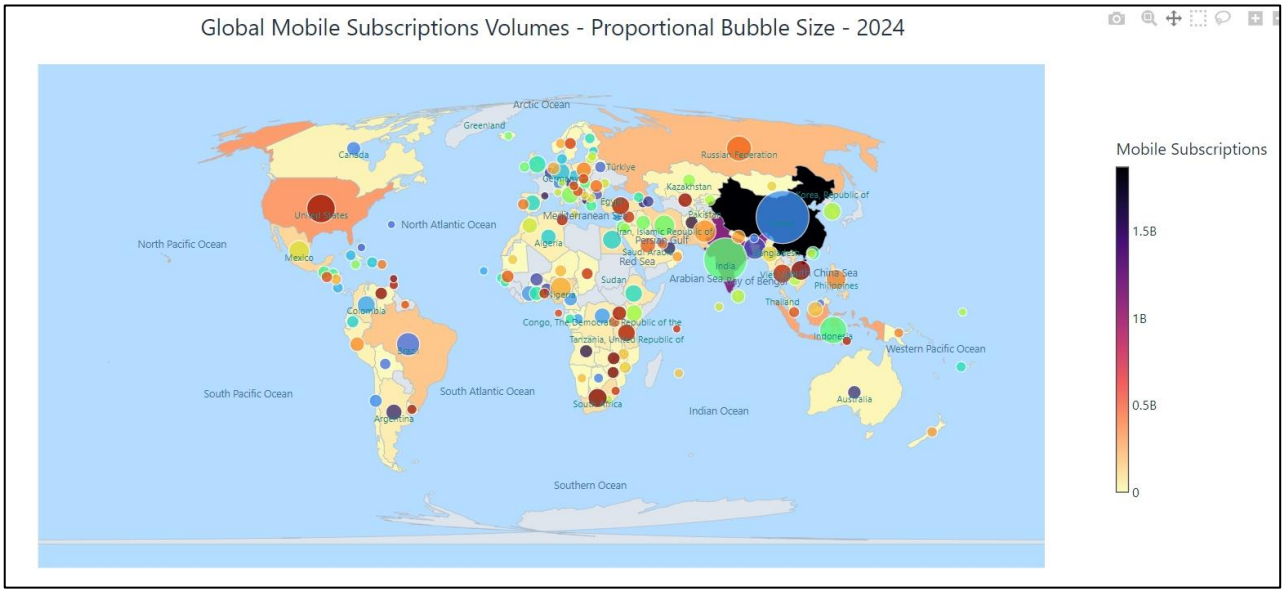


Figure 5-1. Worldwide mobile subscriptions: geographic distribution and absolute volume, 2024.

Source: World Bank/ITU telecommunications indicators; bubble area represents reported connection volumes, not unique users.

A large population can indicate a large underlying demographic market, but commercial demand depends on how many people can afford suitable devices and plans, whether networks are available and reliable, and whether alternative technologies or ownership arrangements already satisfy their needs. Population growth, youth share and GDP per capita are useful context, but are not sales or profit forecasts. The current comparable context uses 2025 demographic estimates, 2024 telecom indicators and some GDP figures labelled “latest available”, with imperfect time alignment.

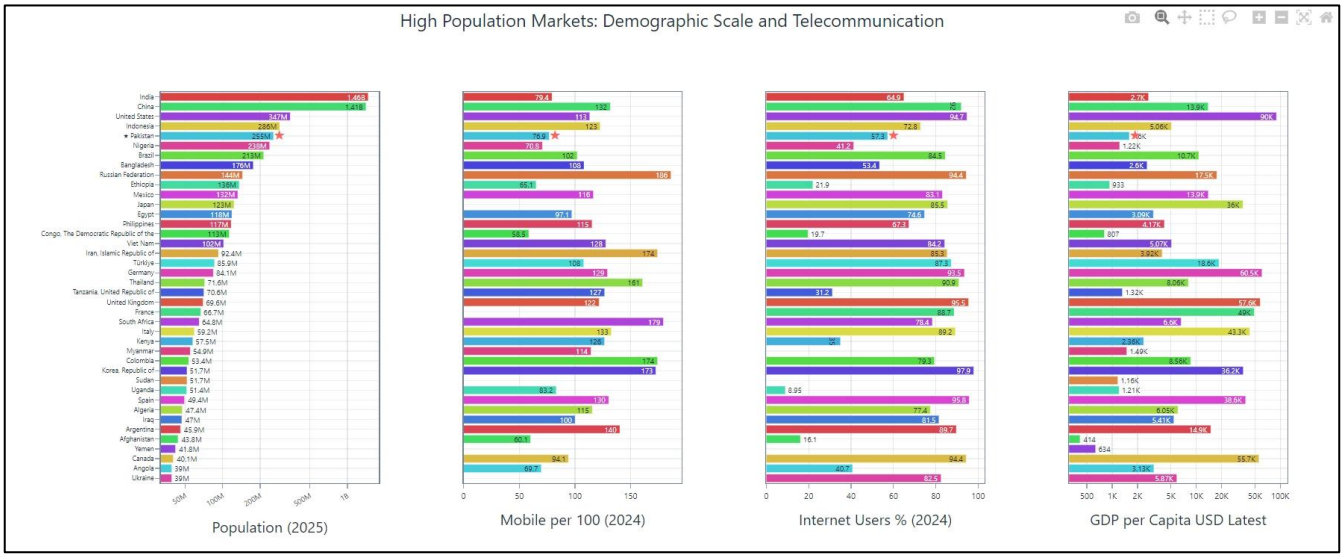


Figure 5-2. Major populous markets compared on population, cellular subscription intensity, Internet use and GDP per capita.

Interpretation limit: Four metrics have different units, denominators and sometimes different reference years.

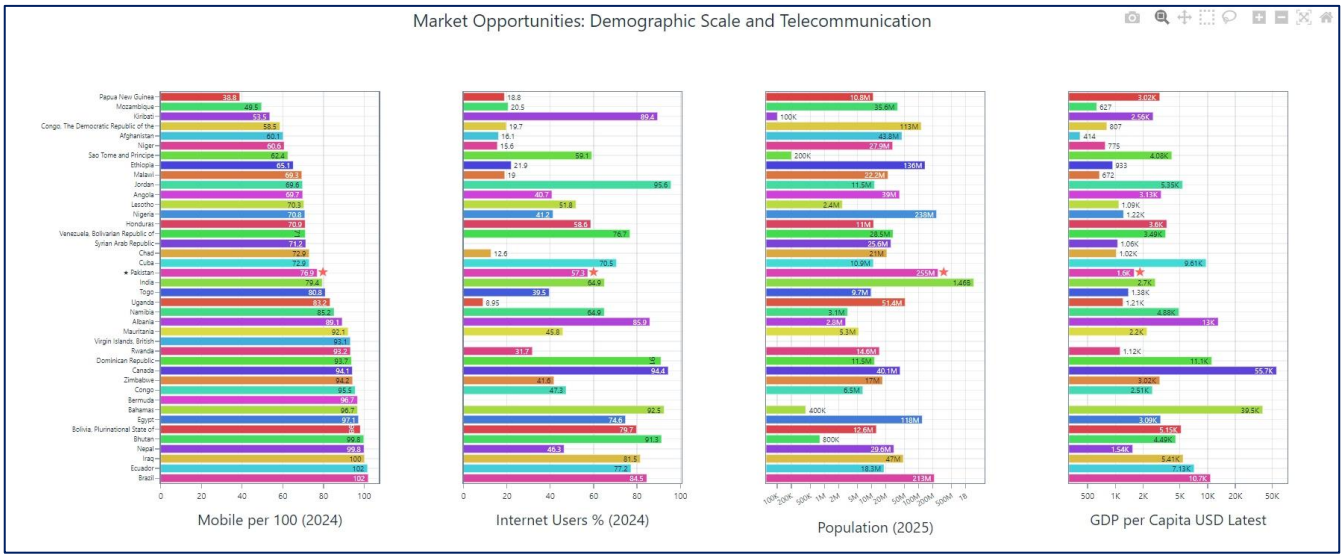


Figure 5-3a. Cross-market opportunity-screening indicators: mobile-cellular subscriptions per 100, Internet use (%), population and GDP per capita in selected economies (mixed reference years).

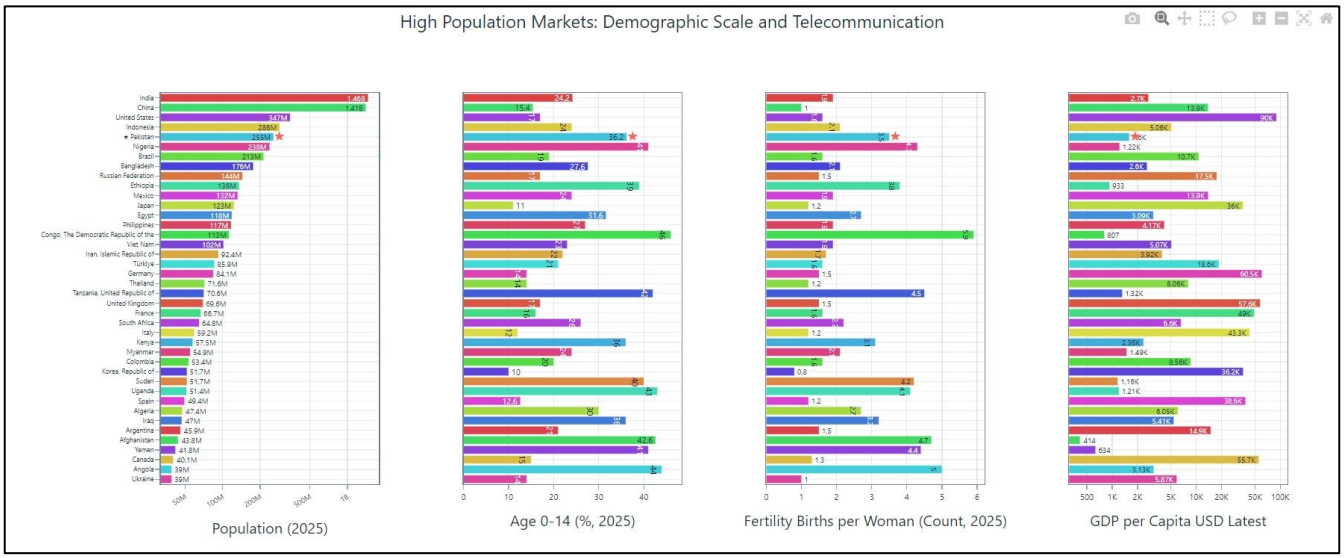


Figure 5-3b. Population, children aged 0–14, fertility and Internet adoption in populous countries.

Interpretation limit: Fertility is births per woman, not a percent; youth cohorts are not automatically purchasing users.

Interpretation of Figures 5-3a–5-3b: These exhibits are complementary screening tools, not estimates of market capture. Figure 5-3a juxtaposes connection intensity and actual Internet participation with population and income context; it helps identify large economies where a substantial difference in the two access measures merits further investigation. Figure 5-3b adds the size of younger age cohorts and fertility to distinguish future demographic exposure from today's economically addressable customer base. Differences in units and country-year coverage prohibit combining the bar lengths or treating their apparent ranking as an investment ranking.

Commercial implications: A low Internet-use rate in a large population can motivate tests of entry-level smartphone affordability, data-package value, rural coverage, device sharing, digital literacy and demand for local-language

services. High cellular subscription intensity combined with lower individual Internet use points instead toward verification of multi-SIM behaviour, smartphone capability and active data usage. Youthful populations may inform long-term demand scenarios but do not establish current purchasing power or near-term subscriber additions. Operators and manufacturers should estimate eligible unique persons, reachable households, willingness to pay and incremental contribution margin before converting any descriptive gap into TAM, SAM or SOM.

Validation required for strategic capture: Before commercial prioritization, link demographic cohorts to geography, household income, handset ownership, actual active Internet use, coverage/quality and local tariff prices; then pilot a segmented proposition and measure activation, 30/90-day retention, cost of acquisition, ARPU and margin. Figures 5-3a and 5-3b define which hypotheses to investigate, not the volume of customers an operator can capture.

5.1 Subscription Intensity Above the Population Threshold

A mobile-subscription ratio above 100 indicates connections exceed residents, which may reflect dual SIMs, separate personal and business lines, enterprise devices or other counted connections. The relationship to Internet adoption is a useful diagnostic: a country may be heavily subscribed without the same proportion of residents using the Internet. Addressing this gap could involve device capability, price, usability, digital skills and network quality, but the gaps themselves are not a commercially obtainable-customer estimate.

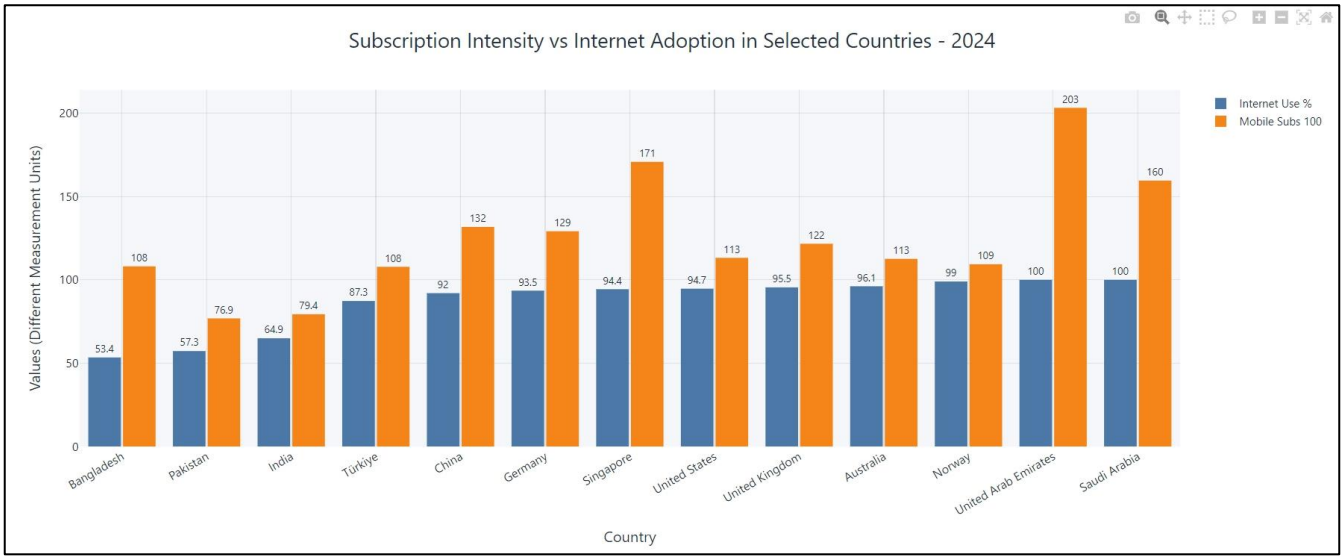


Figure 5-4. Selected economies: cellular subscriptions per 100 alongside Internet use (% population).

Interpretation limit: Bar heights involve related but not identical measurement concepts.

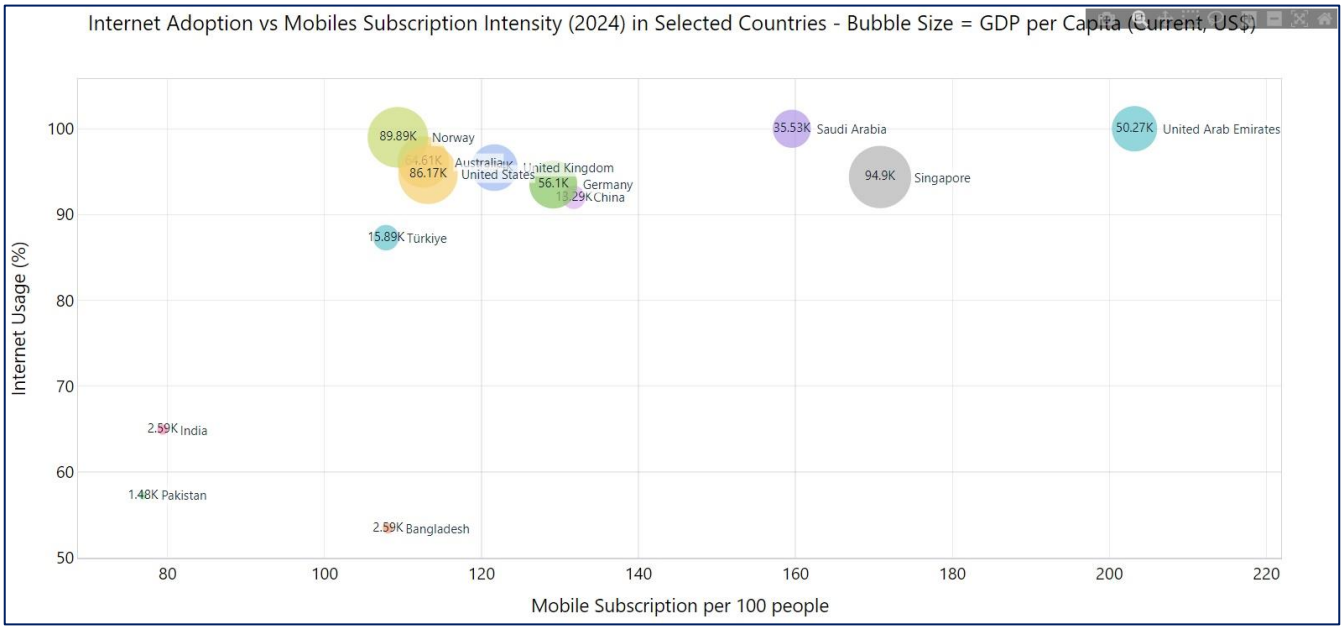


Figure 5-5. Subscription intensity and Internet adoption, with population context.

Interpretation limit: Mixing years is an explicit illustrative screening choice, not a synchronized-year estimate.

5.2 An Opportunity Diagnostic - Not an Investment Ranking

The combined evidence can identify four broad diagnostic situations: (i) large population with low connection intensity and limited Internet use; (ii) high connection intensity but relatively lower Internet use; (iii) high connectivity and Internet use with opportunities mainly in quality, service differentiation or replacement; and (iv) countries with incomplete data where no strong classification is justified. These are descriptive configurations, not measured unmet demand.

A practical framework progresses from demographic scale and age structure, through GDP-per-capita context, actual subscriptions and Internet participation, to potential new adoption, technology upgrading and greater digital engagement. Only the final business-feasibility stage covering serviceable demand, competition, prices, margins and acquisition costs can support credible operator-specific TAM, SAM or SOM.

Different reference years remain explicit: the panels use 2025 population context, 2024 cellular and Internet observations and certain GDP-per-capita figures labelled latest available. The figures are therefore intended for preliminary prioritization and hypothesis generation, not synchronized causal inference.

5.3 From Observation to Opportunity Screening

Table 5-1. Demographic-to-commercial opportunity-screening framework

Analytical stage	Available evidence	Additional evidence for commercial decision
Population and age structure	National population, children/youth context	Household structure, income distribution, accessible adult population
Connection and Internet adoption	Subscriptions/100 and Internet users %	Unique users, smartphone-ready devices, mobile broadband active use
Affordability and willingness to pay	GDP per capita as broad economic context	Price baskets, household disposable income, effective data spending
Network serviceability	Selected national technology information	Subnational coverage, throughput and congestion
Business capture	Country comparison and scenario framework	Competitor share, acquisition costs, churn, expected margin and capacity

TAM, SAM and SOM will be treated as separate concepts. TAM represents the full defined demand pool for a specific service; SAM is the technically and economically reachable share; and SOM is the realistic obtainable share for an identified company and time horizon. Public population and connection statistics alone are insufficient to quantify any operator's SOM. No unsupported addressable-market number is introduced.

5.4 Evidence-Based Cross-Market Opportunity Screens

The following comparative figures show 2024 cellular subscriptions and Internet-use observations; they are descriptive indicators rather than customer counts or forecasts.

Figure 5-4 remains the sole presentation of this cellular-subscription/Internet-use comparison. The 2024 diagnostic is interpreted below, without reproducing the chart.

The 2024 contrast among Pakistan, Bangladesh, India, China and the higher-adoption members of the defined 13-country cohort illustrates why cellular connections and individual Internet participation require distinct strategic responses. A market can have many SIM subscriptions while still warranting investigation of broadband use, affordability or device capability. The difference between the two indicators cannot be converted into a count of unserved or commercially obtainable customers.

The population-context comparison is shown once as Figure 5-5. Its use here is a cross-reference rather than a second figure.

The figure is most useful for selecting comparison groups and generating testable hypotheses: pricing and entry-level devices in lower-income large markets, deeper usage and upgrades in highly connected markets, and distinct propositions for developed-country replacement cycles. Relative position alone does not show customer willingness to pay, operator return on investment or service quality.

6. Expanded International Country Benchmarking

This chapter interprets the same purposively selected 13-country comparison defined in Section 1.2 and used for the principal country-level charts in Chapters 3 and 5: Australia, Bangladesh, China, Germany, India, Norway, Pakistan, Saudi Arabia, Singapore, Türkiye, the United Arab Emirates, the United Kingdom and the United States. Pakistan is the focal economy and the other twelve are peers. The countries provide contrasts in demographic scale, cellular connection intensity, Internet participation and income context; they are not a statistically representative world sample or an investment-attractiveness ranking. No second or expanded core cohort is introduced here.

6.1 The Defined 13-Country Benchmark Cohort

The single core cohort comprises Pakistan and twelve comparator economies: Australia, Bangladesh, China, Germany, India, Norway, Saudi Arabia, Singapore, Türkiye, the United Arab Emirates, the United Kingdom and the United States. Section 1.2 explains the selection rationale. Table 6-1 organizes these same thirteen economies into non-overlapping interpretive groups; the grouping is a reading aid, not a separate dataset or a second selection of countries.

The complementary indicators are illustrated in Chapter 5 (notably Figures 5-2, 5-4 and 5-5) and in the common 13-country histories in Figures 3-4 and 3-5. Those charts are referenced rather than reproduced in this chapter. Figure-specific differences in availability or reference year remain governed by their captions; the core cohort should not be assumed to contain a complete observation for every indicator in every year.

Interpreting the cross-market displays requires separating four concepts: national population and potential demographic scale; cellular subscriptions per 100 inhabitants (which may exceed 100 through multi-SIM activity); individuals using the Internet (% of population); and economic context such as GDP per capita. These measures have different denominators and must not be added, ranked as though interchangeable, or used alone to estimate serviceable market size.

The six high-income benchmarks; Australia, Germany, Norway, Singapore, the United Kingdom and the United States, offer contrasts in Internet participation and economic capacity. They are not direct commercial templates for Pakistan. The UAE and Saudi Arabia provide high-adoption regional contrasts, Türkiye adds a near-regional comparison, China and India provide large-market context, and Bangladesh offers a neighbouring South Asian reference. Pricing, distribution, unique users, local income and network quality require independent validation.

6.2 Interpreting the 13-Country Contrasts as Business Questions

Pakistan, India and Bangladesh should be compared first on the reported indicators and their definitions, rather than presumed to share the same demand barriers. Differences in cellular subscription intensity and Internet use may reflect population age structure, household sharing, active-SIM practices, rural coverage, affordability, smartphone capability and service quality. China adds a contrasting example of large demographic scale with a different observed adoption profile. No numerical gap by itself specifies how many new SIMs, smartphones or paid data users a provider could acquire.

The regional comparators, Saudi Arabia, United Arab Emirates and Türkiye, and the six high-income benchmarks, Australia, Germany, Norway, Singapore, the United Kingdom and the United States, help contextualize differences in participation, economic capacity and market maturity. They do not establish that their prices, subscriber mix or network-investment strategies would be transferable to Pakistan. Each contrast should instead generate testable questions on affordability, coverage, productive usage and possible technology upgrading.

Each country comparison should therefore lead to (a) a clearly dated observation; (b) one or more plausible but unproven explanations; (c) the missing country-, customer- or operator-level evidence needed to discriminate between explanations; and (d) a measurable pilot or decision criterion. The figures support screening and hypothesis formulation, not estimated TAM, SAM, SOM or demonstrated policy effectiveness.

6.3 Comparative Findings, Limits and Next-Stage Validation

Read together, Figures 3-4, 3-5, 5-2, 5-4 and 5-5 support a consistent 13-country descriptive framework. India and Bangladesh are Pakistan's South Asian comparators; China supplies a large-market contrast; Saudi Arabia, the United Arab Emirates and Türkiye provide regional reference points; and Australia, Germany, Norway, Singapore, the United Kingdom and the United States represent six high-income benchmarks. These are thirteen distinct economies including Pakistan, not the former core/extended groups. Observed differences between mobile subscriptions and individual Internet use raise questions about multiple connections, capable devices and meaningful adoption. They do not, without unique-user, tariff, coverage, quality, household and financial data, quantify unmet paying demand, economic causality or operator investment returns.

Table 6-1. Purpose and interpretation of benchmark country groups

Interpretive group	Countries in 13-country cohort	Analytical purpose
Pakistan and South Asian peers	Pakistan, India, Bangladesh	Focal-country comparison; neighbouring adoption and connection-intensity contrasts
Large-market comparator	China	Large population, device-market scale and distinct digital-adoption profile
Regional comparators	Saudi Arabia, United Arab Emirates, Türkiye	Regional economic and adoption contrasts; not presumed transferable business models
High-income benchmarks	Australia, Germany, Norway, Singapore, United Kingdom, United States	High-adoption and income contexts; comparison benchmarks rather than direct demand estimates

7. Pakistan in the Global Connectivity and Adoption Landscape

Pakistan's demographic scale makes it a natural focal economy in the defined 13-country benchmark. The relevant comparisons are with India and Bangladesh in South Asia; China as a large-market contrast; Saudi Arabia, the United Arab Emirates and Türkiye as regional references; and Australia, Germany, Norway, Singapore, the United Kingdom and the United States as high-income benchmarks. These national indicators invite questions about subscription intensity, Internet adoption, income and affordability but cannot independently assess any Pakistani operator's pricing, network quality or commercial strategy. Jazz, Zong, Ufone and the historical Telenor business are not quantitatively ranked here because comparable source-verified operator-level histories are not assembled in this volume; their dated corporate status is described in Section 7.5.

Pakistan is highlighted conceptually in the comparisons already presented in Figure 5-2. The four-metric display is not reproduced here; Figure 13-2 and Figure 13-3 later provide the explicitly Pakistan-relative 2024 adoption and subscription gaps.

Interpretation limit: National cross-sections cannot quantify unserved unique users or operator market share.

7.1 Potential Avenues for Further Validation - Not Proven Opportunities

- Affordable smartphone replacement and financing, subject to actual country device sales, pricing and replacement-cycle evidence.
- Mobile-data-package suitability and affordability, subject to published tariff basket and household-expenditure measures.
- Rural/peri-urban connectivity, subject to detailed network-coverage and site-economics data.
- Youth and education services, subject to school/household connectivity needs and effective ability to pay.
- Enterprise connectivity and financial services, subject to firm-level demand and operator service information.

Given the evidence constraints, Pakistan is retained as an international comparative subsection rather than a fourth standalone research part. A national commercial study can be developed later using PTA data, operator reports and validated market economics, without delaying publication of the current global synthesis.

7.2 Telecommunications, Productivity and Wider Economic Development

Mobile connectivity can enable financial inclusion, e-commerce, better market information, public service delivery, education, healthcare and business coordination. These pathways plausibly support productivity, inclusion and economic growth. However, observed correlations between GDP, subscriptions and Internet use are not proof that higher SIM counts cause GDP expansion; causation also runs through income, investment, skills, policy and institutional conditions. The paper therefore presents these pathways as mechanisms for further analysis, not estimated GDP multipliers.

Table 7-1. Stakeholder applications of the telecommunications evidence

Stakeholder	Potential use of the research
Manufacturers	Explore device affordability, replacement and channel questions with country and income context
Network operators	Compare adoption indicators, identify areas requiring detailed customer/coverage testing
Regulators / policymakers	Distinguish connections, Internet adoption and digital inclusion; recognize geographic evidence gaps
Investors and infrastructure vendors	Screen market scale and serviceability questions before investment appraisal
Academia and researchers	Reproduce international descriptive trends and evaluate hypotheses with suitable additional controls

7.3 What Business Entities Can Use Immediately

Manufacturers can use paired demographic/connectivity panels to shortlist countries for further research on device access, replacement demand and affordability. Operators can screen differences between connections and Internet

participation and then test coverage, package suitability, customer retention and user economics. Infrastructure vendors can examine adoption patterns alongside independently measured coverage and network requirements. Investors can use this approach to identify questions for capital appraisal rather than treating national penetration differences as investable returns.

The public-data approach provides a common external benchmarking language across organizations and geographies. It does not imply that industry participants lack equivalent or more detailed internal analyses; its value is a transparent cross-sector reference frame available to multiple stakeholders.

7.4 Strategic Opportunity-to-Decision Matrix

A rigorous commercial translation links an observation to competing explanations, an evidence request, a feasible test and a clear decision threshold. The same diagnostic should be revisited after execution; strategic leadership is a learning process, not a one-time market ranking.

Table 7-2. Strategic opportunity-to-decision matrix

Observed pattern	Potential strategic pathway	Evidence and decision test
High population; lower Internet participation	Access, device affordability, digital literacy, coverage	Unique-user and affordability research; unit economics of first-time adoption
Subscriptions >100/100; lower Internet use	Upgrade data use and meaningful engagement	Unique-SIM reconciliation; active broadband users; bundle contribution margin
Strong device shipments; uncertain margins	Ecosystem/product-mix differentiation	Matched fiscal periods, segment profit, selling price and replacement rates
High network investment; unclear yield	Prioritize coverage, quality or capacity based on demand	Cell-site economics, utilization, churn, quality and incremental cash flow
Volatile industry positions	Build resilience and adaptive capability	Comparable event timelines, cash-flow buffers, market concentration and stress scenarios

7.5 Pakistan's Telecommunications Industry: Institutional Structure, Operators and Scope

Pakistan's telecom sector connects policy, licensing and spectrum administration, fixed and mobile infrastructure, retail services, and digital applications. The Ministry of Information Technology and Telecommunication provides the federal policy and programme framework; the Pakistan Telecommunication Authority (PTA) is the sector regulator for telecom licensing, compliance and related regulatory functions. The available national participation indicators in this volume do not reveal which operator served a user, whether an individual had multiple SIMs, or what the operator earned from that activity. This institutional overview therefore provides essential context for Pakistan-focused international comparison without converting **Volume I** into an operator-level financial study.

Mobile network structure and consolidation: Jazz and Zong are major mobile network providers; Ufone operates through Pak Telecom Mobile Limited (PTML), a PTCL subsidiary. Telenor Pakistan was a separately identifiable historical operator in the earlier observation period, but PTCL completed its acquisition of Telenor Pakistan and Orion Towers on 31 December 2025. Following regulatory and statutory approvals, Telenor Pakistan formally amalgamated into PTML effective 1 July 2026 and ceased to exist as a separate legal entity. Historical comparisons must therefore

identify their observation dates and not treat the former Telenor company and the combined PTML entity as four separate contemporaneous legal operators or add their pre- and post-merger totals without reconciliation. Network or customer-facing brand migration may occur on a different timetable from the legal transaction. (Sources: PTCL/Ufone announcement, 31 December 2025; Associated Press of Pakistan, 1 July 2026; Pakistan Economic Survey 2025–26, Information Technology chapter.)

Fixed broadband and interconnection: PTCL also has a substantial fixed-network, broadband, enterprise and wholesale connectivity role, distinct from its mobile subsidiary. Other fixed-broadband, fibre and infrastructure companies contribute to national access and backhaul. Since mobile Internet quality depends on radio access, spectrum, fibre transport, site economics, device capability and affordable packages, comparisons of cellular subscriptions and Internet-use rates should not be interpreted as a ranking of individual Pakistani network operators or as a direct assessment of their financial strength.

Research and policy significance: This configuration raises testable questions about the effects of consolidation on market contestability, coverage, quality of service, wholesale access and investment incentives; the affordability of capable smartphones and data packages; and the gap between nominal connectivity and sustained productive use. These are not outcomes demonstrated by the international panel. The Strategy/Policy Paper should separately evaluate the regulator's competition and consumer-protection objectives and operators' commercial incentives, using dated PTA/operator disclosures, geographic quality-of-service measurements, tariffs, unique active users and segment-level economics. **Volume II** will examine service revenues, ARPU, traffic, churn, CAPEX/OPEX, margin and monetization pathways on comparable operator reporting bases.

Source and vintage note: Contemporary transaction statements are checked as at November 2026, while the principal international statistical panel ends in 2024.

Official records: PTCL/Ufone, "PTCL Spreads Its Wings" (31 December 2025), https://www.ufone.com/ptcl-spreads-its-wings-a-new-chapter-for-pakistans-digital-future/ ; Associated Press of Pakistan, "Telenor Pakistan formally amalgamates into PTML" (1 July 2026), https://www.app.com.pk/national/telenor-pakistan-formally-amalgamates-into-ptml-following-statutory-approvals/ ; Pakistan Economic Survey 2025–26, Information Technology, https://finance.gov.pk/survey/chapter_26/15_Information_Technology.pdf

These dated sector developments are contextual and are not merged into the historical econometric dataset.

Part IV: Statistical and Econometric Evaluation

8. Research Questions, Hypotheses and Identification Strategy

The historical synthesis raises a quantitative question: how closely is digital connectivity associated with economic development once common global trends and persistent country differences are considered? This chapter establishes pre-specified tests. All models, tables and visuals in this section are planned analyses, not completed results. Statistical association is distinct from predictive usefulness, investment viability and causality.

Table 8-1. Analytical populations and data-structure definitions

ID	Testable proposition	Primary evidence and method
H1	Internet use is positively associated with GDP per capita in a pooled country-year sample.	Pearson/Spearman; pooled multivariate regression, with year controls.

ID	Testable proposition	Primary evidence and method
H2	The Internet-use association differs after controlling for country and year heterogeneity.	Country and two-way fixed-effects panel regression; clustered uncertainty.
H3	The mobile-subscription relationship differs from the Internet-use relationship.	Common-sample nested regressions; collinearity diagnostics.
H4	Digital adoption dispersion across comparable economies changes over time.	Sigma convergence, robust distributional comparisons; beta convergence cautiously.
H5	Countries exhibit statistically distinguishable digital-development profiles.	PCA and clustering, with stability and scale checks.
H6	Adoption forecasts outperform transparent benchmark projections out of sample.	Rolling-origin tests; naive and drift baselines versus ARIMA/ETS.

8.1 Analytical Populations and Data Provenance

Cohort governance: The 13-country selected comparator set is described in Section 1.2. It supports exploratory Pakistan-versus-peers visualization and does not replace the global estimation, stable-cohort or complete-case samples. Always report the sample definition and missing-year policy alongside a coefficient, chart or forecast.

Econometric sample definition: The global estimation sample comprises country-year observations with jointly available variables under the stated specification; it is distinct from the 13-country descriptive peer cohort.

Three populations are kept separate: (A) broad cross-country descriptive telecommunications observations; (B) common-year economic pilot observations; and (C) company/industry financial histories. No model will silently combine national observations with company accounts or 2025 population snapshots.

8.2 Variables, Transformations and Definitions

Table 8-2. Variables, transformations and measurement conventions

Variable	Role	Treatment / constraint
ISO3 / Country; Year	Panel entity and time IDs	Unique ISO3 + Year keys, sorted; non-country aggregates flagged.
Individuals using the Internet (% population)	Adoption outcome or explanatory variable	Bounded percentage; not interchangeable with mobile Internet use.
Mobile subscriptions per 100 inhabitants	Connectivity intensity	May exceed 100; not unique users or device ownership.
GDP per capita, current USD	Pilot contextual economic outcome	Use log only for strictly positive values; currency and inflation caveats.

Variable	Role	Treatment / constraint
Real GDP per capita (target acquisition)	Preferred growth/development outcome	Constant-price or PPP definition with source-specific vintage.
Population, urbanization, education, investment	Candidate controls	Use annual harmonized series only; assess missingness and source.
Country/group classifications	Stratification and interpretation	Document transparent peer criteria; avoid data-derived outcome leakage.

9. Exploratory Statistics and Quantitative Relationships

This section reports observed country coverage, global adoption distributions, year-specific correlation patterns and diagnostic outliers. Matched samples and indicator units are specified for each figure wherever verified; the cross-sectional analyses are not interpreted causally.

The observation coverage shown here is indicator-specific and should not be confused with the number of complete cases in an econometric specification.

Reporting Coverage of Global Telecommunications Indicators



Figure 9-1. Availability of national/territorial observations for mobile subscriptions and Internet use, 2000–2024.

Interpretation: The two coverage series are relatively stable for much of the historical record, but reporting becomes uneven in the most recent years, especially for mobile subscriptions. The reduction in record counts does not represent a fall in subscriptions or Internet use. Different reporting coverage can affect comparisons between years.

Coverage counts describe data availability rather than a change in telecommunications activity; modelling samples can be smaller because all required indicators must be jointly observed.

Scope note: A separate global paired-year global paired-year comparison scatter is not included because no verified matched sample and paired-N export accompanied this edition. Existing selected-country scatter and correlation figures are retained under their own definitions; no global global paired-year comparison result is inferred from them.

International Internet-Adoption Distributions, 2000–2024

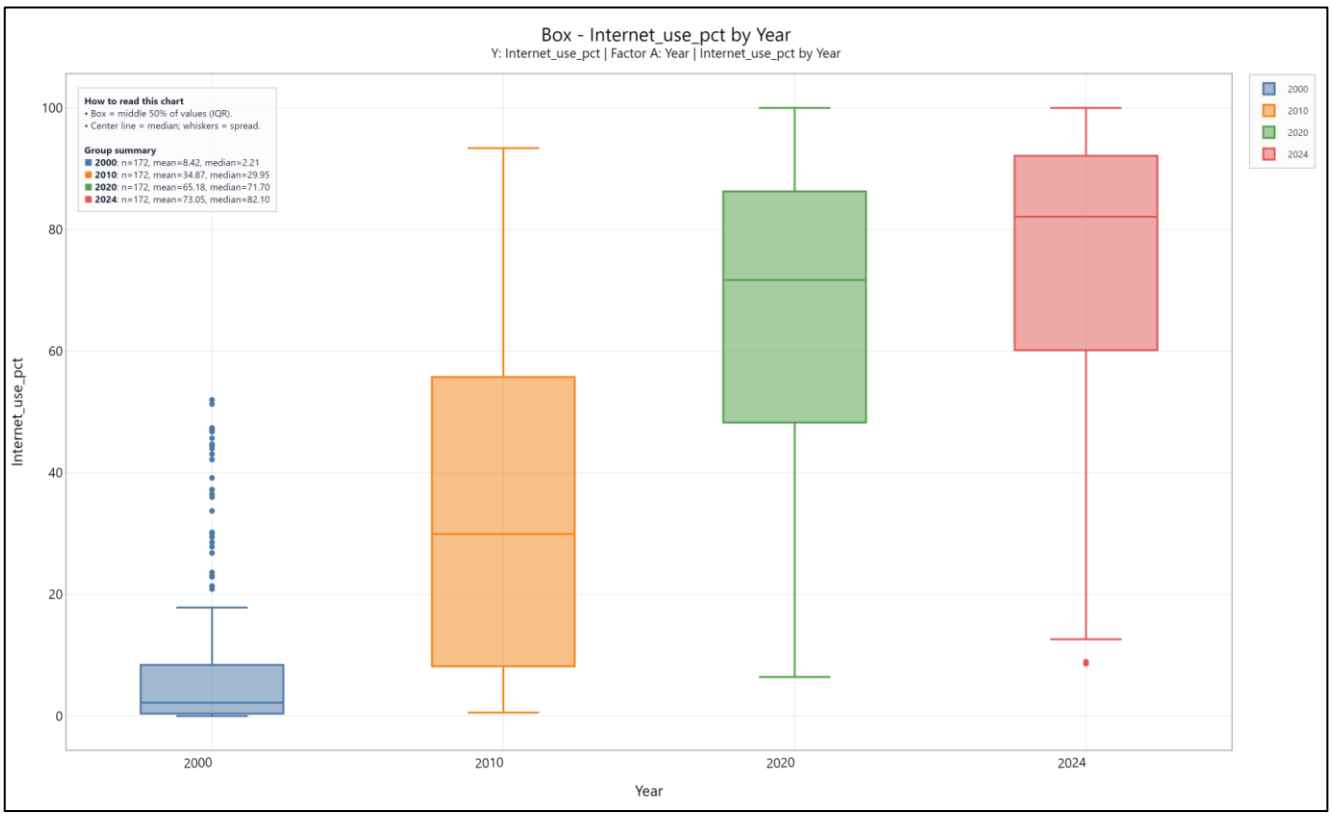


Figure 9-2. Internet use (% of population) in 2000, 2010, 2020 and 2024, based on the same 172 countries/territories represented in each benchmark year (unweighted entity distributions).

Results. Across the matched cohort, the median Internet-use share increased from 2.21% in 2000 to 29.95% in 2010, 71.70% in 2020 and 82.10% in 2024. The respective means were 8.42%, 34.87%, 65.18% and 73.05%. The changing widths of the boxes show substantial cross-entity heterogeneity during diffusion and continued dispersion in 2024.

Interpretation: The distribution shifted strongly upward, indicating widespread digital adoption. Yet significant differences persisted: country-level medians do not describe the average experience of the world population, and a high national Internet-use percentage does not establish smartphone ownership or service quality.

Method note: Each benchmark has n=172 entities; distributions are unweighted, the same entity cohort is used, and the whiskers/outliers follow the Brill-Viz boxplot convention. Comparisons between years are descriptive and do not establish causes.

Correlation Structure: Mobile Subscriptions and Internet Use

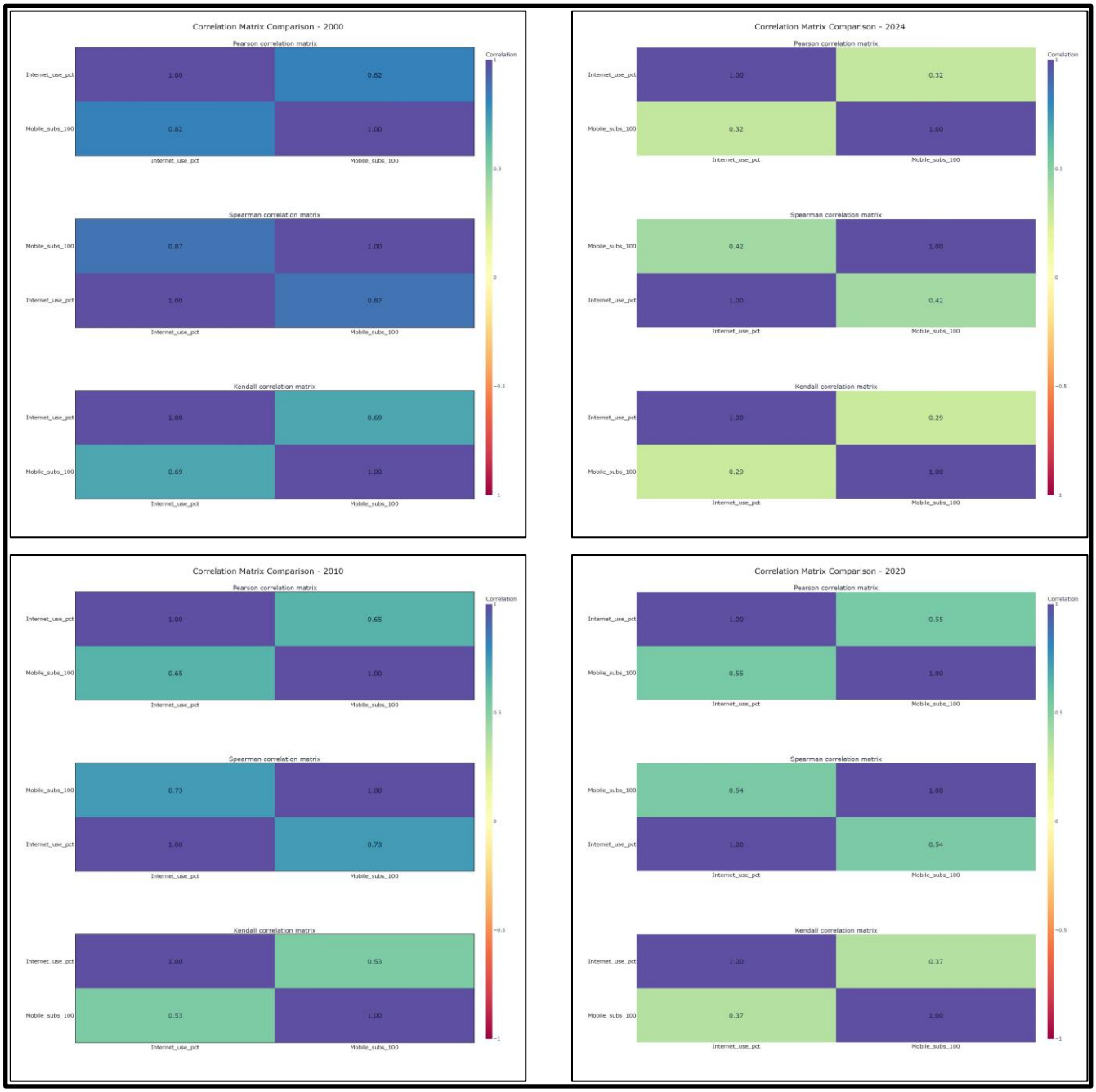


Figure 9-3. Year-specific Pearson, Spearman and Kendall correlation matrices for mobile-cellular subscriptions per 100 inhabitants and individual Internet use (%), 2000, 2010, 2020 and 2024.

The four panels show symmetric two-variable matrices (diagonal = 1.00); interpretation concerns off-diagonal coefficients only.

Heatmap interpretation: In 2000, all three coefficients indicate relatively strong positive cross-country association between connection intensity and Internet use. By 2024, the Pearson coefficient is appreciably weaker, while rank-based correlations remain positive but lower than in 2000. This divergence is consistent with the two indicators reflecting progressively different aspects of connectivity; it does not by itself identify the contribution of multi-SIM

subscriptions, fixed access or changing country composition. The maps make the size and sign of each year-specific relationship visible; the following trend figure isolates their evolution for direct comparison.

Summary of Year-specific Correlation Coefficients

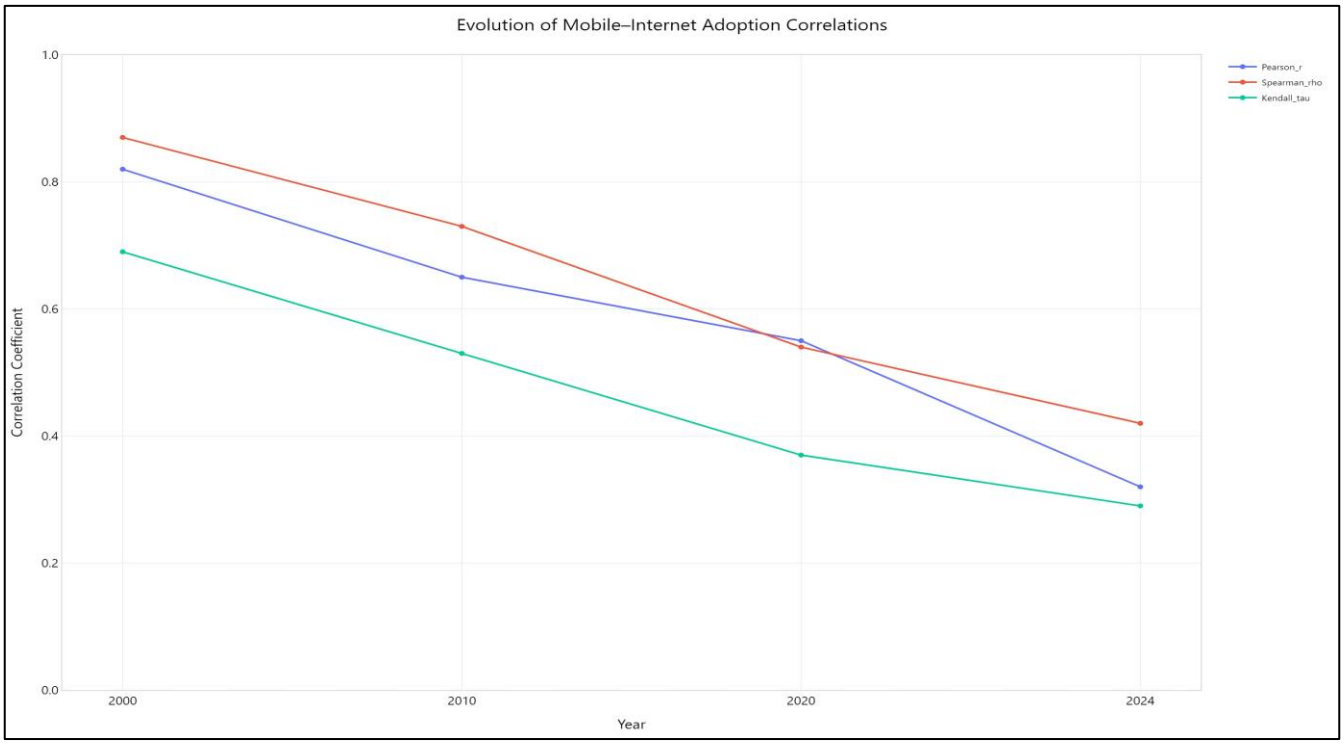


Figure 9-4. Pearson, Spearman and Kendall coefficients for mobile subscriptions per 100 inhabitants versus Internet use (%) in 2000, 2010, 2020 and 2024. Values transcribed from supplied Brill-Viz correlation heatmaps (rounded to two decimals); paired sample sizes to be verified before final publication.

Results: Pearson r fell from 0.82 (2000) to 0.65 (2010), 0.55 (2020) and 0.32 (2024). Spearman ρ declined from 0.87 to 0.73, 0.54 and 0.42; Kendall τ declined from 0.69 to 0.53, 0.37 and 0.29. Across all three measures, the observed cross-sectional association is weaker at the latest benchmark.

Interpretation: Subscription intensity becomes less closely aligned with the national share using the Internet as these indicators mature. Possible explanations include multi-SIM connections, differing paths to Internet access, adoption saturation and cross-country differences. These mechanisms are hypotheses, not separately estimated effects of this correlation analysis.

Caution: The four year-specific samples may contain different countries/territories and missing-data patterns; pairwise n, classification and ideally a constant-cohort sensitivity analysis are required before asserting a confirmed temporal decline. Correlation does not establish causation. Figure 9-3 reports the underlying matrices, while Figure 9-4 summarizes their benchmark-year coefficients. Matched pairwise sample sizes are not displayed in the supplied outputs, so any assertion of a temporal structural change remains provisional.

Distribution Diagnostics and Country-Level Outliers

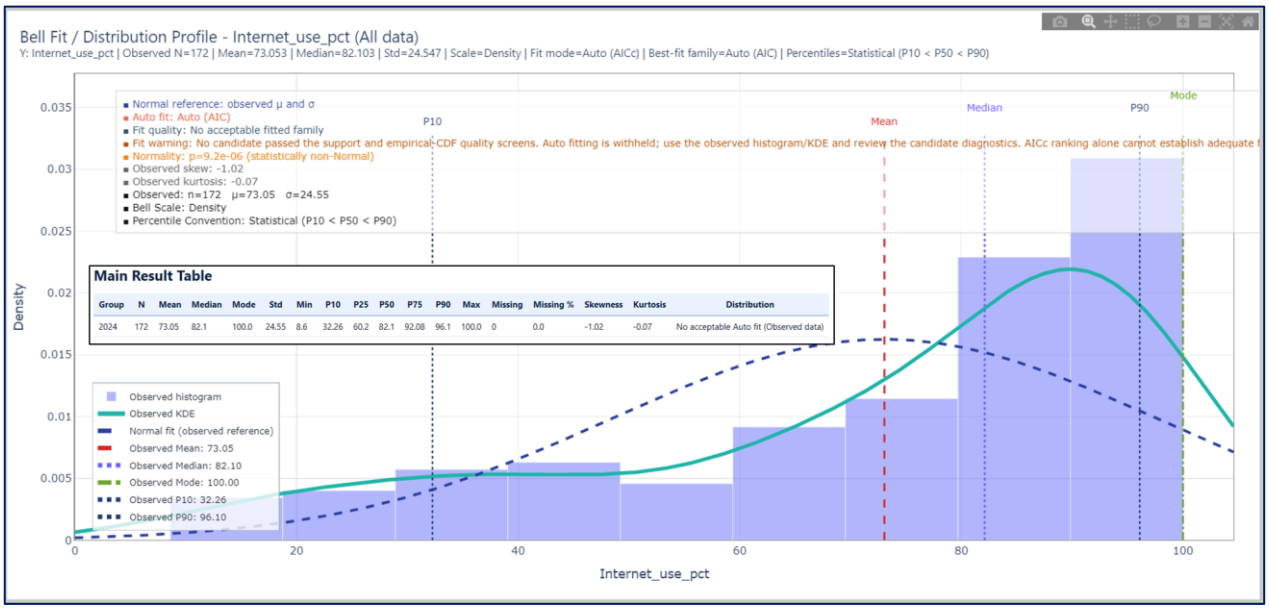


Figure 9-5: Distribution of Internet use across the stable geographic cohort, 2024

Source: Brill-Viz Grouped Stats; stable 2024 reporting cohort. Observed Internet use (% of population), n = 172. Histogram, KDE, normal reference, observed mean, median and standard percentiles. Auto AICc fitting was withheld because no candidate passed the implemented support/CDF quality screens.

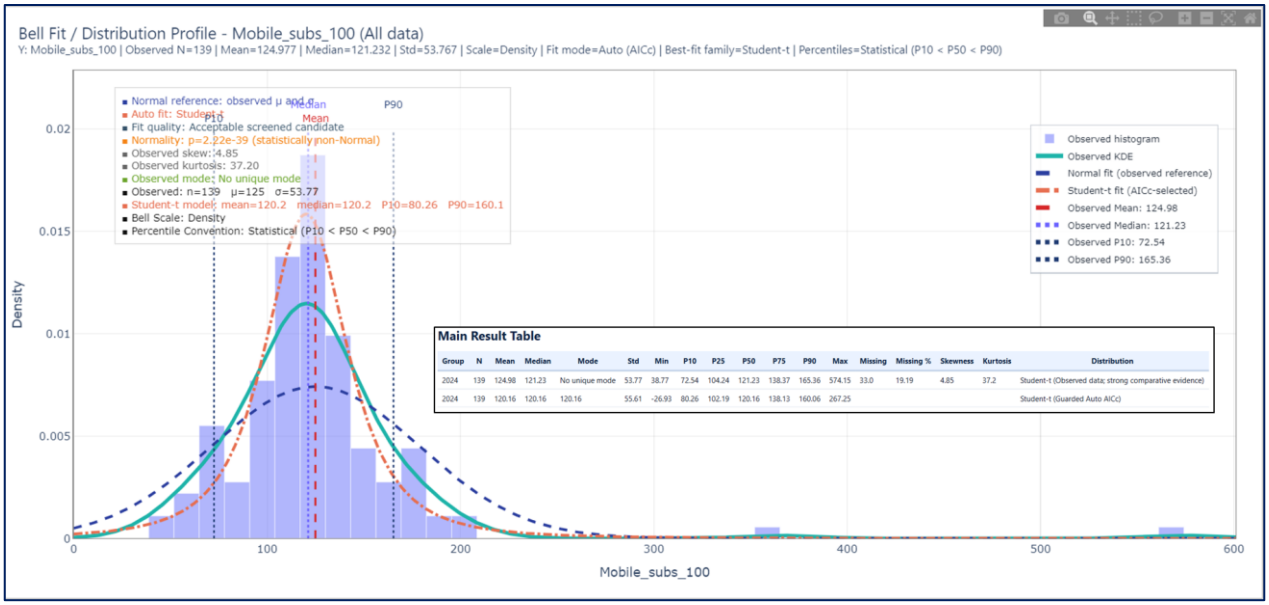


Figure 9-6: Distribution of mobile subscriptions per 100 inhabitants, 2024

Source: Brill-Viz Grouped Stats; stable 2024 reporting cohort. Observed mobile subscriptions per 100 residents, n = 139. Histogram, KDE, normal reference and exploratory Student-t candidate. An inset displays the observed versus fitted summary table.

Table 9-1: Observed distribution statistics, 2024

Statistic	Internet use (%)	Mobile subscriptions / 100
Nonmissing observations	172	139
Mean	73.05	124.98
Median (P50)	82.10	121.23
Standard deviation	24.55	53.77
P10 (non-exceedance)	32.26	72.54
P90 (non-exceedance)	96.10	165.36
IQR	31.89	34.13
Skewness	−1.02	+4.85
Excess kurtosis	−0.07	+37.20
IQR-flagged values	2	6
Maximum	100.00	574.15
Auto fit outcome	No acceptable fit	Student-t (screened candidate)

Results: Internet adoption: Among 172 reporting countries and territories in the fixed 2024 cohort, mean Internet use was 73.05% and median was 82.10%. The observed distribution is left-skewed (skewness −1.02), with P10 = 32.26% and P90 = 96.10%. The 63.84-percentage-point P10–P90 difference illustrates substantial cross-economy dispersion. The observed histogram and KDE provide the main descriptive evidence.

Distribution-fit diagnosis: Although a triangular model previously ranked well under AIC, the updated guarded Auto routine reports no acceptable fitted family for this sample; no selected parametric curve is presented. This does not invalidate the observed histogram, KDE or sample quantiles. A normal reference curve remains for comparison, not as an accepted model.

Results: Mobile subscriptions: Of the 172-entity cohort, 139 entries have nonmissing 2024 mobile-subscription intensity observations; 33 are missing (19.19% of the cohort). Observed mean and median were 124.98 and 121.23 subscriptions per 100 residents. The marked positive skewness (+4.85), high excess kurtosis (+37.20) and six IQR-flagged observations show strong upper-tail influence. The observed maximum was 574.15. Subscriptions above 100 are possible because these are connections rather than unique users.

Distribution-fit diagnosis: Student-t was the lowest-AICc eligible screened family (AICc ≈ 1394; BIC ≈ 1402; KS distance ≈ 0.0452; Cramér–von Mises statistic ≈ 0.0475). These are descriptive model-selection diagnostics, not calibrated goodness-of-fit p-values or proof of a true data-generating distribution. Student-t has unbounded support and assigns some probability to impossible negative subscription intensities; its curve is exploratory and not the substantive basis for country-level conclusions.

Interpretation: The two variables measure different telecommunications phenomena: Internet use describes individuals participating in online activity, while mobile-subscription intensity counts cellular connections relative to population. Their differing shapes, high mobile-tail values and unequal missingness reinforce why one indicator must not substitute for the other. These unweighted, country/territory-level distributions do not quantify the share of the world population connected, unique ownership or causal economic effects.

Verification and robustness note: The highest mobile intensity in the source worksheet was attributed to Fiji (574.15 in 2024); this and other extreme records are checked against the original agency series and indicator definitions. The source-sample identities and nonmissing counts were re-audited for unique ISO3–Year records.

10. Panel Econometric Models and Validation

Baseline pooled association: ln(GDPpc_it) = a + b1 Internet_it + b2 Mobile_it + e_it. Preferred two-way specification: ln(GDPpc_it) = a_i + t_t + b1 Internet_it + b2 Mobile_it + X_it gamma + e_it, with country and year effects. Additional models reverse the dependent variable (Internet adoption as outcome), and test lagged predictors to reduce simultaneity concerns; none alone identifies a causal effect. Controls X_it will be introduced only if reliable annual country-year data exist.

The new baseline uses the natural log of World Bank constant-price GDP per capita (Log_GDP_pc_real), with Internet-use share and cellular subscriptions per 100 people as predictors. Country and year effects are included in the preferred specification, and standard errors are clustered by country. These estimates capture associations within countries conditional on time effects, not causal effects or necessarily GDP growth rates.

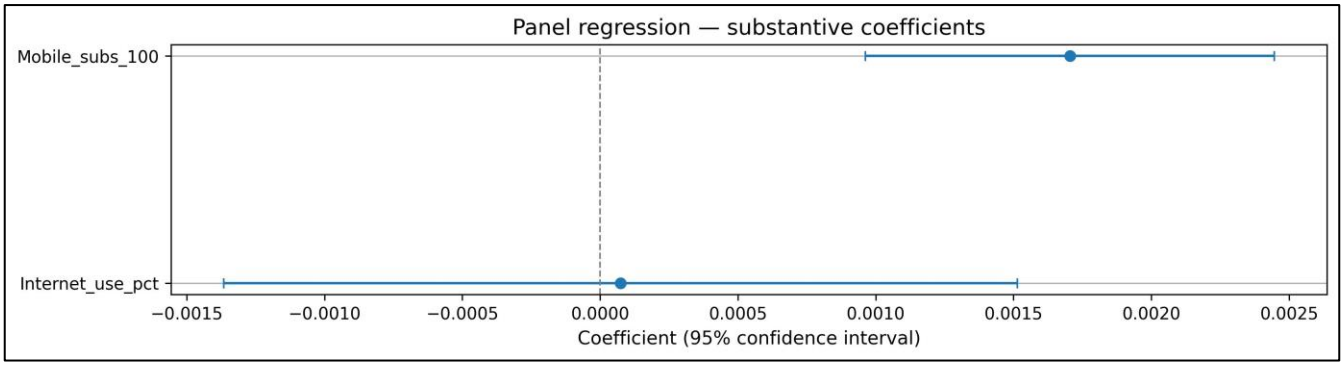


Figure 10-1. Global panel regression: two-way country/year fixed-effects estimates (95% confidence intervals).

Source: Brill-Viz Panel Econometrics; model-ready global telecom/WDI dataset, 4,622 complete country-year observations, 196 entities, 2000–2024. Y = log real GDP per capita; predictors = Internet use (%) and mobile subscriptions per 100; country-clustered standard errors.

Result and interpretation: The country-and-year fixed-effects coefficient for mobile subscriptions per 100 is +0.001705 (95% CI +0.000962 to +0.002447; p < 0.001). In the log-level outcome model this is about 0.17% greater real GDP per capita per additional subscription per 100 inhabitants, conditional on the model. Internet use is +0.000074 (95% CI −0.001366 to +0.001514; p = 0.920), offering no distinguishable association from zero under this specification. Overall $R^2 \approx 0.991$ includes fixed effects and must not be presented as the explanatory contribution of telecom indicators alone. Strong serial correlation in residuals motivates additional caution in inference.

Global Panel Regression Residual Diagnostics

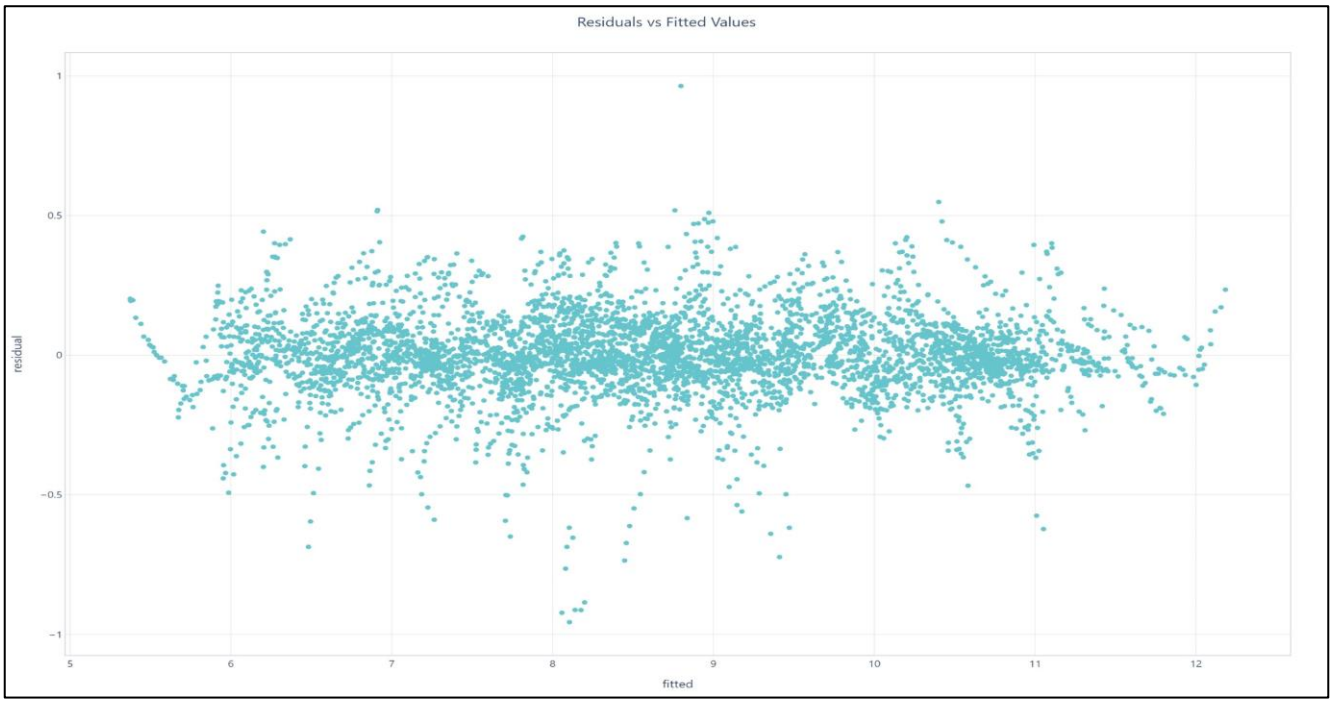


Figure 10-2. Residuals versus fitted log GDP per capita.

Residuals broadly concentrate near zero, but display clusters of uneven spread and pronounced outliers. Visual inspection alone cannot establish homoskedasticity or correct specification.

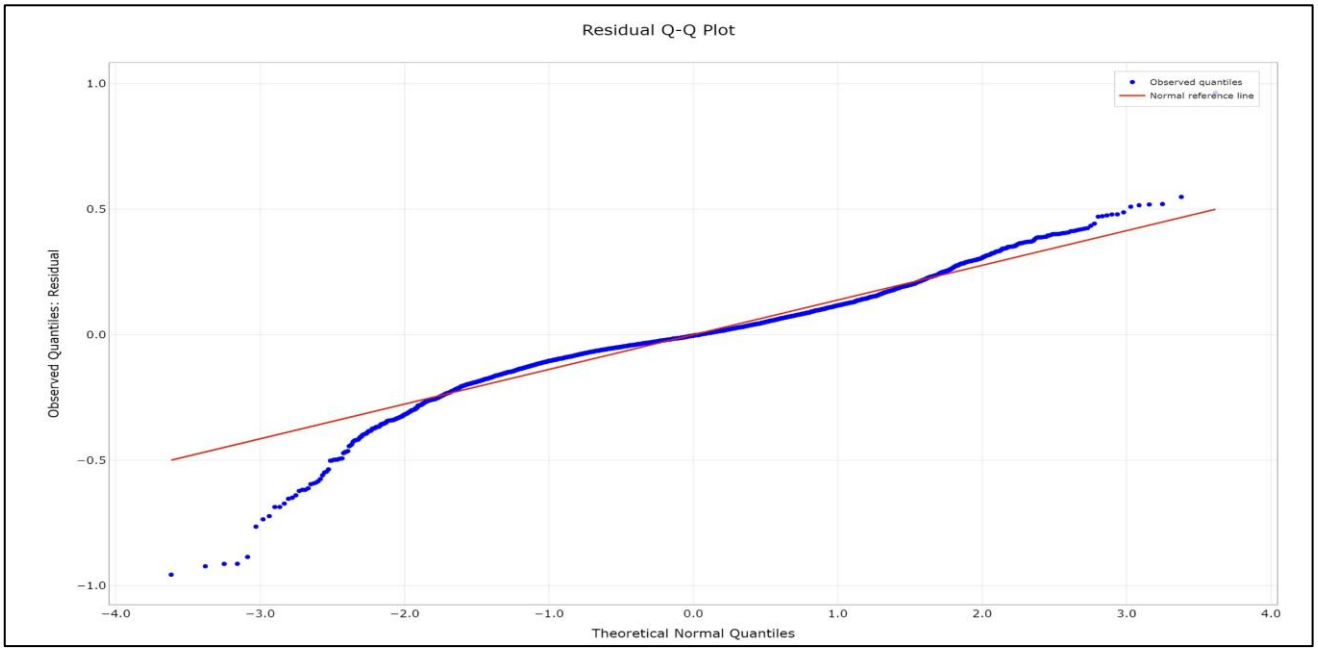


Figure 10-3. Normal Q–Q plot of panel regression residuals.

Marked departures in both tails, especially the negative tail, indicate heavier-than-normal residual tails. Normal residuals are not an absolute requirement for fixed-effects consistency.

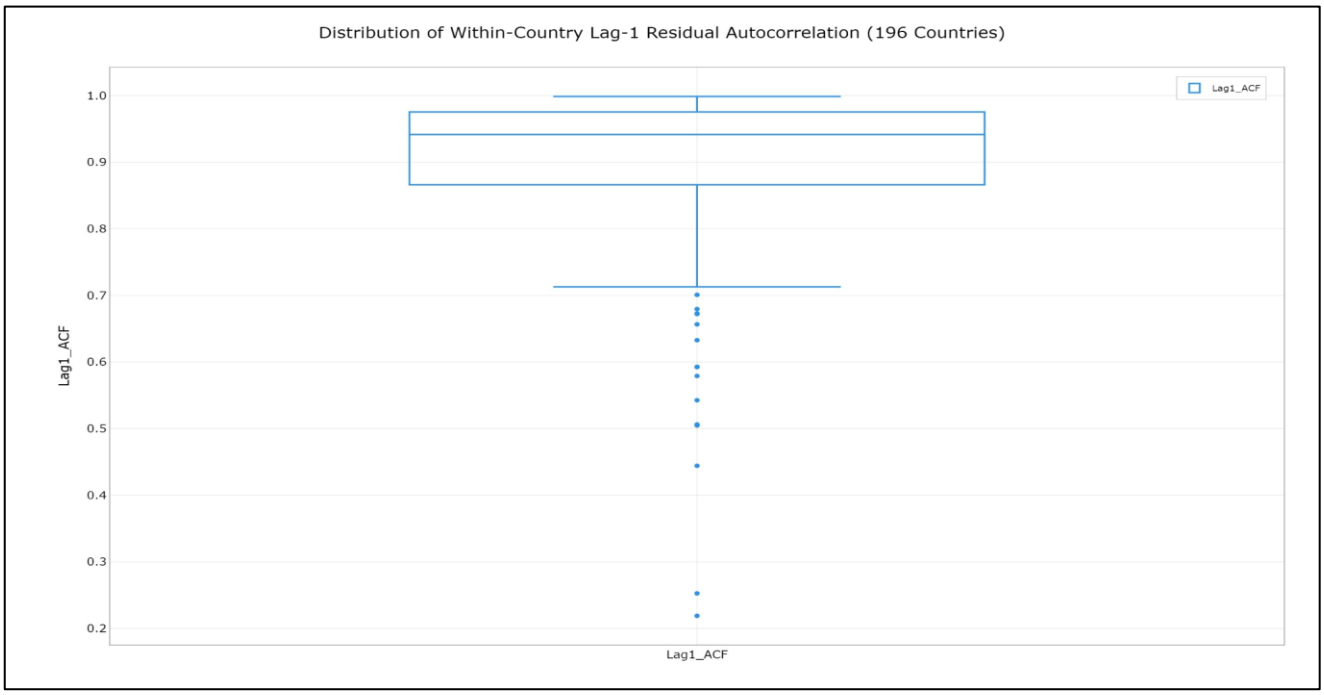


Figure 10-4. Distribution of within-country lag-1 residual autocorrelations across 196 countries.

Country-specific consecutive-year residual correlations are strongly positive (reported median approximately 0.942 from 4,378 within-country consecutive-year pairs). This is descriptive evidence of persistent country-level residuals, not a formal panel serial-correlation test.

Diagnostic synthesis: Figure 10-2 shows a generally zero-centered but heterogeneous cloud. Figure 10-3 identifies departures from a normal reference at the tails. Figure 10-4 shows marked serial persistence across countries. Taken together, these findings limit confident inference from a single static model. Country-clustered standard errors address arbitrary within-country correlation under suitable asymptotics, but complemented by specification checks for time-varying confounding, common shocks and dynamic adjustment.

Country Histories: Market Scale and Economic Context

The 13-country mobile-intensity and Internet-adoption histories are already presented in Chapter 3 and are not repeated here. The remaining four Figures 3-4, 3-5 and 11-5–11-8 panels provide distinct evidence on absolute mobile connections, nominal GDP per capita, total nominal GDP and population. These measures have different units and are interpreted separately. Comparable sources, country coverage and year gaps must be preserved.

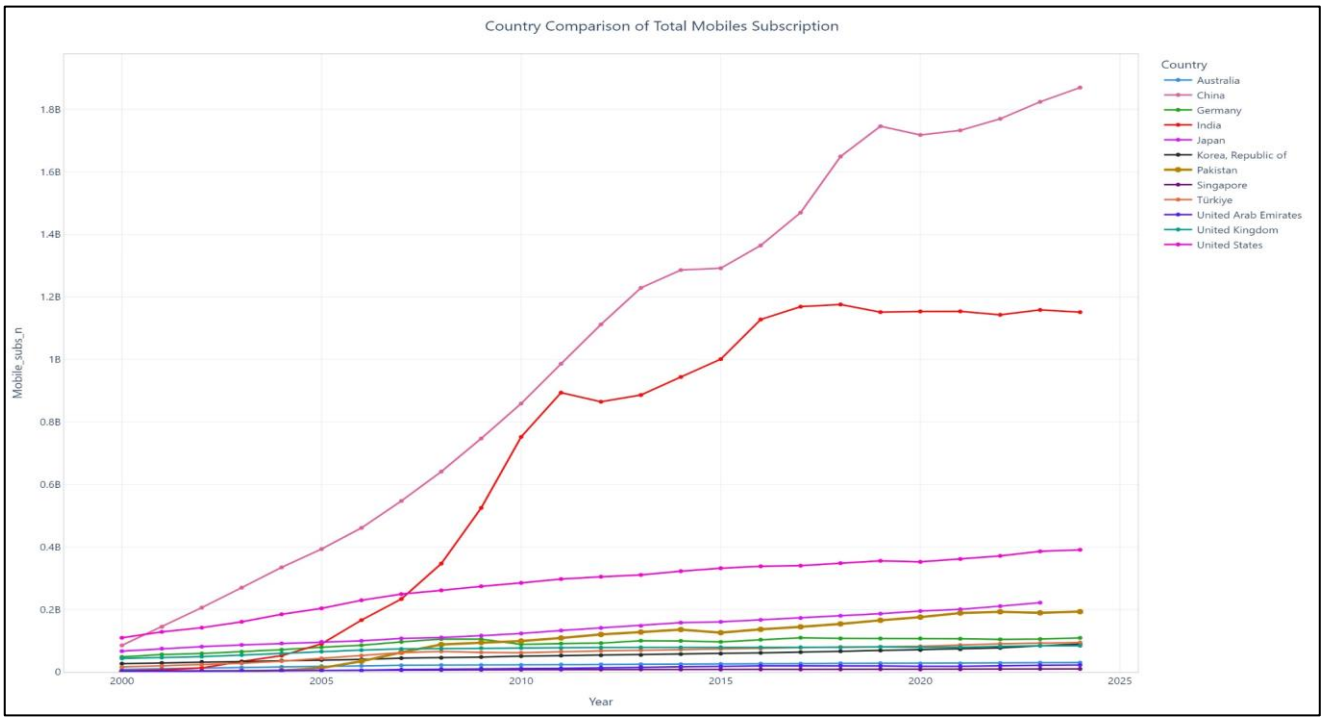


Figure 10-5: Total mobile-cellular subscriptions: selected-country market volumes, 2000–2024

Interpretation: Figure 10-5. China and India dominate absolute mobile subscription volumes among the selected countries, largely reflecting their much larger population bases. Comparing Figure 10-5 with Figure 3-4 shows why absolute market size must be distinguished from per-capita connection intensity. The figures do not directly estimate mobile-device shipments, operator turnover or the number of people without service.

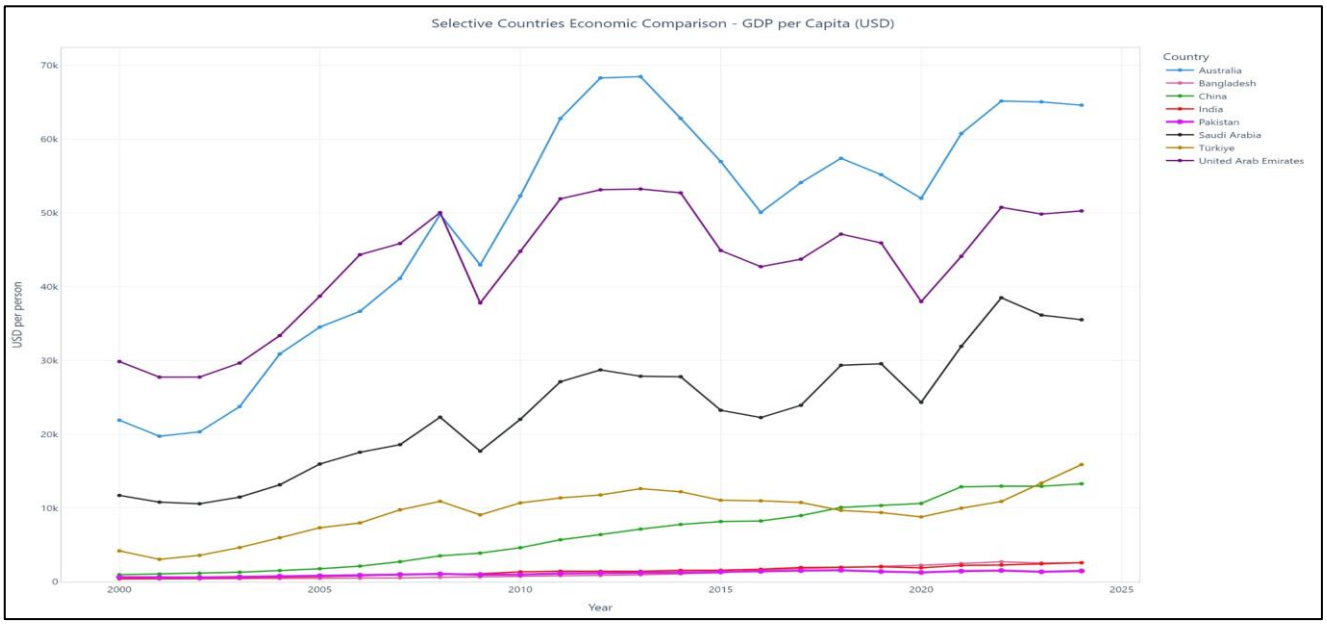


Figure 10-6: GDP per capita (current US$): selected-country economic trajectories, 2000–2024

Source/basis: Brill-Viz country/entity trends using annual GDP per capita in current US dollars for eight selected economies (Australia, Bangladesh, China, India, Pakistan, Saudi Arabia, Türkiye and the United Arab Emirates). Values

are nominal current-US$ series rather than inflation-adjusted constant-price income. Cross-country levels therefore reflect both real income differences and price/exchange-rate effects.

Interpretation: Figure 10-6. Australia and the United Arab Emirates remain the highest-income economies in this comparator set, with Saudi Arabia also well above the South Asian economies. China and Türkiye show substantial medium-term gains, while Bangladesh, India and Pakistan remain at much lower nominal income-per-person levels. These descriptive patterns help contextualize connectivity differences, but they do not by themselves establish that higher GDP per capita causes stronger telecommunications adoption.

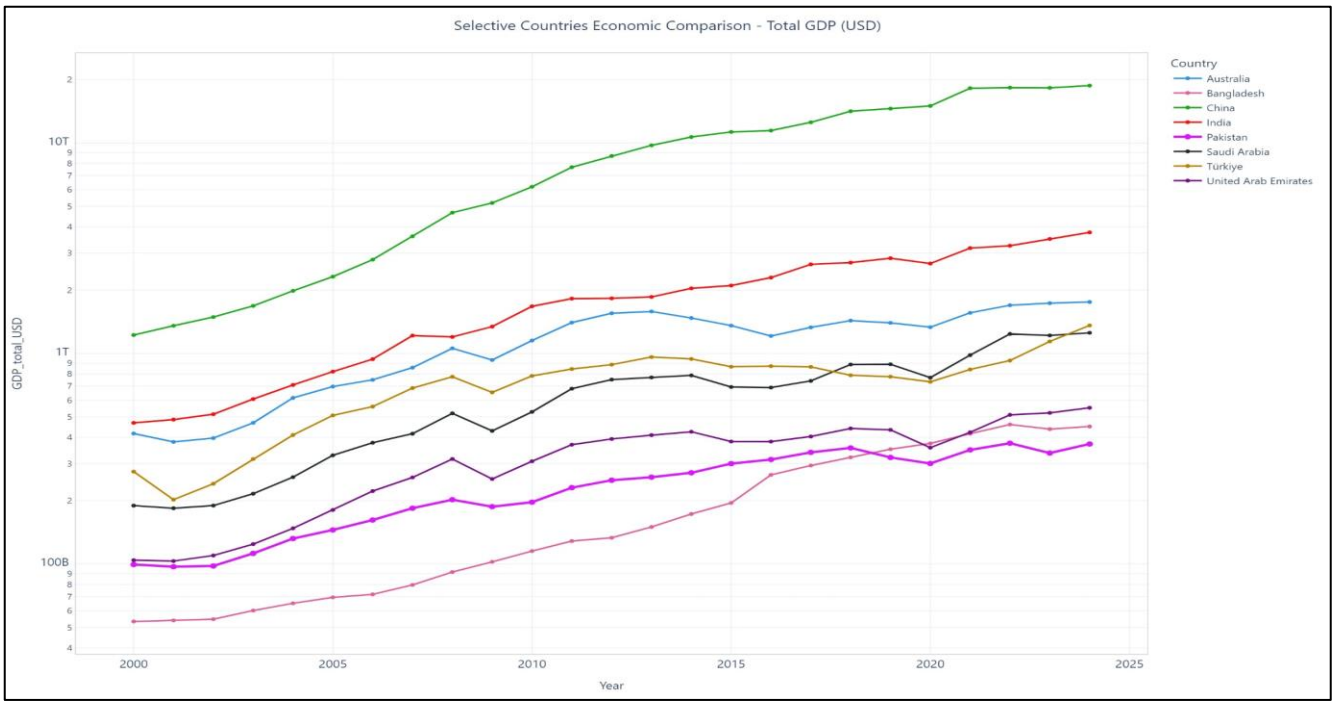


Figure 10-7: Total GDP (current US$): selected-country market-scale trajectories, 2000–2024

Source/basis: Brill-Viz annual total GDP in current US dollars for the eight economies displayed in Figure 10-7. This figure-specific eight-country subset is distinct from the 13-country core benchmark (Section 1.2), and is not a replacement country-selection rule.

The chart uses a logarithmic Y-axis to allow countries with very different economic scale to be displayed together. Because the values are in current US dollars, long-run movements can reflect inflation, exchange-rate shifts and structural economic growth simultaneously.

Interpretation: Figure 10-7. China and India dominate absolute economic scale, while Australia, Saudi Arabia and Türkiye form a middle tier and Pakistan, Bangladesh and the United Arab Emirates occupy lower total-GDP positions within this specific set. The log scaling is analytically appropriate because it preserves the visibility of smaller economies while retaining the very large gap between China and the rest. Total GDP is useful for market-size context, but it is interpreted jointly with population and per-capita income rather than in isolation.

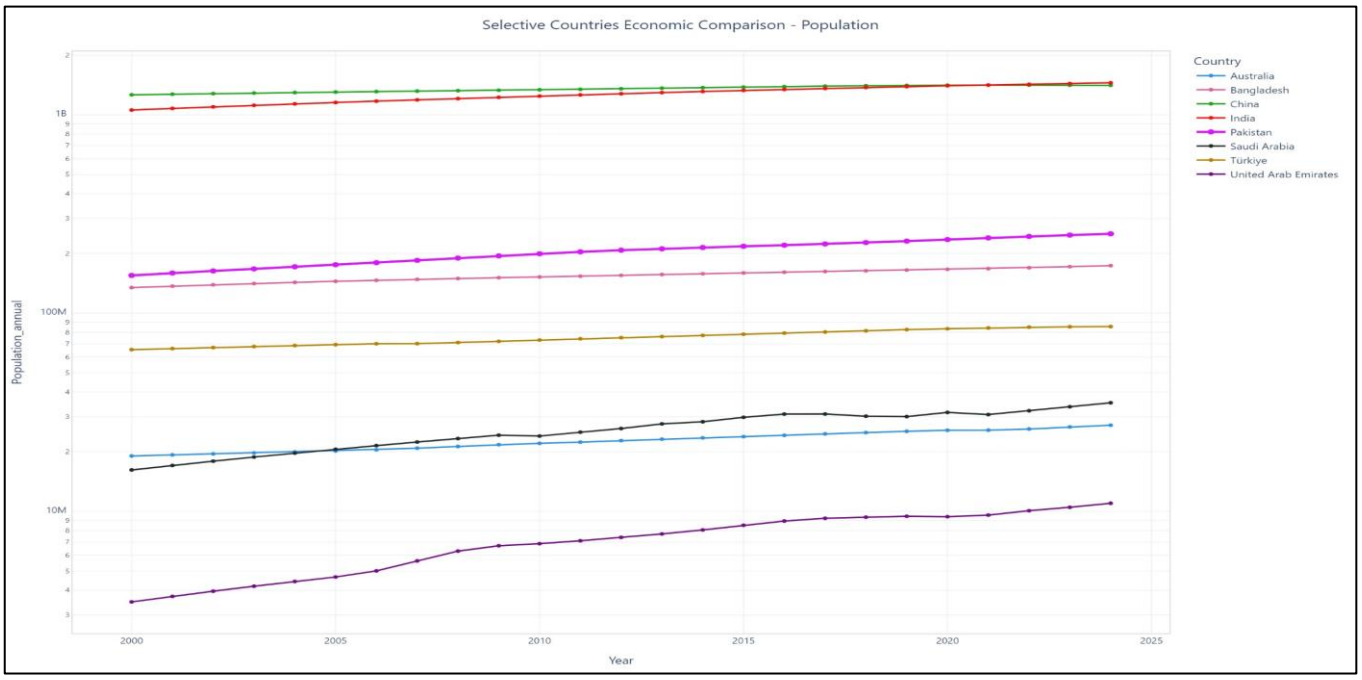


Figure 10-8: Population: selected-country demographic trajectories, 2000–2024

The chart is displayed on a logarithmic Y-axis because country populations span several orders of magnitude, from the United Arab Emirates to China and India. Population is included to separate demographic scale from telecommunications intensity and income effects.

Interpretation-Figure 10-8: China and India account for by far the largest population bases, followed by Pakistan and Bangladesh, while Australia, Saudi Arabia and especially the United Arab Emirates remain much smaller in demographic scale. This figure explains why absolute mobile-subscription totals can be very large even when per-capita connection rates are lower than those in smaller high-income markets. Population scale is therefore essential for interpreting Figures 3-4–Figure 10-7 coherently.

Figures 3-4, 3-5 and 11-5–11-8 synthesis and analytical boundary: The historical subscription-intensity and Internet-adoption trajectories are presented in Figures 3-4 and 3-5, respectively. Figures 10-5–11-8 add the complementary dimensions of absolute connection volumes, GDP per capita, total GDP and population. These are descriptive histories, not causal estimates, and their differing measures must remain clearly labeled.

Fixed-Effects Specification Comparisons

Robustness scope: Three supplied specification plots are retained: M1 country-only fixed effects, M2 country-and-year fixed effects, and M3 two-way effects with inflation and gross-capital-formation controls. The M3 coefficients below are described visually because a matching M3 result table was not supplied. M4 lagged predictors and M5 sensitivity restrictions are deferred, not silently treated as completed.

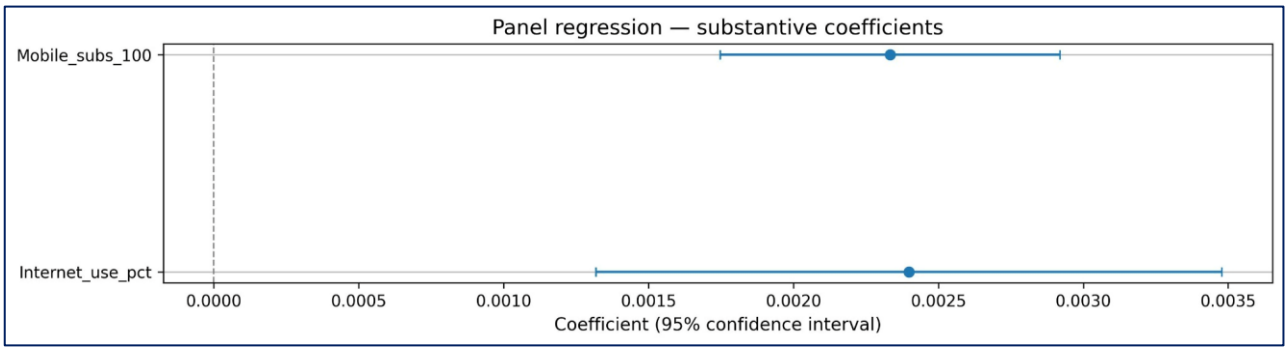


Figure 10-9 (M1). Country-only fixed effects: telecom coefficients with 95% CIs.

From supplied Excel estimates: Internet use +0.002398 (95% CI +0.001318 to +0.003479; p < 0.001); mobile subscriptions +0.002334 (95% CI +0.001747 to +0.002920; p < 0.001). Both intervals are positive without year effects.

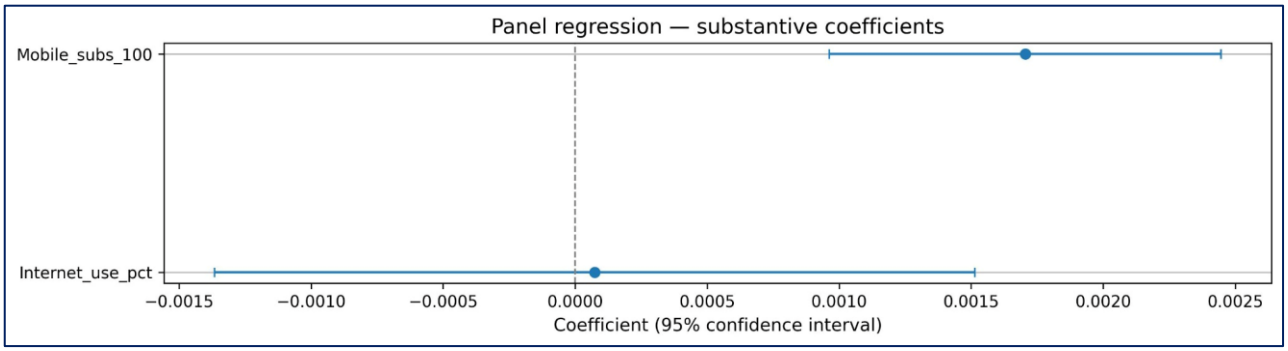


Figure 10-10 (M2). Country-and-year fixed effects: telecom coefficients with 95% CIs.

From supplied Excel estimates: Internet use +0.000074 (95% CI −0.001366 to +0.001514; p = 0.920); mobile subscriptions +0.001705 (95% CI +0.000962 to +0.002447; p < 0.001). Internet association is sensitive to year controls.

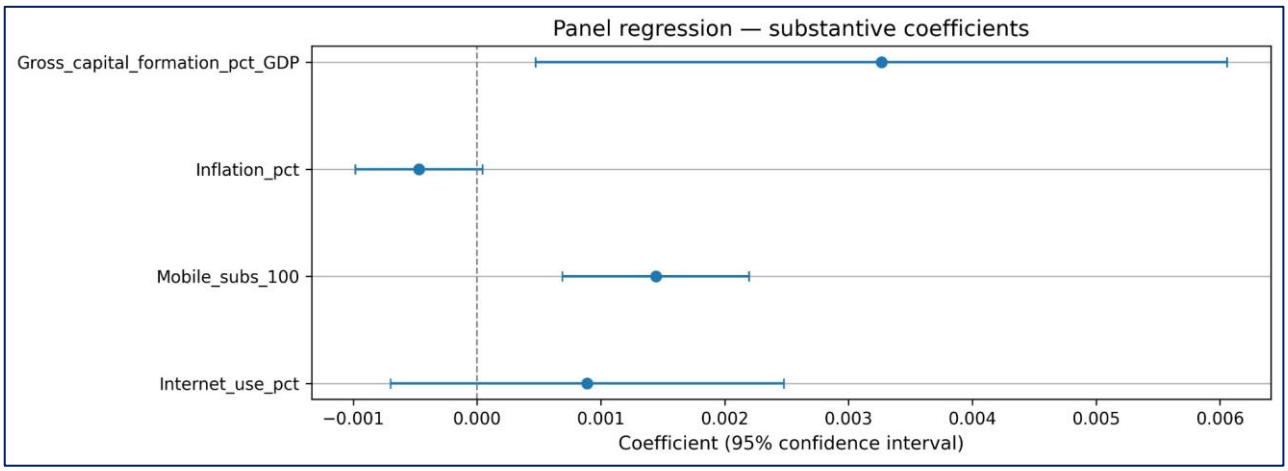


Figure 10-11 (M3). Two-way fixed effects with inflation and investment controls.

Visual evidence only: mobile subscriptions and gross capital formation have positive 95% confidence intervals, while Internet use and inflation intervals cross zero. Exact coefficient values, sample size and matched-sample controls require the exported M3 Excel result before definitive quantitative comparison.

Comparative finding: The Internet-use association loses conventional statistical significance when common year effects are controlled (M1 versus M2), indicating important time-related confounding or shared trends. The mobile-

subscription association remains positive across the plotted models; its magnitude and interpretation was checked on identical samples, particularly because M3 adds controls with missing records. Figures 10-9–11-11 represents preliminary specification sensitivity, not a comprehensive causal robustness exercise. The deferred lagged-predictor M4 can be investigated in a later revision.

10.1 Digital Connectivity and Economic Development: Evidence, Growth Dynamics and Structural Differences

Purpose and evidence boundary: The international economic comparisons in Chapters 5 and 6 and Figure 13-1 describe relationships between observed connectivity and GDP per capita. Chapter 10 discusses pooled and country/year fixed-effects estimates with log real GDP per capita as the dependent variable (4,622 complete country-year observations; 196 economies; 2000–2024). These analyses address economic levels and conditional within-country associations, not the annual growth rate of GDP, causal economic returns or operator profitability.

Internet participation and GDP per capita: The selected-country scatter illustrates income/adoption contrasts, while the preferred two-way fixed-effects specification reports an Internet-use coefficient of +0.000074 (95% CI −0.001366 to +0.001514; p = 0.920). This estimate is not distinguishable from zero in that specification. The country-only model gives a different result, emphasizing sensitivity to common time trends; it does not imply that Internet access has no productive or social value.

Mobile subscriptions and GDP per capita: The corresponding two-way fixed-effects coefficient is +0.001705 (95% CI +0.000962 to +0.002447; p < 0.001), a positive conditional association with log real GDP per capita in the reported model. Multiple SIM connections and differences in service utilization mean that subscription intensity is not equivalent to unique users or productive digital activity. Residual persistence, unmeasured time-varying influences and possible reverse causality restrict causal interpretation.

Growth-on-growth relationships - analytical gaps rather than findings:. This study has not estimated (a) annual change in Internet-use percentage points versus annual real GDP-per-capita growth, or (b) annual change in mobile subscriptions per 100 inhabitants versus annual real GDP-per-capita growth. A subsequent analysis should define changes and growth rates separately; align country-year observations and revisions; examine one- and multi-year lags; include country/year effects and relevant controls; test sensitivity to nonlinear saturation, missingness, outliers and serial dependence; and avoid interpreting short-run covariation as causality. Annual GDP growth and real GDP-per-capita growth are distinct outcomes and must not be silently interchanged.

Regional and income-group heterogeneity: The 13-country sample is a purposive comparison across South Asian, Gulf/near-regional, major-market and high-income contexts, not a population-weighted regional analysis. The global PCA/clustering and convergence exercises identify heterogeneous digital-development profiles, but they are not formal estimates of separate telecom–income relationships for World Bank regions or income groups. Such tests would require consistently dated region/income classifications, sufficient within-group observations, and explicit interaction or subgroup models.

Country-level exceptions and implications: Pakistan and Bangladesh demonstrate that higher mobile-subscription intensity need not coincide with higher Internet participation. China, Gulf comparators and high-income benchmarks provide additional descriptive contrasts, not verified causal exceptions. A systematic exception analysis should diagnose unusually large prediction residuals and divergences between adoption, connection intensity and income; check definitional or reporting anomalies; and evaluate affordability, coverage, devices, usage quality, institutions and sector structure before assigning a mechanism. The strategic conclusion remains to investigate productive and affordable digital use rather than equate additional connections with GDP gains or market size.

Part V: Digital Convergence, Prediction and Decision Intelligence

11. Digital Divide, Convergence and Country Typologies

The global telecom panel supports a broader descriptive study of the digital divide than the earlier limited economic pilot. Convergence is assessed on consistent country sets, not changing reported populations. Sigma convergence examines dispersion of Internet-use rates; beta convergence investigates whether lower-initial-adoption countries subsequently recorded faster adoption, conditional on measurement and saturation effects.

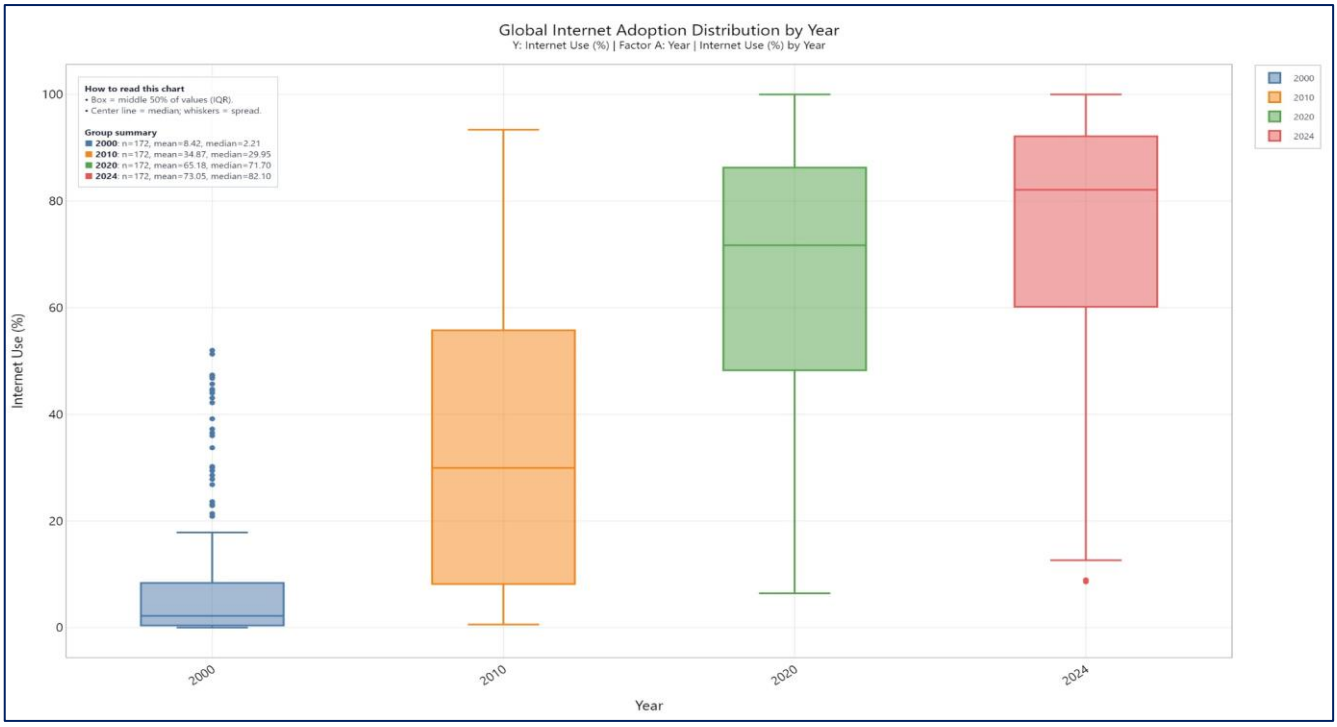


Figure 11-1. Distribution of national Internet use, 2000, 2010, 2020 and 2024 (172 consistent country observations per year).

Interpretation: Median Internet use increased from 2.21% in 2000 to 29.95% in 2010, 71.70% in 2020 and 82.10% in 2024. The 2024 distribution is concentrated at higher values but retains a substantial lower-adoption tail. The same 172-country cohort is used at all four benchmarks. A common cohort removes one source of composition bias, but does not establish causal convergence.

Brill-Viz workflow: Grouped Stats histograms, violin/box comparisons

Input variables / transformations: Internet users %, selected years 2000, 2010, 2020, latest sufficiently observed

Reporting: Identical 172-country sample across 2000/2010/2020/2024; values are percent of population.

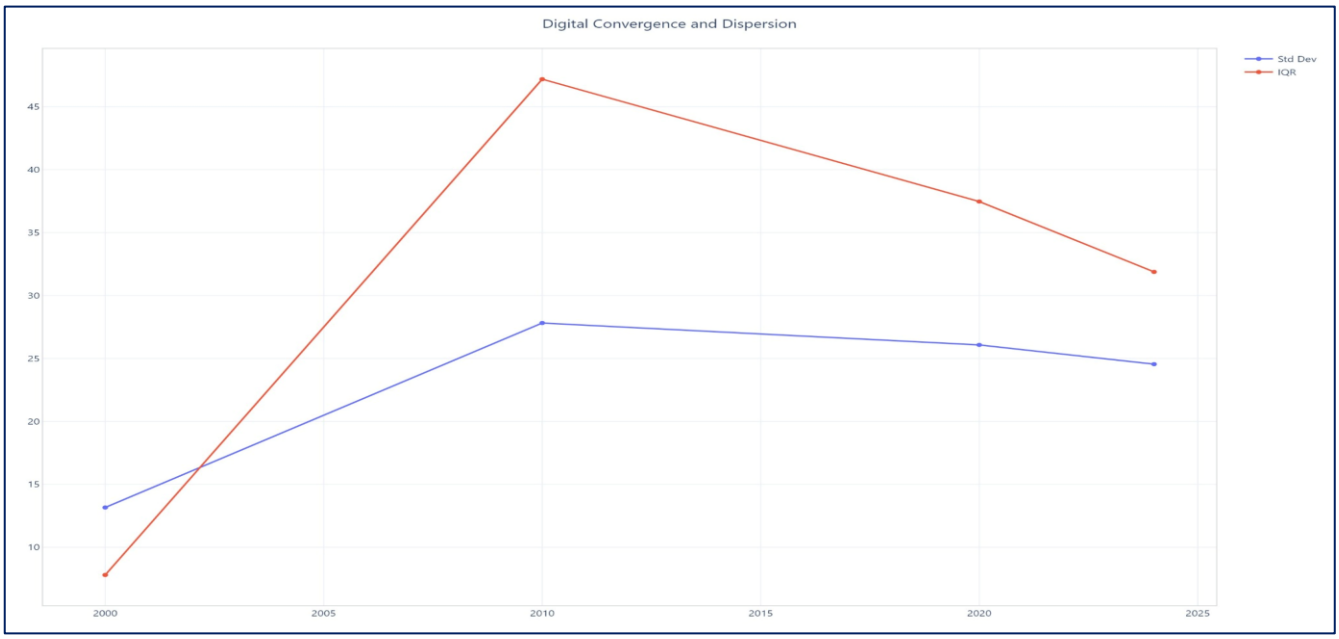


Figure 11-2. Cross-country dispersion in Internet use: standard deviation and interquartile range, 172-country cohort.

Observed descriptive statistics (percentage points): 2000 SD 13.16 / IQR 7.80; 2010 SD 27.82 / IQR 47.19; 2020 SD 26.08 / IQR 37.47; 2024 SD 24.55 / IQR 31.88. Dispersion first widened and subsequently moderated, while remaining above the 2000 SD. An IQR decline from the 2010 peak is consistent with partial compression of the middle 50% of the country distribution, not complete global convergence. The 0–100% upper bound may mechanically reduce dispersion as adoption becomes widespread.

Data / basis: Global telecom panel; defined common-sample country group

Brill-Viz workflow: Grouped Stats / Research lines with uncertainty

Input variables / transformations: Year; SD or IQR of Internet-use shares; country count

Reporting: Same 172-country cohort; cross-sectional SD and IQR expressed in percentage points. Interpret bounded-rate saturation separately from socioeconomic convergence.

Principal Component Analysis of Digital Development

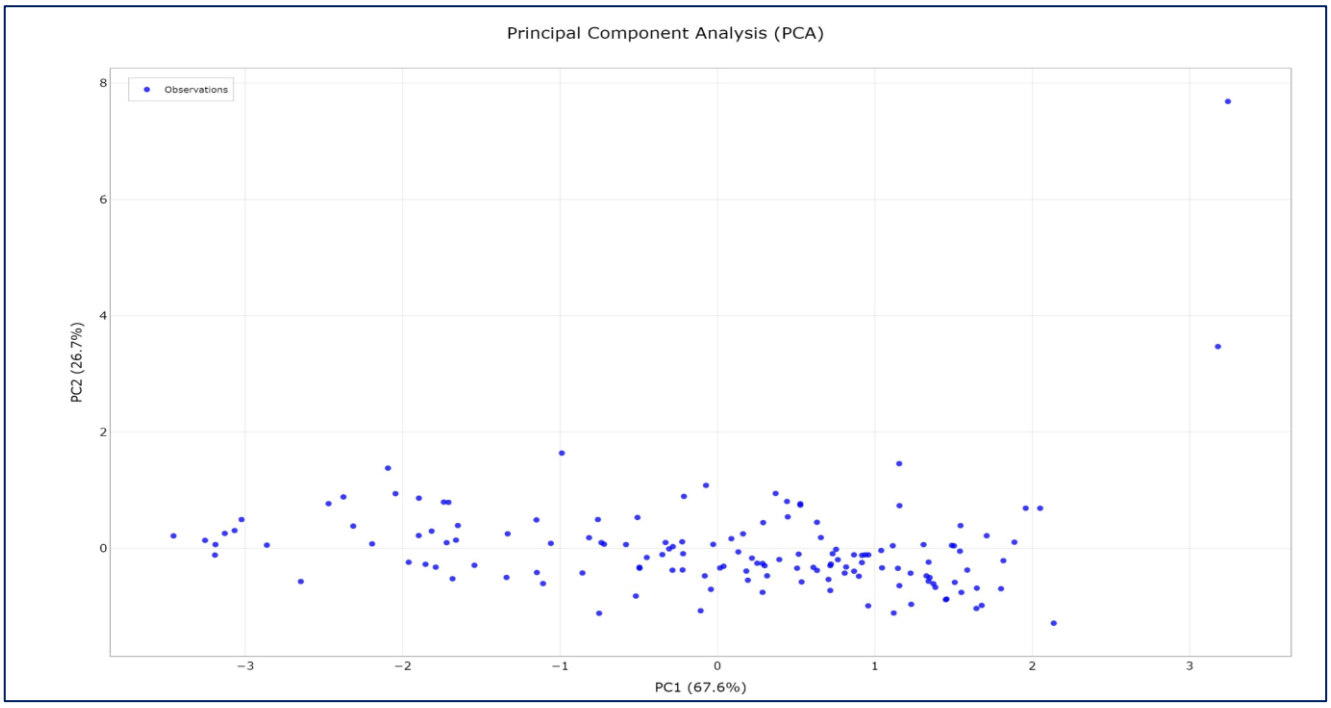


Figure 11-3. Three-indicator PCA scores, 2024 global cross-section.

PC1 67.6%; PC2 26.7% (94.3% cumulative). Z-score scaling; variables: Internet use, mobile subscriptions per 100, log real GDP per capita. Country labels and exact complete-case N require confirmation from output tables.

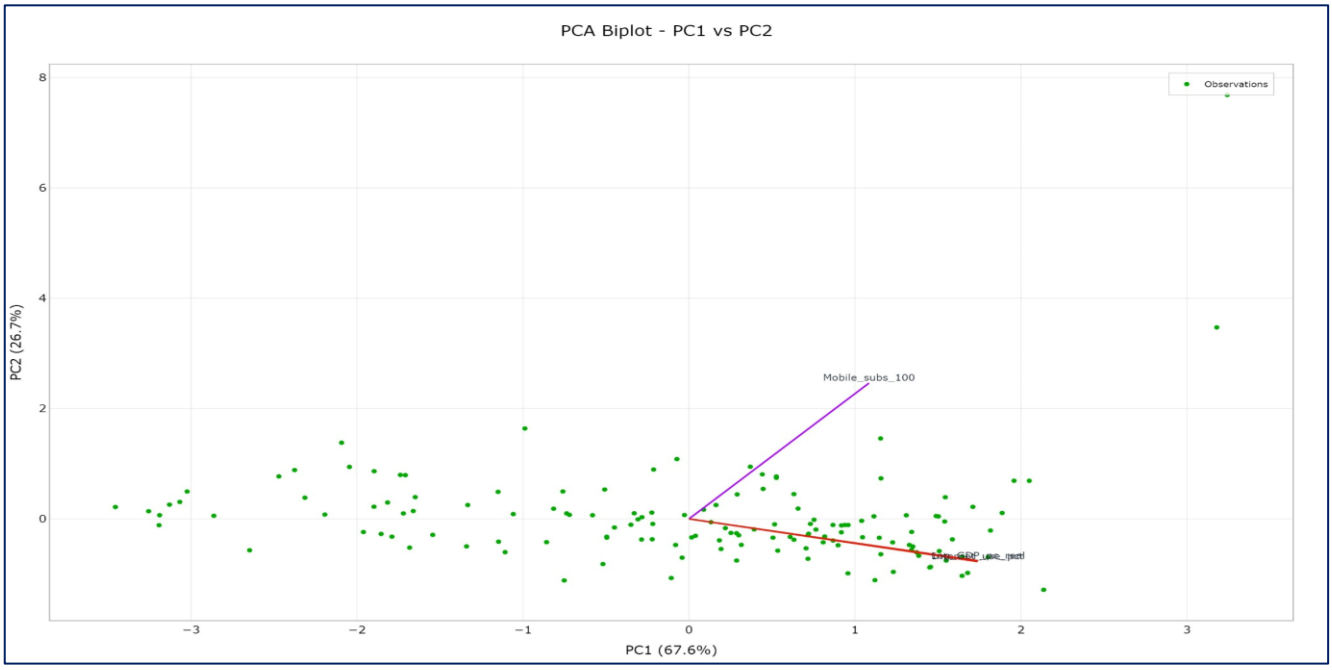


Figure 11-4. PCA biplot: digital adoption, subscription intensity and real GDP per capita.

Loading directions describe variable contributions to the principal components; loading labels for Internet use and GDP per capita overlap in the current rendering. Association in PCA space does not establish causal effects.

Methodological note: PCA was rerun on the 2024 cross-section using the selected features Internet_use_pct, Mobile_subs_100 and Log_GDP_pc_real with Z-score standardization. The updated scores show PC1 = 67.6% and PC2 = 26.7%, together 94.3% of the three-variable variance. The biplot now shows the three intended loadings rather than 10 automatic numeric fields. This is an exploratory cross-sectional description, not a causal or validated country-ranking model. The two loading labels near the positive PC1 direction overlap slightly and would benefit from a final aesthetic adjustment.

Data / basis: 2024 cross-section; 3 selected national indicators, complete-case country observations (number and ISO3 coverage to be confirmed from export).

Brill-Viz workflow: Smart Stats → Charts → PCA / PCA Biplot; Choose PCA / KMeans inputs → select three metrics → Scaling: Z-score.

Input variables: Internet_use_pct, Mobile_subs_100, Log_GDP_pc_real. Retain ISO3 as a country identifier, not a numeric PCA feature.

Reporting requirement: Interpret loadings; report scaling, explained variance and missing-data policy.

Country Digital-Development Clusters

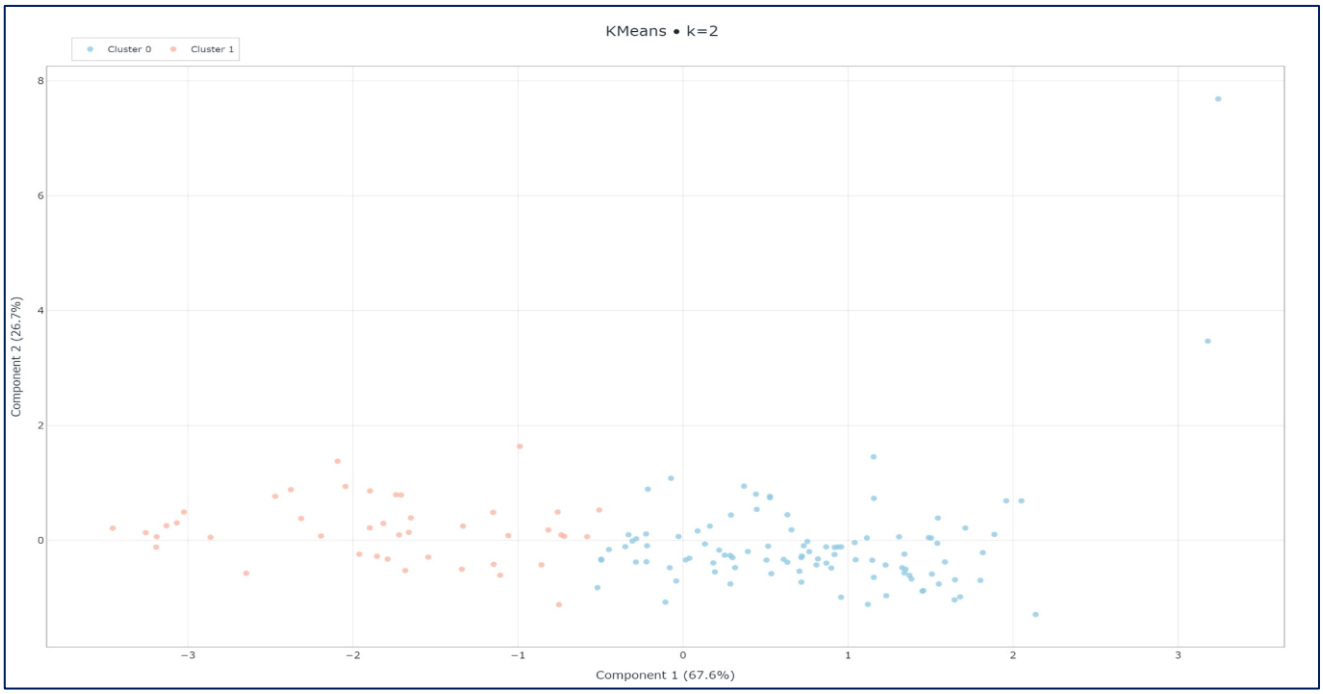


Figure 11-5. Three-indicator KMeans clustering, k=2.

Same 2024 standardized features as Figures 11-3 and 12-4. Broad split along PC1; cluster names are arbitrary and do not rank countries.

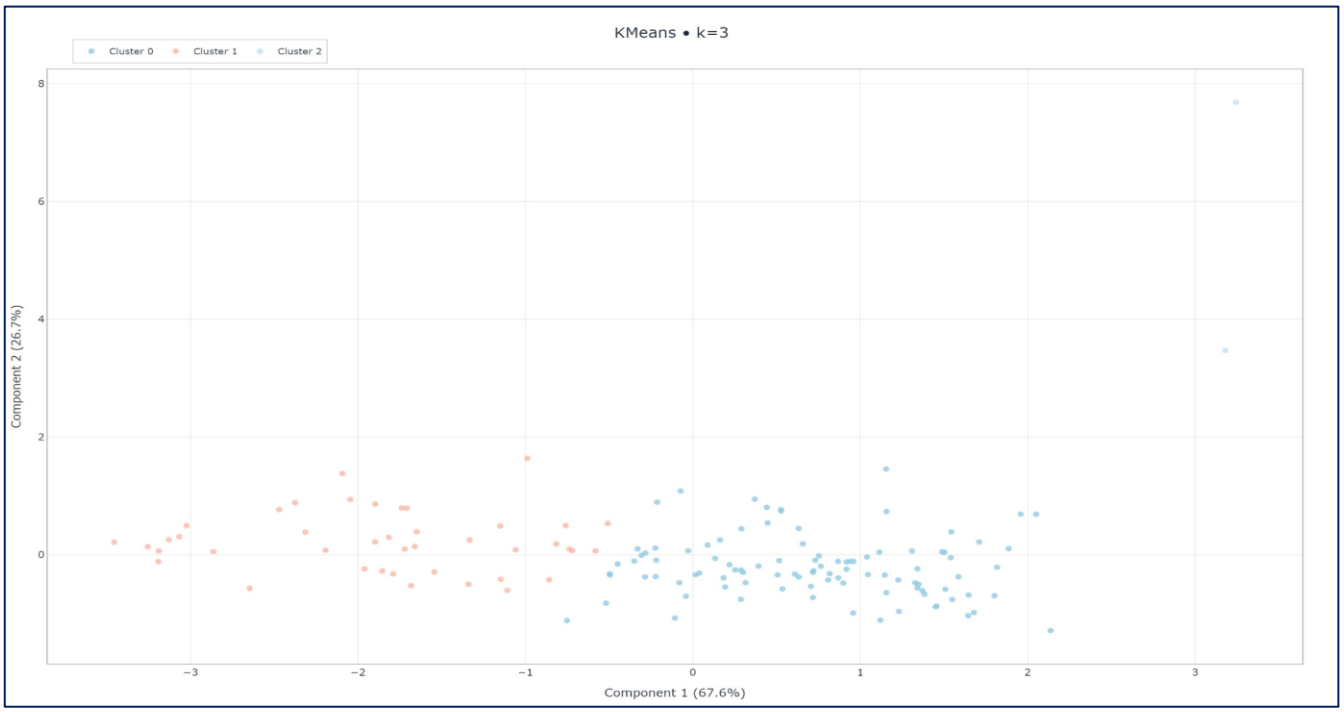


Figure 11-6. Three-indicator KMeans clustering, k=3.

A small high-PC2 group emerges; check counts, country identities, stability and influence of extreme observations.

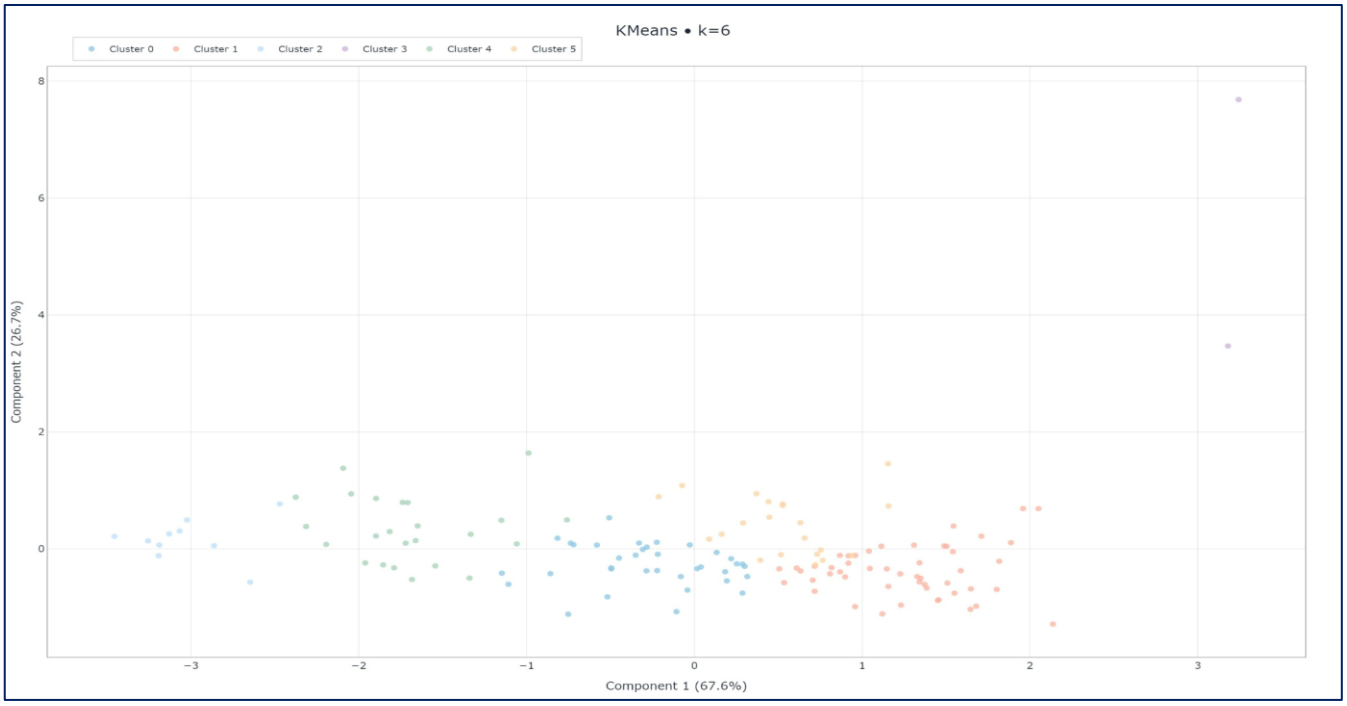


Figure 11-7. Three-indicator KMeans clustering, k=6.

A six-cluster partition produces a two-observation cluster (N=143) and comparatively weak mean silhouette (~0.33). Retain as exploratory sensitivity only, not a preferred solution.

Methodological note: KMeans uses three standardized 2024 variables (Internet_use_pct, Mobile_subs_100, Log_GDP_pc_real). Projection explains PC1 67.6% and PC2 26.7% of feature variance for each k. The six additional

figures (Figures 11-8–12-13) make cluster sizes, silhouette, inertia and random-initialization stability visible. This strengthens methodological transparency but does not establish any one k as universally optimal.

Data / basis: Same filtered 2024 complete-case country sample and three-variable scaled feature matrix as Figures 11-3 and 12-4.

Brill-Viz workflow: Smart Stats → Charts → KMeans; Choose PCA/KMeans inputs; Z-score; run k=2, 3 and 6 on unchanged observations.

Input variables / transformations: Z-scored Internet_use_pct, Mobile_subs_100, Log_GDP_pc_real; Country/ISO3 only as label.

Validation update: N=143 in all displayed k=2, k=3 and k=6 validation size plots. Silhouette and initialization-based ARI are now available, but country identities, centroid profiles in original units, and outlier/subsample stability require verification before substantive cluster labels.

Cluster-Number Validation and Stability

These plots use the fixed, complete-case, 2024 telecom/economic feature sample (N=143) and three Z-score-scaled indicators. Values are read from supplied Brill-Viz screenshots and are rounded; original exported tables are retained for exact reproducibility. Figures 11-1 and 11-2 use a different 172-country cohort.

Validation summary: mean silhouette peaks at k=3 (~0.515), followed by k=2 (~0.490); it drops to ~0.413 for k=4 and ~0.33 at k=6. Initialization-based mean adjusted Rand index (ARI) is highest around k=4 (~0.97), not at k=3 (~0.74). Inertia decreases monotonically with k, as expected, so its decline alone does not select k. These criteria trade off cluster compactness, separability, balanced coverage and reproducibility.

Table 11-1. Cluster-size and diagnostic summary from supplied charts (approximate values).

k	Cluster sizes (N=143)	Mean silhouette (approx.)	Mean ARI (approx.)	Interpretation
2	100 / 43	0.49	0.86	Parsimonious; unequal but usable groups
3	99 / 42 / 2	0.515	0.74	Best silhouette; tiny outlier group
6	50 / 36 / 24 / 21 / 10 / 2	0.33	0.56	Overfragmented; tiny group

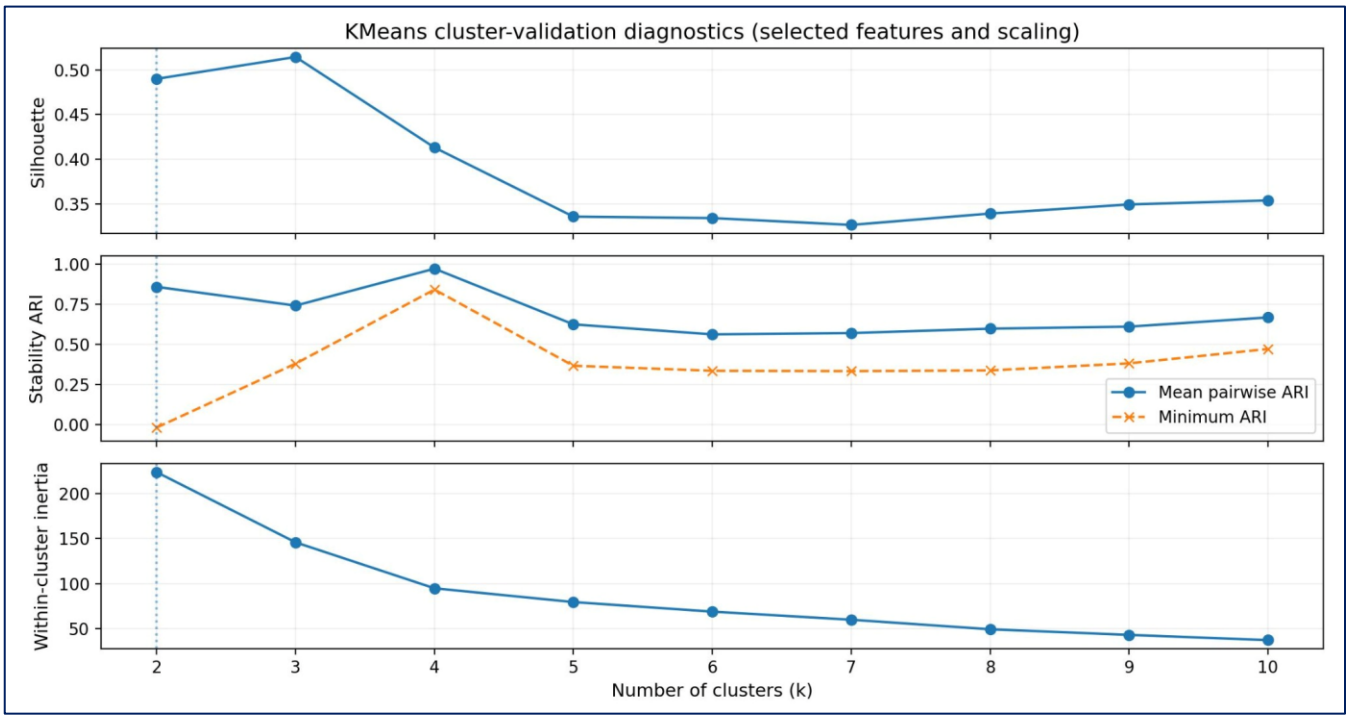


Figure 11-8. Cluster sizes at k=2 (validation sample, N=143).

Two groups contain 100 and 43 countries/observations, respectively; cluster labels are arbitrary.

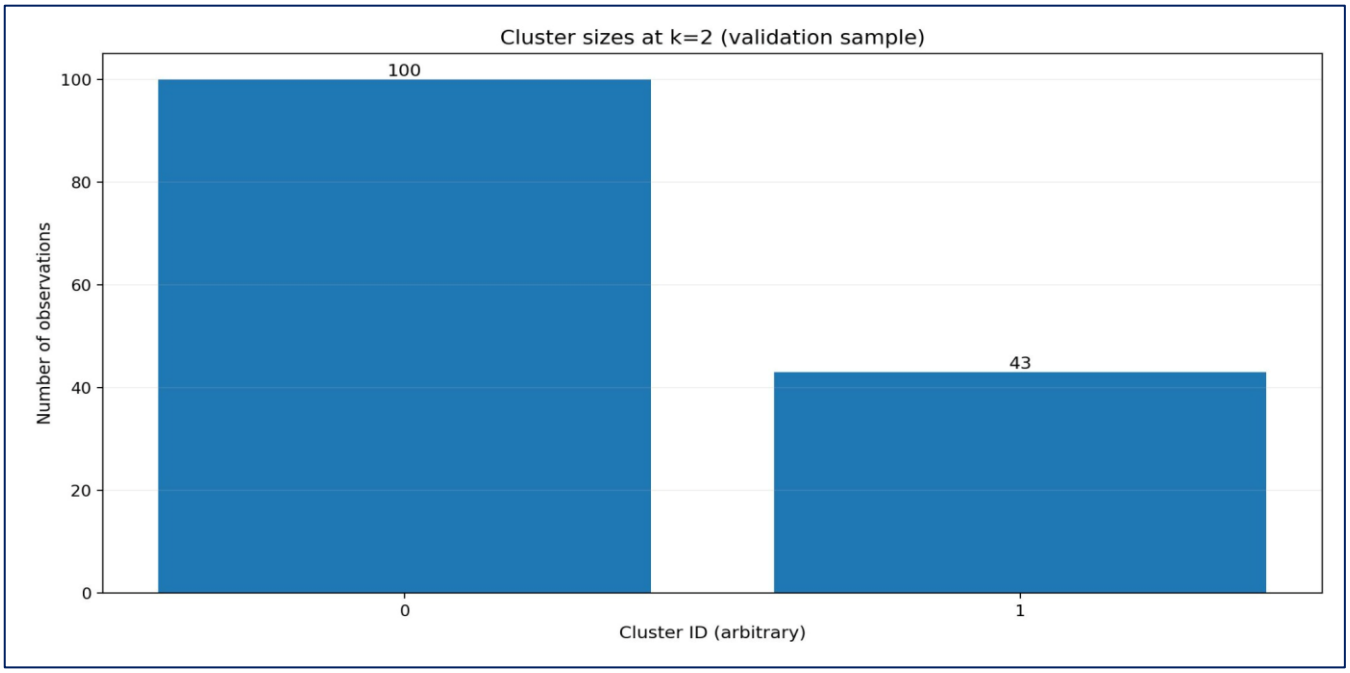


Figure 11-9. Silhouette, initialization stability and inertia across k=2–10 (k=2 highlighted).

k=2 has a near-leading silhouette (~0.49) and relatively high mean initialization ARI (~0.86); caution: the minimum ARI displayed is near zero, indicating at least one unstable pair of solutions.

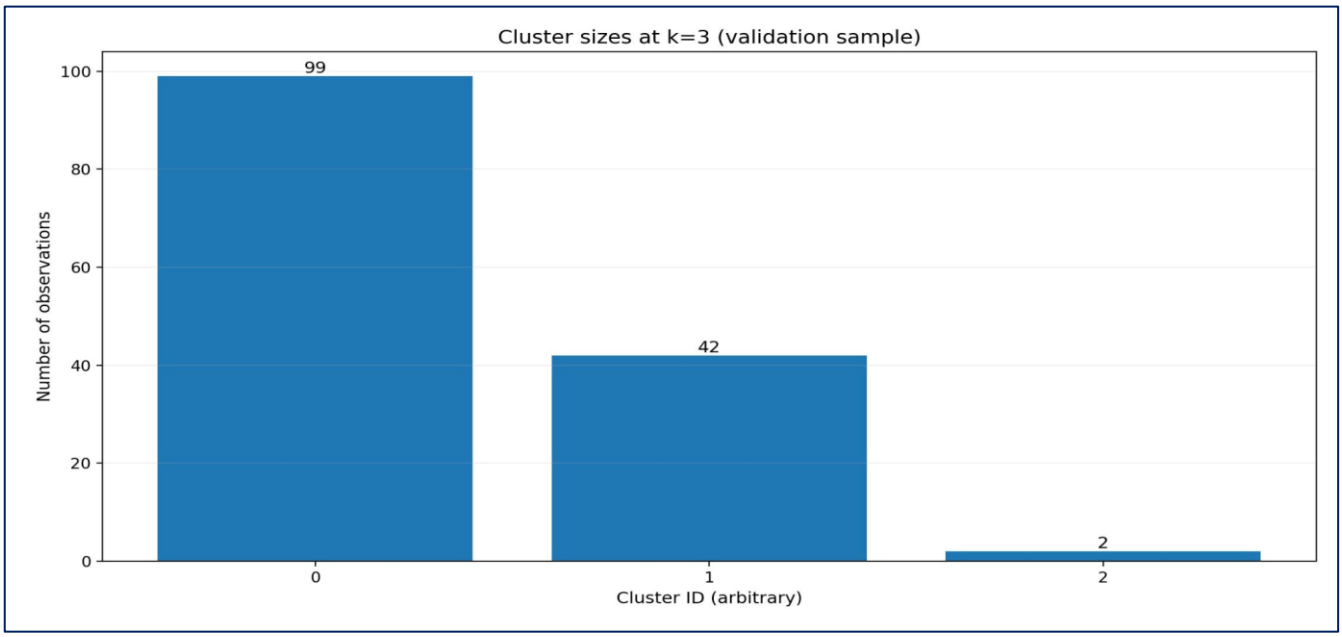


Figure 11-10. Cluster sizes at k=3 (validation sample, N=143).

Group sizes are 99, 42 and 2. The two-observation group should be identified and examined as a possible outlier cluster before substantive interpretation.

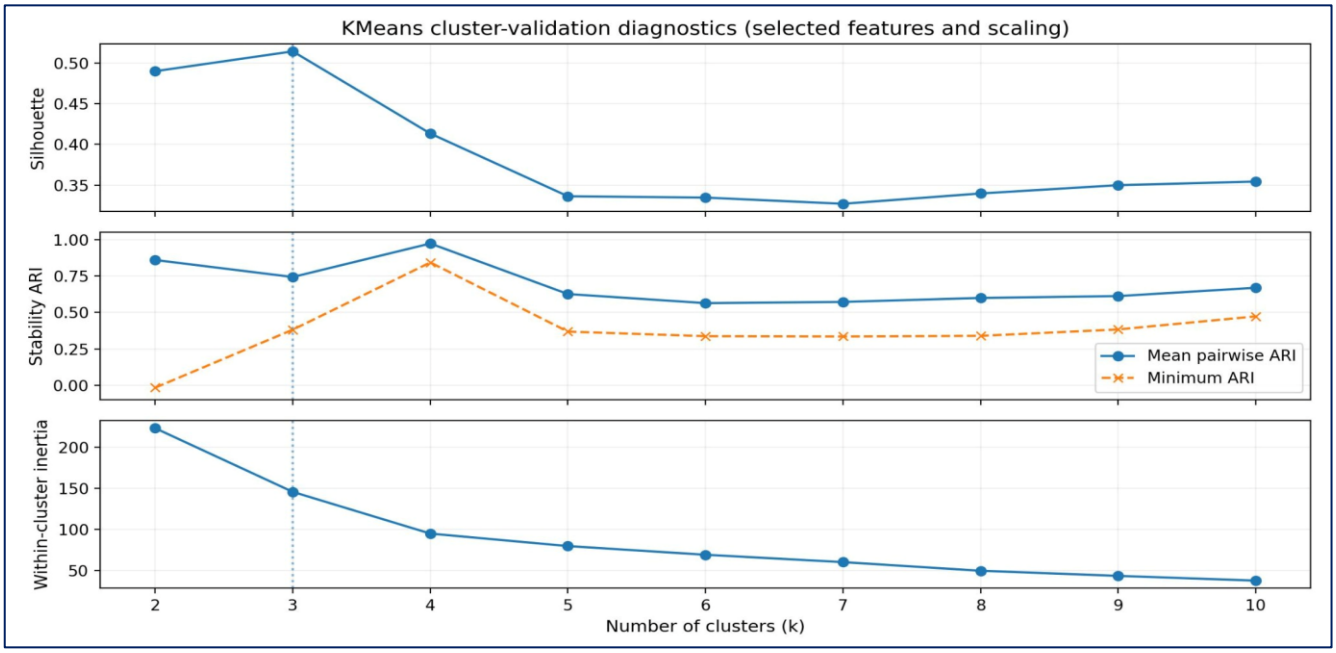


Figure 11-11. Silhouette, initialization stability and inertia across k=2–10 (k=3 highlighted).

k=3 has the highest displayed mean silhouette (~0.515) but only moderate mean initialization agreement (~0.74). Its maximum silhouette is not sufficient proof of a stable, generalizable three-group typology.

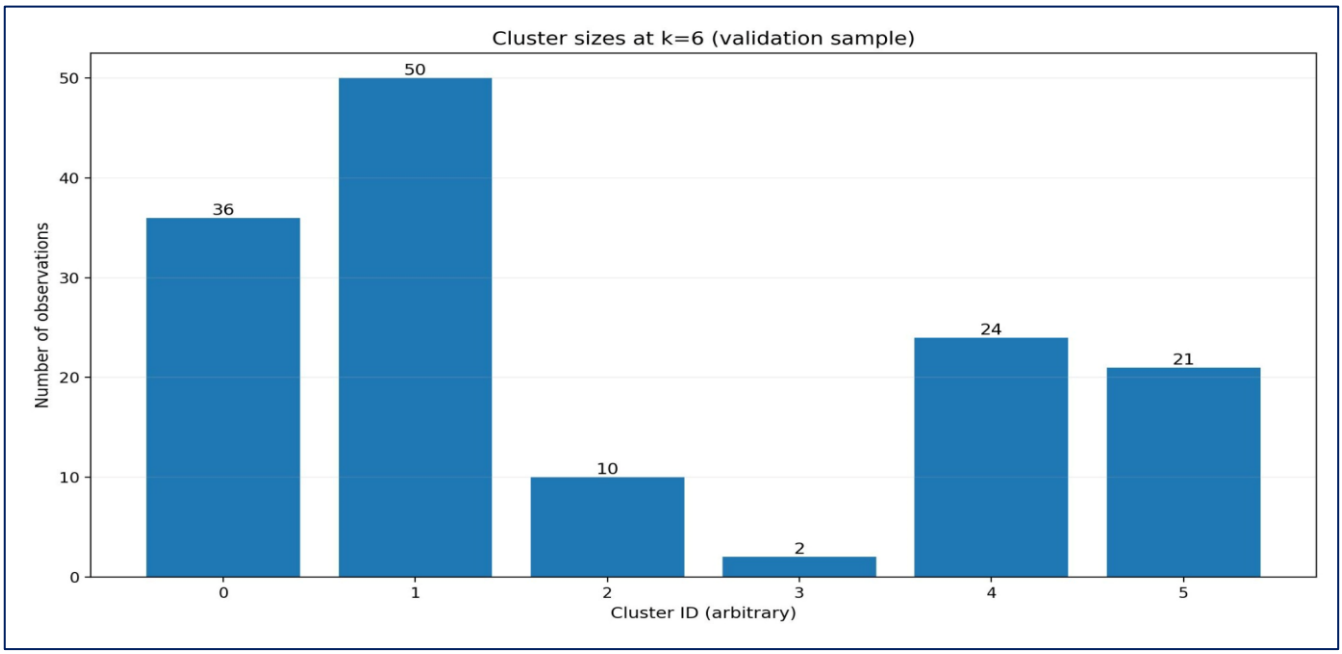


Figure 11-12. Cluster sizes at k=6 (validation sample, N=143).

Counts are 50, 36, 24, 21, 10 and 2 (order assigned by algorithm). The smallest group is 1.4% of sample; detailed segmentation is sensitive to rare cases.

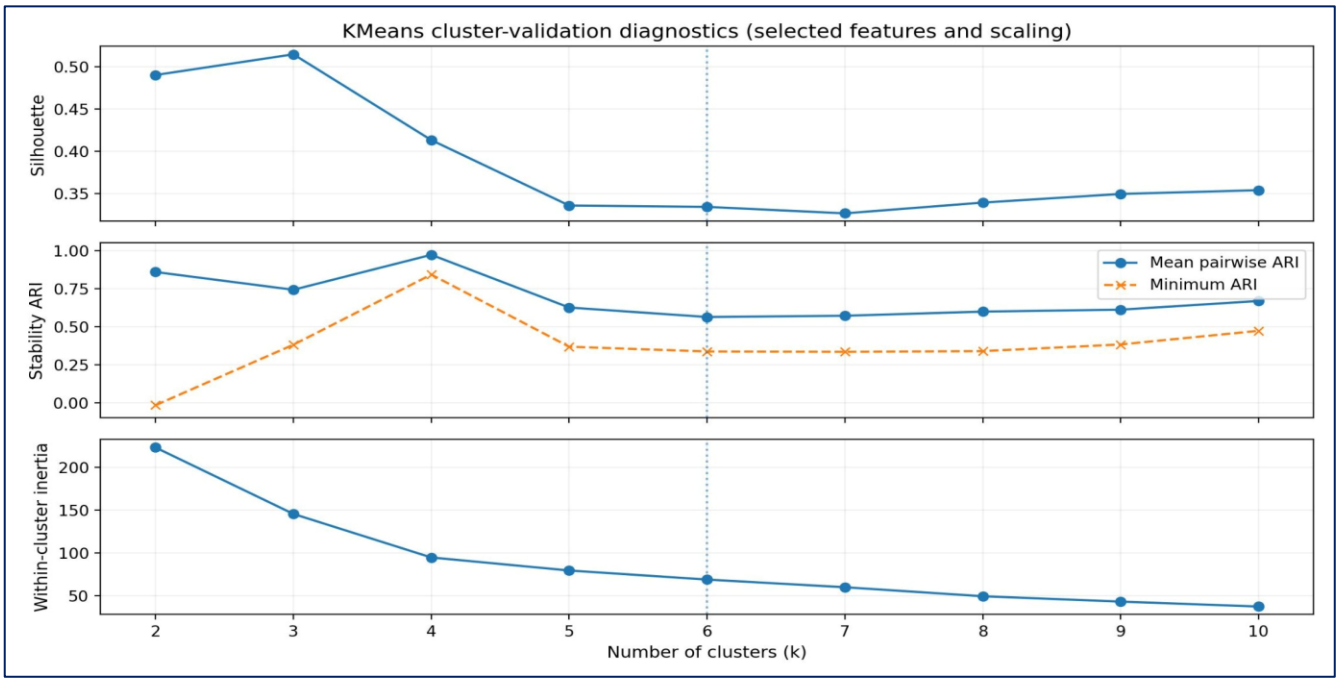


Figure 11-13. Silhouette, initialization stability and inertia across k=2–10 (k=6 highlighted).

k=6 has mean silhouette ~0.33 and mean initialization ARI ~0.56; these diagnostics do not justify treating six clusters as a preferred model.

Research interpretation and decision: For manuscript exposition, k=2 is the most defensible simple exploratory partition because it avoids tiny two-observation groups while retaining relatively strong separation. k=3 can be reported as the maximum-silhouette sensitivity result and k=6 as over-segmentation sensitivity. This is an interpretive

preference, not a statistically established optimal k; the 2024 cross-section cannot establish global digital-development tiers or causal effects.

Remaining validation before stronger claims: reconcile exact country/ISO3 memberships; export cluster centroids and descriptive profiles in original units; identify the two-country outlier group; compare k across bootstrap/subsample perturbations and temporal snapshots; assess external interpretability and data coverage. The ARI shown here measures different random initializations on the same observations, rather than robustness to a changed sample.

12. Time-Series Analysis and Predictive Validation

Forecasting extension completed in this edition: separate country-year Internet-use series are projected using ETS and ARIMA, with six-year and ten-year forward comparisons and model-specific backtesting. The historical validation origins (2018/2020) and the latest future-projection origin (2024) must not be conflated. Country forecasts near 100% require caution and naive/drift benchmark verification remains outstanding.

Observed and Forecast Internet Adoption: Pakistan and Comparator Countries

Scope and observed basis: Country-separated annual Internet-use series are plotted with the fitted future paths. Model training histories terminate at the most recent available national observation; selected-country series do not share identical historical coverage. Observed Internet use is a percentage of individuals, not subscriptions or smartphone ownership.

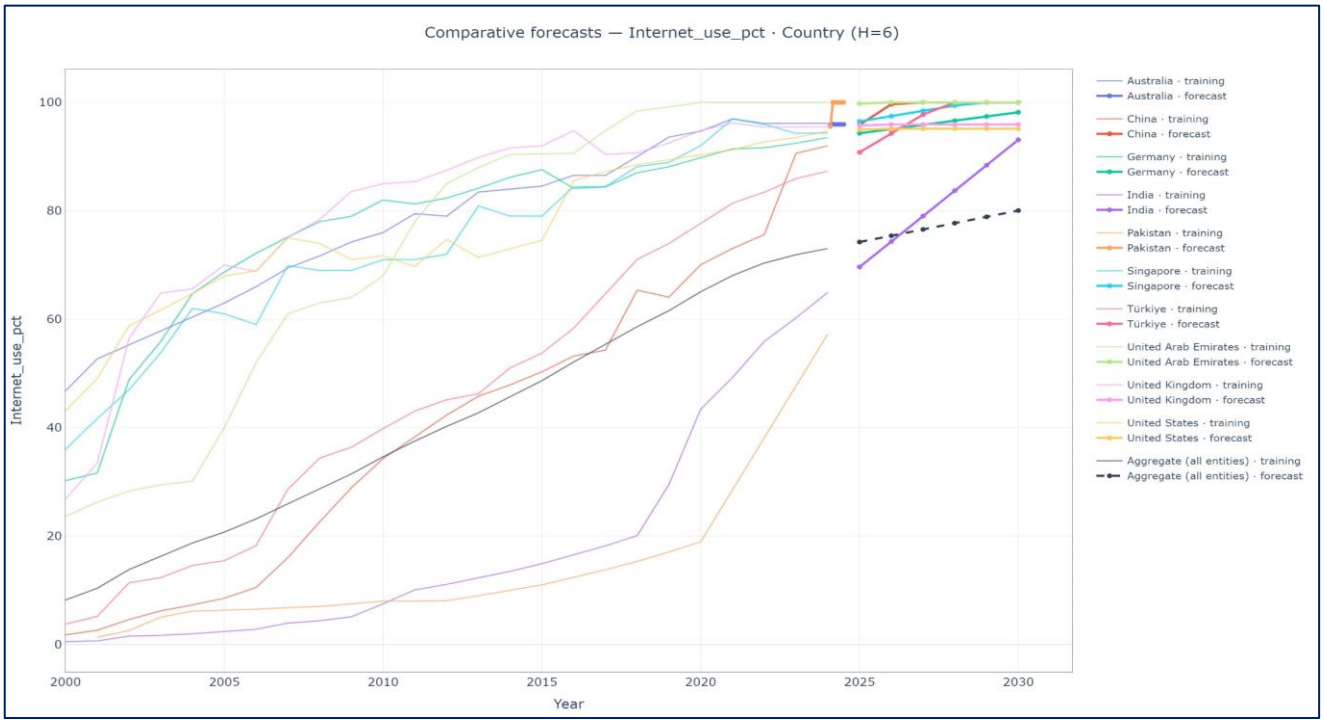


Figure 12-1. Internet adoption histories and six-year comparative forecasts, 2025–2030 (Brill-Viz, ETS/ARIMA forecasting workflow).

Interpretation: The international spread is persistent: highly connected economies cluster near saturation while India, Bangladesh and Pakistan have lower historical levels and different adoption trajectories. These results are exploratory projections rather than established adoption targets. The 2025–2030 window is inferred from a 2024 latest forecast origin; any series with earlier last observations must be explicitly identified.

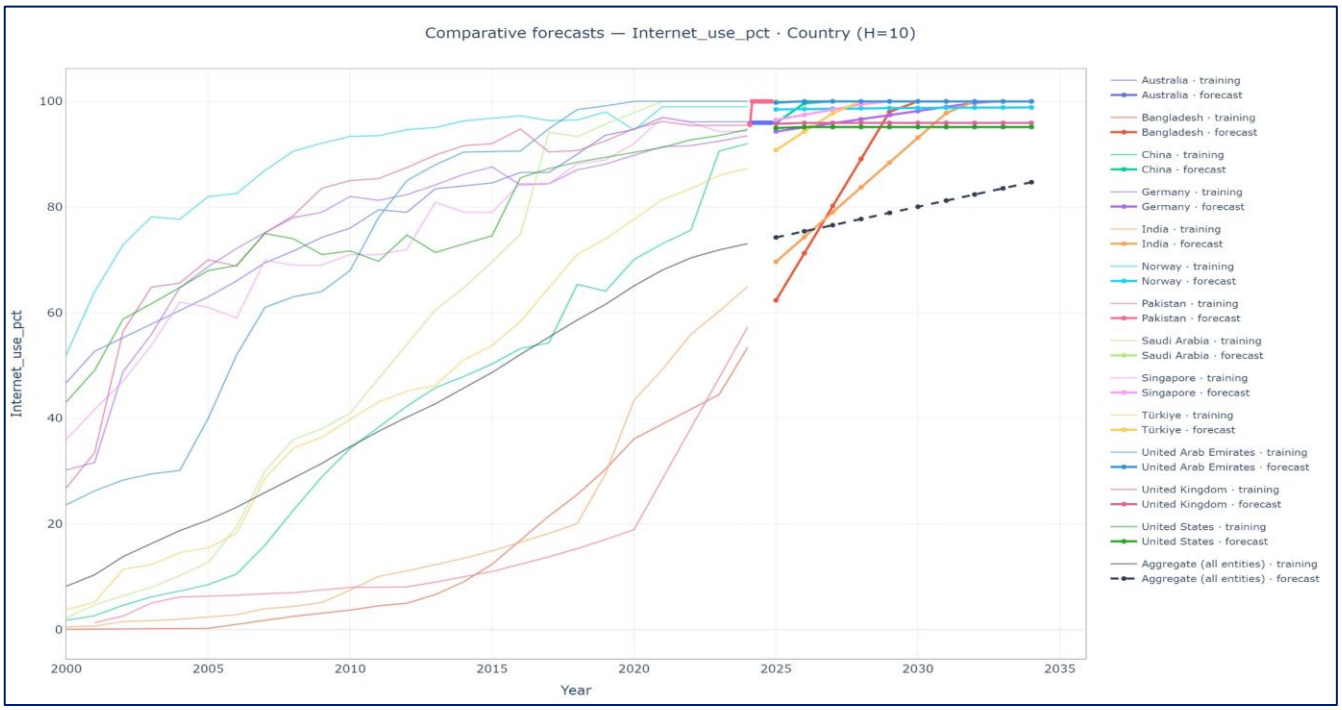


Figure 12-2. Longer-horizon sensitivity: observed Internet adoption and indicative ten-year projections, 2025–2034.

Limits: *Ten-year extrapolations are more fragile than six-year projections. Abrupt trajectories to 100% may result from extrapolation or capping; percentages constrained to 0–100 are not guaranteed to have calibrated uncertainty. Countries are fitted independently, and an all-entity aggregate must not be interpreted as a sum or a population-weighted figure unless expressly calculated that way.*

ETS/ARIMA Backtesting and Country-Specific Forecast Accuracy

Validation design: The historical-origin comparison trains through 2020 and evaluates observed years 2021–2024 where available. A separate rolling backtest holds out observations from 2019–2024 after its specified training origin. Because origins and scored observation counts differ, the results must not be pooled or interpreted as a single uniform test.

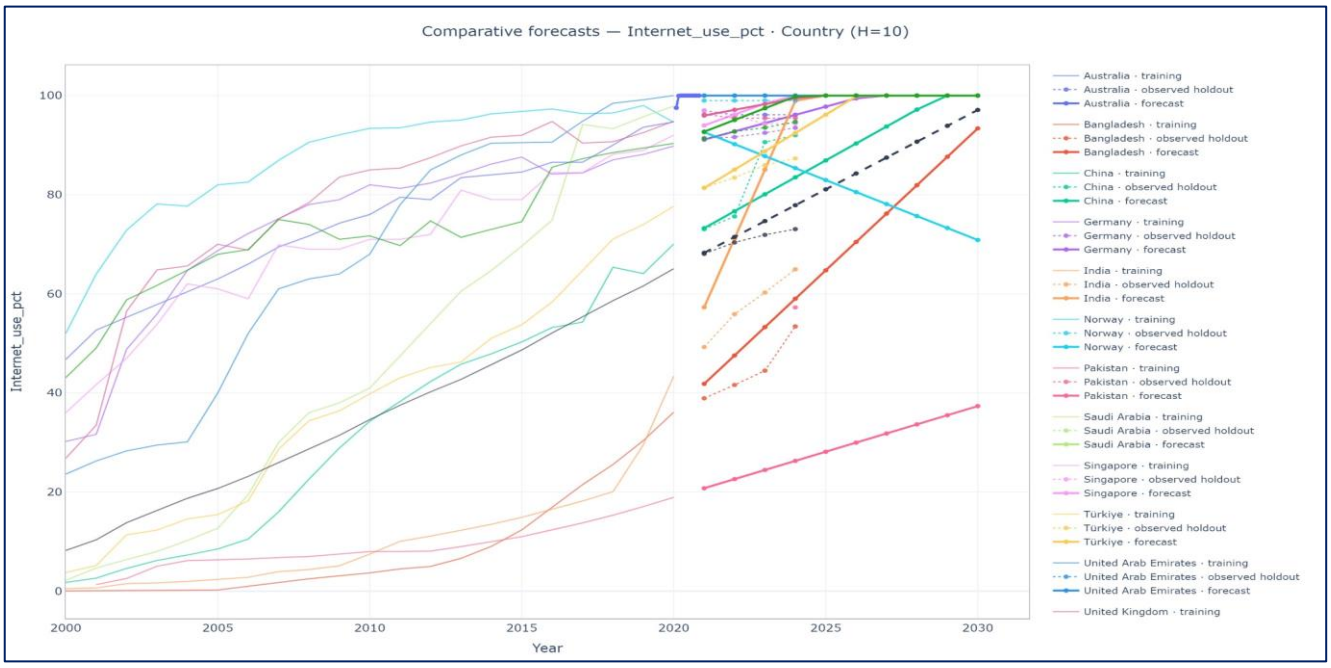


Figure 12-3. Comparative historical-origin Internet adoption forecasts and out-of-sample evaluation.

2018-origin six-year backtest results (MAE, percentage points): Pakistan ETS 13.27 versus ARIMA 10.43 (three matched years, therefore limited evidence); India 24.47 versus 22.75 (ARIMA); Bangladesh 1.56 versus 3.87 (ETS); China 4.50 versus 23.35 (ETS); Türkiye 2.50 versus 5.66 (ETS). For the independently modelled all-entity aggregate, ETS 1.31 versus ARIMA 1.96. Under this vintage, ARIMA is the lower-MAE method for Pakistan and India, but errors, especially for India and Pakistan, remain substantial.

Sensitivity to validation origin: In the 2020-cutoff workbook, the Pakistan forecast has no sufficiently matched scored holdout values and its model winner is Pending. The other-country comparison changes with cutoff, e.g., India favors ETS in the 2020-cutoff four-year evaluation but ARIMA in the 2018-cutoff six-year evaluation. Thus, no model family is claimed universally superior. Accuracy results are conditional on holdout availability, forecasting origin and the metric used.

Reproducibility boundary. The forecast comparison uses ETS and ARIMA with distinct training origins, holdout years and matched observation counts; results cannot be pooled across test designs.

Comparative Forecast Sensitivity: ETS versus ARIMA

Completed component - forecast model sensitivity: Figures 12-4 and 13-5 is presented here as a comparison of candidate future paths and model disagreement. The previously planned ACF/PACF/stationarity diagnostic and a comprehensive uncertainty-band assessment (prediction-interval analysis) were not completed in the supplied materials and are not described as performed.

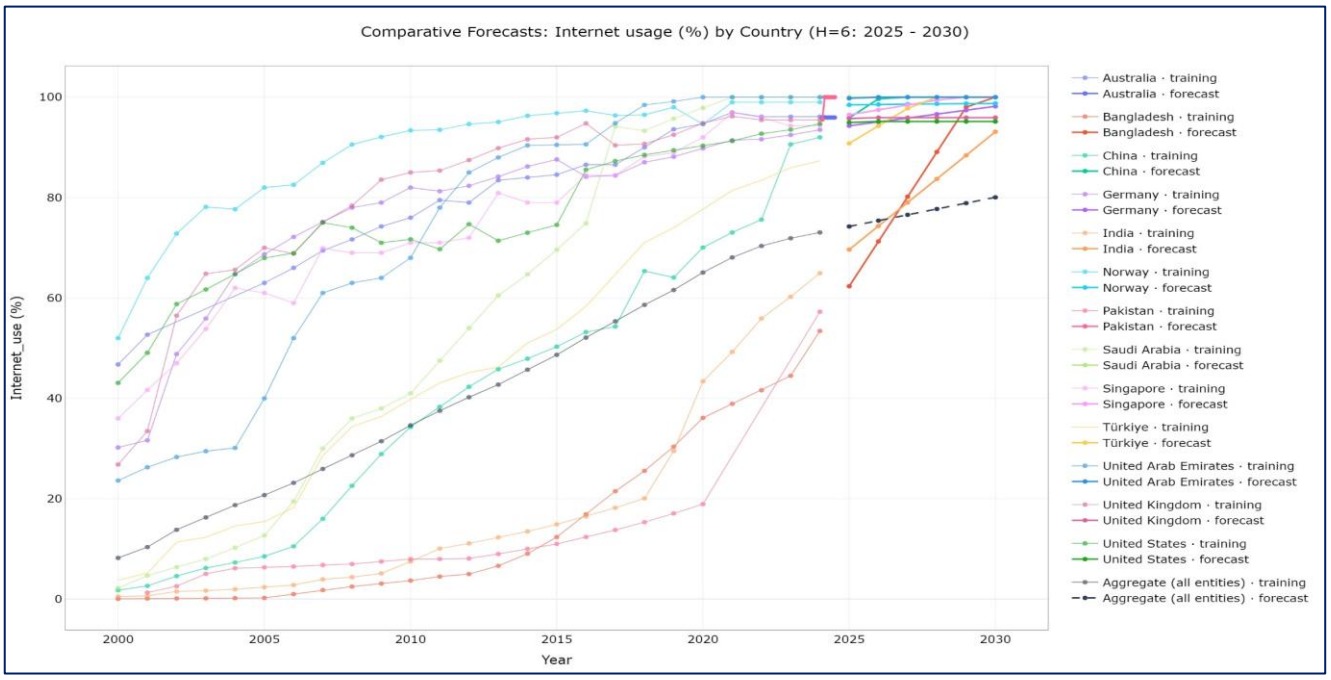


Figure 12-4. Country-level comparative Internet adoption forecasts, 2025–2030, with 2024 latest historical origin.

Interpretation: Models project divergent rates of convergence; Upper-bound clustering around 95–100% should be treated cautiously rather than as a validated certainty that Pakistan or other countries will reach near-universal use in the early forecast period. The independently fitted aggregate describes a country-cohort mean, not the mean of just the displayed peers and not the population-weighted world Internet-use rate.

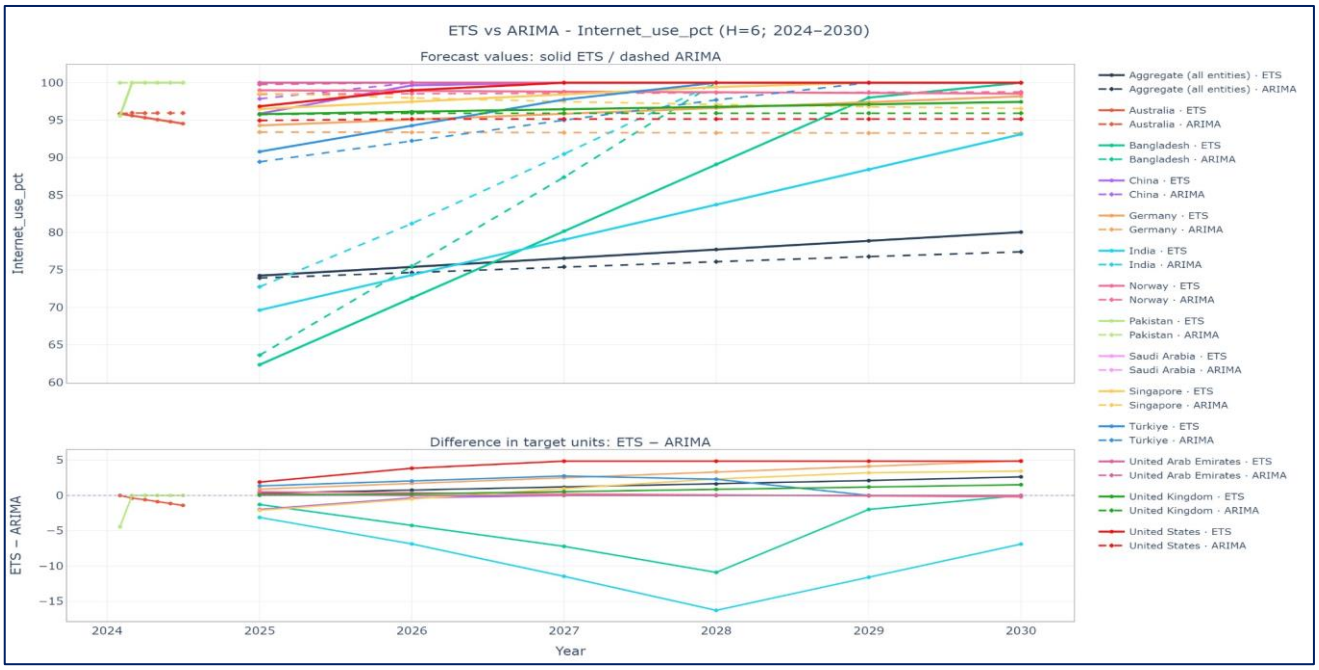


Figure 12-5. ETS versus ARIMA forecast sensitivity by country, with a second panel showing ETS minus ARIMA (percentage points).

Sensitivity to validation origin: With the 2020 training cutoff, Pakistan has insufficient matched observations for a scored holdout comparison; no model winner can be established for that case.

Scope / safeguards: No prediction-interval analysis prediction-interval figure is claimed. Future adoption is bounded conceptually by 0–100%, while clipping an unbounded model does not yield well-calibrated uncertainty. Model comparison is interpreted alongside Figure 12-3 errors, sparse Pakistani validation observations, time-series revisions and country-level last-observed-year differences.

13. Pakistan Peer Evaluation and Strategic Interpretation

Pakistan is benchmarked against twelve selected international peers through separate 2000–2024 Internet and subscription trajectories, a 2024 nominal GDP-per-capita association, and same-year Pakistan-relative gap rankings. These observed comparisons add decision-useful context without claiming unique-user deficits, causal growth effects or operator-level investment returns.

Comparator rationale: The purposive 13-country cohort is defined in Section 1.2: Pakistan is compared with South Asian neighbours, populous-market and regional peers, and high-income digital-adoption benchmarks. Country selection helps structure interpretation but is not representative statistical sampling. Comparisons use matched reported years whenever available.

Historical Pakistan–Peer Trajectories (Figures 3-4 and 3-5)

The 2000–2024 trajectories are presented once in Chapter 3: the mobile-subscription and Internet-adoption figures cover the common 13-country analytical set, with Pakistan visibly identified. Those two figures serve as the Figures 3-4 and 3-5 historical baseline. The evidence documents heterogeneous diffusion and a persistent participation gap; it does not imply that counted subscriptions equal unique users. The Pakistan-relative 2024 gaps are quantified separately in the Figures 13-2 and 14-3 figures below.

Selection and provenance: Thirteen countries are depicted in the selected comparison: Pakistan, Australia, Bangladesh, China, Germany, India, Norway, Saudi Arabia, Singapore, Türkiye, United Arab Emirates, United Kingdom and United States. Unobserved years are not imputed as zero. The highlight color is an emphasis device and does not confer statistical significance.

Internet Adoption and GDP per Capita: Pakistan and Selected Peers

Figure 13-1 examines the contemporaneous association between Internet use and GDP per capita at current US-dollar market exchange rates in a selected 2024 cross-section. The empirical quantity is a *level*, not real purchasing-power-adjusted GDP or a panel coefficient. Country selection is strategic rather than representative of the world population.

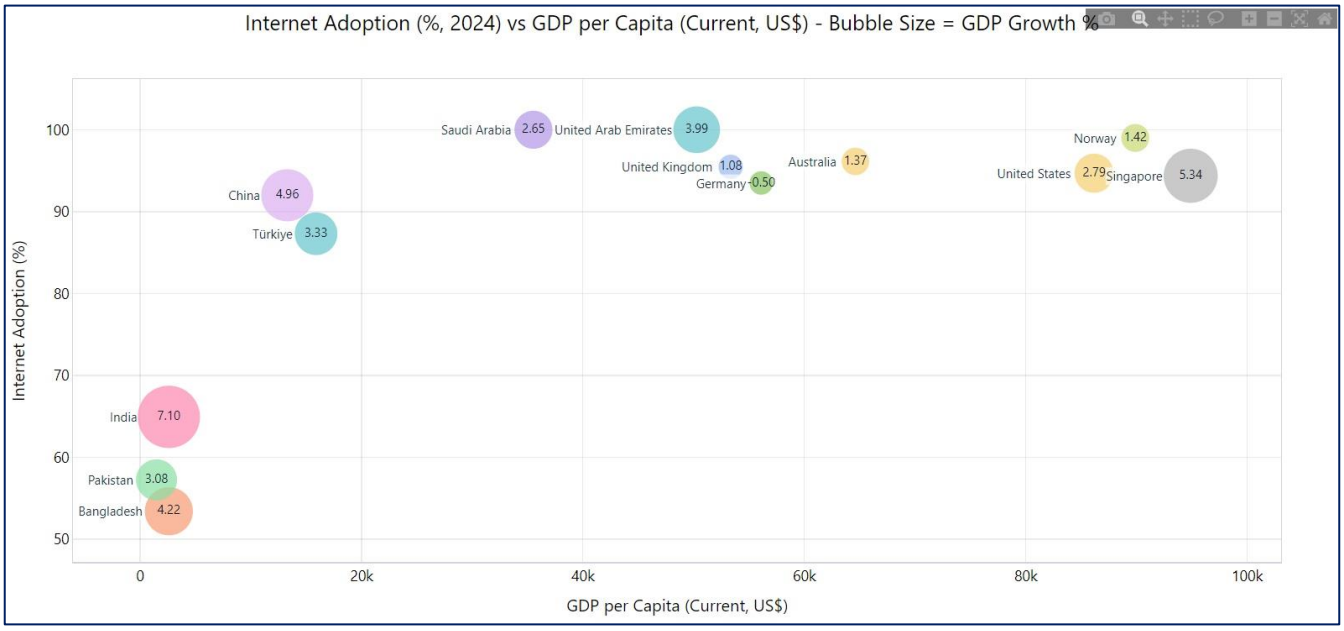


Figure 13-1. Internet adoption versus GDP per capita (current US$, 2024): Pakistan and twelve selected economies, bubbles size show GDP Growth (%)

Interpretation: Pakistan and Bangladesh occupy the low-income, low-adoption end of the comparator sample; India has somewhat higher Internet use, while most high-income economies have adoption close to the ceiling. China and Türkiye illustrate that high adoption is also possible at substantially lower income levels than the wealthiest peers.

Important qualification: The plotted economic variable is GDP per capita in current US dollars, which is sensitive to exchange rates and is not identical to the real GDP-per-capita variables used in other panel analyses. Internet adoption is bounded, creating ceiling effects and potentially nonlinear relationships. A stronger comparative test would use more countries, common-year indicator coverage, sensitivity to outliers and real/PPP income specifications.

Publication safeguard: The scatter does not establish that increasing Internet adoption will cause proportional GDP gains. It supports comparative positioning and hypotheses for subsequent econometric or country-specific investigation.

Pakistan-Relative Connectivity Gaps in 2024

Figures 13-2 and 13-3 present two historical 2024 gap rankings against Pakistan. Values are derived by subtracting Pakistan's reported 2024 observation from each peer's same-year observation. The figures do not estimate unmet unique-user numbers or commercially obtainable demand.

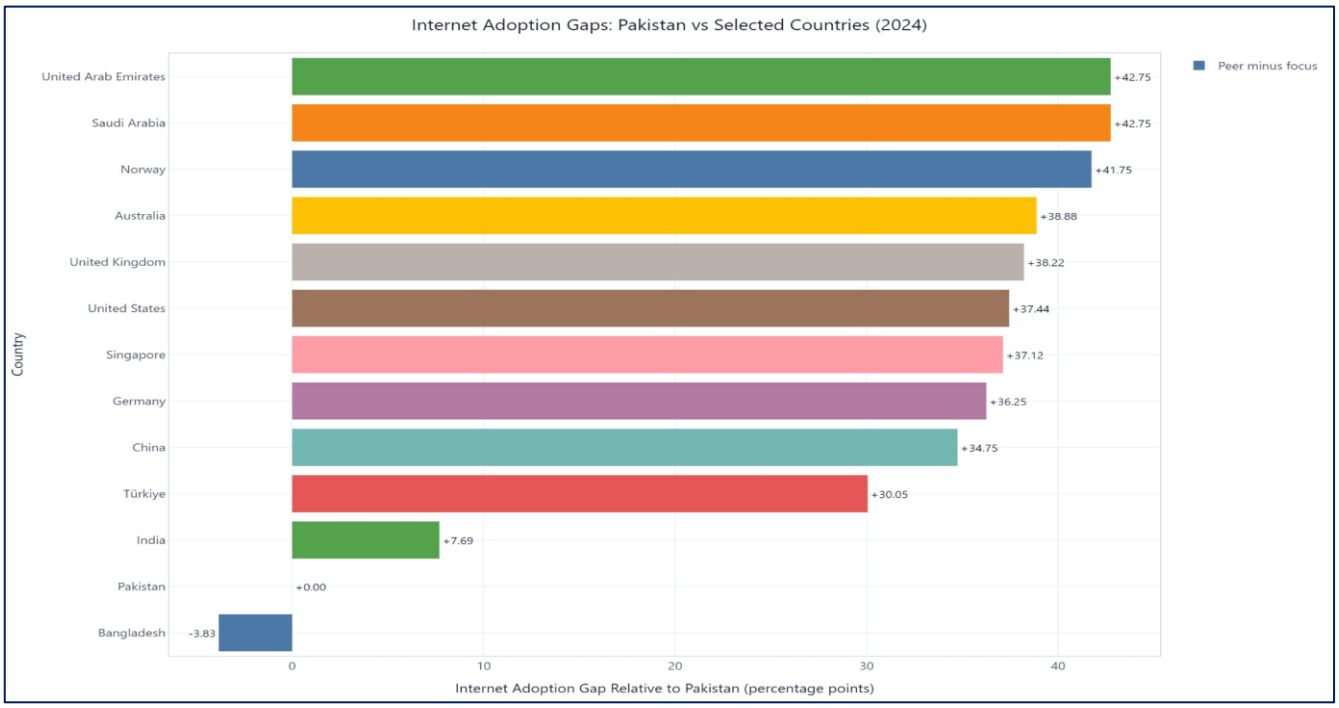


Figure 13-2. Internet adoption gap relative to Pakistan, 2024; peer Internet-use percentage minus Pakistan Internet-use percentage (percentage points).

Interpretation: Of the twelve comparator economies, eleven exceed Pakistan's reported Internet-use percentage in 2024. UAE and Saudi Arabia each exceed Pakistan by 42.75 percentage points, Norway by 41.75, China by 34.75 and Türkiye by 30.05. India is higher by 7.69 points; Bangladesh is lower by 3.83. The metric is a *difference between percentages*, hence percentage points rather than relative percent change. Pakistan is the zero reference.

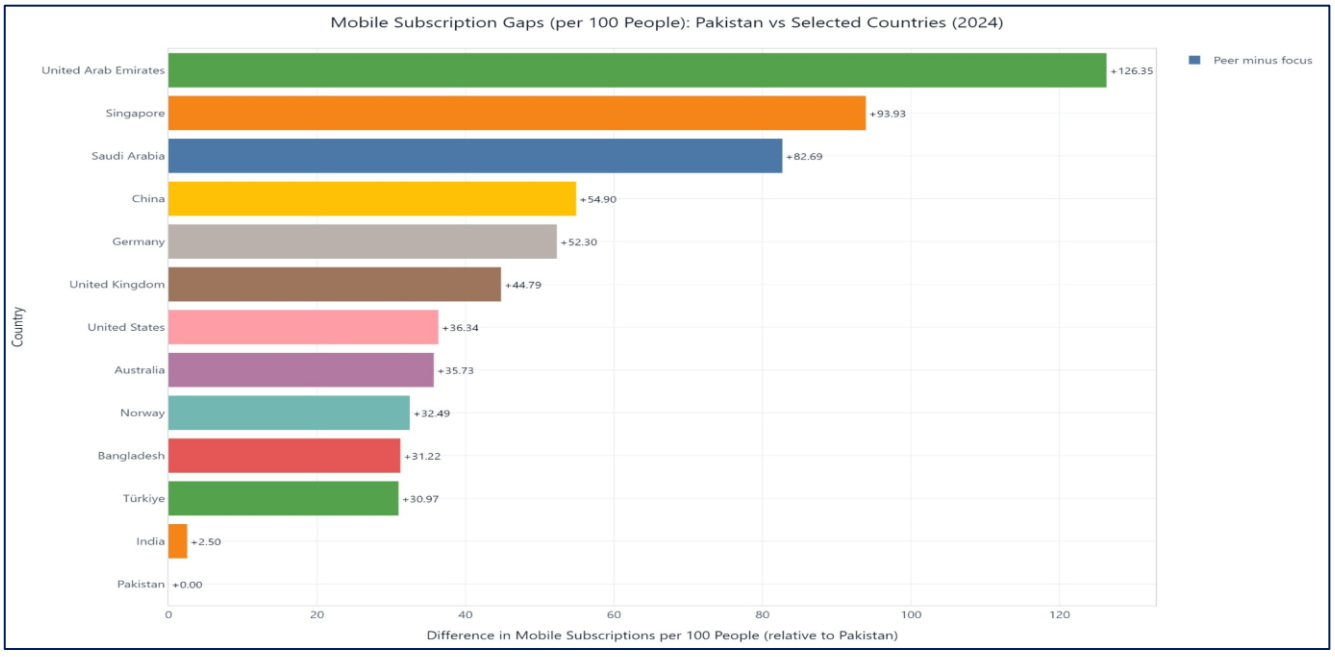


Figure 13-3. Mobile-cellular subscription intensity gap relative to Pakistan, 2024; difference in subscriptions per 100 people.

Interpretation: The UAE exceeds Pakistan by 126.35 mobile subscriptions per 100 inhabitants, Singapore by 93.93, Saudi Arabia by 82.69, China by 54.90 and India by 2.50. Bangladesh is also 31.22 above Pakistan in subscriptions per

100 even though its measured Internet-use percentage is 3.83 points below Pakistan. This *discordance* is a central research finding: subscriber/connection intensity and Internet participation are distinct dimensions of digital inclusion.

Strategic relevance: The combined charts motivate evidence-gathering around affordable data-capable devices, access quality, active use, digital skills, consumer affordability, pricing and geographic service gaps. Differences from developed countries are benchmarks, not mechanically attainable commercial markets. They cannot by themselves yield individual unique-user deficits, operator revenue, return on investment, ARPU, churn, NPV or SAM/SOM.

13.1 Strategic Implications for Pakistan's Mobile Network Operators: Connectivity Gaps, Digital Inclusion and Market Opportunities

Purpose and evidence boundary: The 2024 comparative results establish Pakistan's relative position in Internet participation and cellular subscription intensity, not the number of unique unserved customers. They are a historical strategic baseline, not an up-to-date November 2026 operator census. The accompanying Pakistan Telecommunications Industry strategy draft adds 2025 Pakistan Economic Survey, PTA and GSMA observations and describes selected 2026 sector changes. Those later figures are quoted here as reported in the companion draft; their original vintages, definitions and current validity require checking before an operator-specific decision.

13.1.1 What the International Evidence Means for the Pakistan Market

Pakistan's reported 2024 Internet-use rate trails eleven of twelve selected peers. The UAE and Saudi Arabia are each 42.75 percentage points higher, while India is 7.69 points higher and Bangladesh is 3.83 points lower. All twelve peers have higher reported mobile subscriptions per 100 people; the Bangladesh contrast (+31.22 subscriptions per 100 but −3.83 percentage points in Internet use relative to Pakistan) demonstrates that additional connections cannot be equated with incremental digital participation. These observations motivate targeted diagnosis, not national market-size or revenue extrapolation.

13.1.2 Complementary 2025 Pakistan Evidence: Why Definitions Matter

Pakistan Economic Survey 2024–25 reports estimates of 91% population coverage by cellular service, over 81% 3G/4G signal reach and 147.2 million broadband subscriptions by March 2025. It also cites a GSMA August 2025 research basis reporting 81% mobile-broadband coverage, 68% smartphone ownership and 29% mobile-Internet use. These figures use different samples, periods and denominators; they must not be subtracted to claim a 52-point commercially obtainable market, nor compared directly with the ITU/World Bank "individuals using the Internet" series. The draft also refers to FY2024–25 sector revenue exceeding PKR 1 trillion; this does not quantify the financial return of a proposed initiative.

13.1.3 Three Distinct Operator Growth Pathways

For practical decision-making, national gap rankings are translated into testable operator hypotheses rather than marketing targets. The companion strategy paper distinguishes first-time adoption, digital upgrading and usage deepening; each requires different denominators, customer interventions and evidence of commercial sustainability.

Table 13-1. Operator growth pathways and supporting evidence

Strategic pathway	Potential intervention	Minimum evidence / decision gate
First-time meaningful access	Targeted entry bundles, assisted onboarding and affordable-device financing in demonstrably underserved segments	Unique eligible individuals, effective network coverage, new-user activation, 90-day retention, margin after acquisition and financing costs
Digital upgrading	Smartphone partnerships, device-capability assessment, assisted first data use and relevant services	Existing voice-only/low-use cohorts, device readiness, successful upgrades, data-usage retention, attributable net revenue
Usage deepening and customer trust	Improve service reliability, price/bundle transparency, complaint response, safety and relevant digital services	Cohort engagement, churn, complaint resolution, effective price/GB, network QoS, service contribution net of promotions

13.1.4 Operator and Policy Validation Scorecard

At minimum, an operator-level pilot should monitor: (i) verified unique activated users, not SIM cards alone; (ii) 30/90-day active mobile-Internet use and cohort retention; (iii) device capability and affordability; (iv) local coverage, latency, availability and congestion; (v) tariff clarity, disputes, fraud and first-contact resolution; and (vi) incremental ARPU, servicing costs, acquisition payback and contribution margin. Where relevant, commercial scenarios should also assess spectrum/capacity costs, CAPEX/OPEX, financing, taxes and plausible downside cases. Public country statistics alone cannot support a bankable TAM/SAM/SOM, NPV or IRR.

Economic inference boundary: The fixed-effects estimates use log real GDP per capita (an income-level outcome), not year-on-year economic growth. Neither the Internet-use-growth/GDP-growth relationship nor the mobile-subscription-growth/GDP-growth relationship has been independently estimated here. Regional and income-group model heterogeneity and systematically identified country exceptions remain future tests; the observed Pakistan–Bangladesh divergence already warrants targeted investigation.

13.1.5 Sector Comparability and Next Evidence Update

The companion strategy paper should incorporate the verified industry transition: PTCL acquired Telenor Pakistan and Orion Towers on 31 December 2025; Telenor Pakistan was amalgamated into PTML effective 1 July 2026. Analyses of earlier years should keep the separate legacy operators identifiable; later market shares and company financials should use the actual post-merger reporting perimeter and avoid double counting. The report should still verify the latest customer-facing integration and regulatory conditions before making forecasts or competition-policy recommendations. The 2024 international country panel remains a historical benchmark, separate from these 2025–2026 sector developments.

Evidence-to-action proposition: The global research provides a defensible external benchmark; the Pakistan sector strategy translates it into pilot designs. The two documents remain complementary: the global manuscript reports the descriptive/econometric evidence, while the standalone strategy paper develops more detailed marketing, trust and investment options subject to operator verification.

Decision linkage to Volume II: The next volume should measure how people move from basic voice/SMS connections to active mobile Internet and then to sustained data consumption. It will need a consistent operator-level time series

for active unique subscribers, smartphone-capable devices, data users, traffic per user, package take-up, ARPU by service type, churn, network cost and investment returns. Only those measures can establish whether a descriptive country-level participation gap is monetizable or whether commercial effort is better directed toward upgrading and deeper use among existing customers.

Decision linkage to the Pakistan strategy paper: The strategy study can convert the three pathways in Table 13-1 into distinct field-test propositions: (i) affordable first-time access, (ii) migration from voice/basic handsets to usable smartphones and data, and (iii) increased value and retention among existing mobile-Internet customers. Each pathway should specify eligible unique users, geographic segments, the affordability constraint, a counterfactual, acquisition/retention KPIs and a minimum contribution-margin threshold. Regulatory, operator and survey data from 2025–2026 must remain labelled separately from the historical 2024 international benchmark.

14. Integrated Synthesis, Conclusions and Research Outlook

The conclusions below synthesize the completed manufacturer, network, global descriptive, econometric, convergence, forecasting and Pakistan peer evidence. They distinguish observed differences, sample-dependent statistical associations, provisional predictions and opportunities that require independent commercial validation.

1. **From connections to participation:** Cellular subscription intensity measures counted connections and is not a proxy for unique mobile-phone ownership or Internet use. The global histories and 2024 Pakistan peer gaps demonstrate why counting additional SIMs alone is an inadequate definition of digital development.
2. **Unequal diffusion and convergence:** A stable cohort shows a pronounced upward shift in Internet adoption between 2000 and 2024, but both the time-series comparisons and the 2024 country-level gaps document persistent heterogeneity. PCA and clustering help organize profiles, not rank governments or identify a universally optimal cluster structure.
3. **Economic context without false causality:** The selected 2024 current-dollar GDP-per-capita scatter and the larger two-way fixed-effects model answer different questions and use different data definitions. Their observed relationships provide informed hypotheses but neither establishes an independent causal GDP payoff from subscription or Internet adoption changes.
4. **Forecasting as qualified evidence:** The six- and ten-year Internet-use projections are illustrative scenario inputs rather than verified adoption targets. ETS and ARIMA disagreement, sensitivity to historical cutoff, Pakistan's sparse holdout observations, saturation constraints and missing naive/drift comparisons restrict claims about 2030 outcomes.
5. **Pakistan's relative position and opportunity screening:** In the selected 2024 cohort, eleven of twelve peers exceed Pakistan in Internet use, but Bangladesh combines higher mobile-subscription intensity with lower Internet participation. This points to the importance of service quality, device capability, affordability, coverage, skills and active-use behavior as questions for targeted investigation, not quantified missing customers or projected operator revenues. Section 7.5 places these country-level findings in Pakistan's dated institutional and operator context, including the 2025–2026 PTML–Telenor transaction; it does not use national correlations to attribute performance to particular operators.
6. **Decision and research value:** The integrated framework links device competition and product evolution, connectivity adoption, demographic-economic conditions, diagnostic modelling and evidence-based policy questions. It supports comparable monitoring and disciplined hypothesis generation while recognizing the achievements and commercial constraints of operators and manufacturers; it does not judge undisclosed management choices.

7. **Role and limitations of the 13-country core group:** The selected-country design makes Pakistan's relative Internet-use and subscription position visible against both nearby and high-adoption comparators, but its purposive composition prevents extrapolation to the world or direct estimation of an operator's obtainable market. Commercial implications remain hypotheses requiring timely operator-level validation.

Synthesis across figures: Figure 5-3a and Figure 5-3b identify demographic, participation and economic screening contrasts; Figure 9-3 and Figure 9-4 show why subscriptions and Internet participation have become less tightly associated in observed cross-sections; Figures 13-2 and 13-3 translate international comparisons into Pakistan-relative differences. Together they form an evidence chain from market context to hypotheses for verification, not a numerical forecast of customers or financial value. The one-figure-one-location principle applies: later discussions cite the original visual instead of repeating it.

Research transition: Volume I establishes historical baselines, comparative patterns, econometric associations and qualified forecasts. **Volume II** should examine service monetization and operator economics using data on voice, SMS, mobile broadband traffic, tariffs, customer behaviour and network investment. The companion Pakistan telecommunications strategy paper should then assess feasible actions, differentiated market segments, competitive options, risks and measurable pilots using current Pakistani evidence. The two follow-on studies should test, rather than assume, the demand and profitability hypotheses raised here.

Statistical contribution to this transition: The econometric results show why a relationship visible in cross-sectional or country-only models may change once common year effects are included; the convergence work quantifies progress while preserving distributional differences; PCA and clustering organize exploratory country profiles; and the backtested forecast comparisons reveal decision-relevant uncertainty. These findings justify a research sequence rather than a predetermined policy prescription: define an observable participation or service problem, test its proposed economic mechanism with suitable operator and household evidence, select a proportionate intervention, and evaluate changes in adoption, active usage, quality, affordability, retention or unit economics against a documented baseline and counterfactual. Sections 14.3-14.4 and Table 14-1 provide the corresponding evidence-to-decision framework.

14.1 Established Evidence and Remaining Boundaries

Established within the reported source and sample boundaries: historical shifts in manufacturer positions; unequal cellular and Internet diffusion; statistical relationships conditional on the evaluated global sample; distinctive 2024 digital-development profiles; a descriptive Pakistan-versus-peers positioning; and time-aware ETS/ARIMA validation and comparison. The findings are more robust as a combined, qualified synthesis than as isolated rankings.

Not established: unique users still unserved, national smartphone ownership or annual handset purchases, pricing elasticities, Pakistan operator TAM/SAM/SOM, changes in GDP caused by connectivity, calibrated forecast uncertainty or superior future investment returns. Source-year and model-validation caveats remain relevant after this editorial finalization.

14.2 Strategic Contribution and 5–15-Year Outlook

The strategic contribution is a transferable four-domain screening framework: (a) meaningful market access and digital inclusion; (b) service quality, customer value and trust; (c) technological and competitive adaptation; and (d) economic resilience and investment discipline. Each domain requires distinct outcome indicators and additional firm or household data for operational decisions.

The priority agenda is to verify Pakistan's source-year discontinuities and peer baseline, test forecast families against simple benchmarks, document Figure 9-4 matched-country samples, improve comparability of nominal/real income measures and acquire network coverage, tariff, unique active-user, device affordability and customer-economics evidence. Illustrative strategic horizons are not independently modelled 2030–2040 outcomes.

The study is a substantial research synthesis, not a finalized investment recommendation or a formal causal impact evaluation. Publication is defensible as an evidence-qualified independent analytical report when the unresolved data-provenance checks are transparently disclosed and the final figure citations and references are verified against their original sources. The companion Pakistan strategy paper offers a more detailed operational agenda; it is not treated as an independent validation of the 2000–2024 data or of current customer demand.

14.3 From Statistical Evidence to Strategic and Policy Decision-Making

The statistical and econometric analyses undertaken in **Volume I** serve a purpose beyond documenting historical telecommunications development. They provide a quantitative framework for distinguishing observed connectivity expansion, meaningful digital participation, socioeconomic associations, structural differences among economies and uncertainty in future adoption trajectories. Together, these analyses help identify which apparent market opportunities merit further investigation, which relationships remain conditional on model specification and which evidence gaps must be resolved before commercial or regulatory interventions can be justified.

The panel econometric findings demonstrate the importance of distinguishing cross-sectional relationships, within-country associations and common international trends. The convergence analyses establish that widespread progress in Internet adoption coexists with persistent differences among economies. Principal component analysis and clustering provide exploratory classifications of digital-development profiles, while forecasting comparisons demonstrate the sensitivity of projected adoption trajectories to modelling assumptions and historical data availability. None of these findings independently establishes causal economic benefits, commercially obtainable subscriber numbers or guaranteed returns on telecommunications investment.

Their combined strategic contribution is therefore to guide the formulation of testable policy and business hypotheses. For Pakistan, these include improving meaningful Internet participation, examining barriers to affordable smartphone access, evaluating the transition from basic connectivity to productive digital use, investigating service quality and customer retention, and assessing the commercial sustainability of future network investment. **Volume II** will extend the analysis to operator service consumption, tariffs, data monetization and financial performance, while the companion Strategy/Policy Paper will translate validated findings into targeted interventions, implementation priorities, measurable outcomes and monitoring arrangements.

- The estimated two-way fixed-effects relationships concern log real GDP per capita, not GDP growth; dedicated growth-on-growth models, formally stratified regional/income-group effects and a systematic residual-based country-exception analysis have not been completed.

In this way, the research moves from statistical description toward evidence-informed decision-making without treating association as causation or demographic potential as established commercial demand.

14.4 Operational Evidence-to-Decision Framework

For application in the forthcoming Strategy/Policy Paper, each analytical result should be traced through six explicit stages:

Statistical finding → Economic interpretation → Strategic implication → Policy option → Evidence required → Measurable outcome.

The examples in Table 14-1 are research and policy-design propositions; they are not effects estimated or interventions endorsed by the present country-level models.

Table 14-1. Translating Volume I statistical evidence into testable strategic and policy decisions

Statistical finding	Economic interpretation and strategic implication	Policy option, evidence required and measurable outcome
Subscription–Internet-use divergence	Finding: subscription intensity and Internet participation are related but not interchangeable. Economic interpretation: additional SIM connections do not necessarily imply additional meaningful users. Strategic implication: distinguish access, activation and sustained use.	Policy option: investigate affordable capable devices, onboarding and local service-quality barriers. Evidence required: verified unique users, active data cohorts, device ownership, local affordability and coverage. Measurable outcome: first-time active Internet users and 30/90-day retained users, with intervention-versus-comparison results where feasible.
Cross-sectional and fixed-effects economic relationships	Finding: GDP–connectivity coefficients depend on country, year and model specification. Economic interpretation: common trends and unobserved conditions may influence apparent links. Strategic implication: do not equate association or statistical significance with a causal return.	Policy option: evaluate targeted connectivity and productive-use pilots before broad spending. Evidence required: comparable real-income definitions, robust uncertainty estimates, investment costs and credible evaluation design. Measurable outcome: verified use for work, learning or services; cost per sustained active user; and independently assessed economic outcomes.
Persistent adoption gaps and convergence	Finding: historical Internet participation increased substantially, while country and group differences persist. Economic interpretation: national averages conceal heterogeneous barriers. Strategic implication: prioritise diagnosis by population segment and geography.	Policy option: test focused inclusion measures in underserved groups. Evidence required: disaggregated baseline adoption, affordability, literacy, network-quality and demographic information. Measurable outcome: subgroup adoption gaps, successful activation, retention and service-quality improvements.
PCA and exploratory clustering	Finding: national digital profiles vary across the observed standardized indicators; cluster assignments are exploratory. Economic interpretation: similar headline penetration can mask different development conditions. Strategic implication: avoid uniform country rankings and one-size-fits-all programmes.	Policy option: tailor diagnostic priorities to verified local constraints. Evidence required: cluster-stability checks and external indicators covering geography, pricing, device access and quality. Measurable outcome: programme performance by predefined segment, rather than improvement in a PCA score itself.
ETS/ARIMA forecasts and validation	Finding: projected paths depend on model, training cutoff and data availability; Pakistan holdout evidence is sparse. Economic interpretation: planning exposure increases when future adoption is treated as certain. Strategic implication: use adaptive scenarios and staged commitments.	Policy option: construct conservative, central and higher-adoption planning cases, separately calibrated to policy assumptions. Evidence required: matched backtests, naive/drift benchmarks, observed revisions and well-specified uncertainty. Measurable outcome: forecast error, scenario trigger performance and capital utilisation against verified demand.

Statistical finding	Economic interpretation and strategic implication	Policy option, evidence required and measurable outcome
Pakistan peer gaps and market screens	Finding: Pakistan differs markedly from a purposively selected international peer cohort, but gaps do not measure capturable customers. Economic interpretation: potential demand depends on ability and willingness to use and pay. Strategic implication: assess distinct first-time access, upgrading and usage-deepening pathways.	Policy option: run separate, measurable pilots before national rollout. Evidence required: operator-level unique-user data, device capability, tariff, ARPU, churn, network costs and segmentation. Measurable outcome: incremental sustained users, upgrades, data use, retention, net contribution and cost per acquisition.

Decision rule: No intervention should be justified from a significant coefficient, a cluster label, a forecast projection or a peer gap alone. The Strategy/Policy Paper should record the source figure or table, the identification limitation, the proposed causal mechanism, the responsible institution, the pilot design, the required baseline and a pre-specified success threshold before recommending scale-up.

Transfer to the subsequent studies: Volume II is intended to include the missing operator-level service and financial evidence (voice and SMS activity, mobile-data users and traffic, tariffs, ARPU, device upgrading, churn and investment economics). The Pakistan Strategy/Policy Paper should then distinguish regulatory actions from operator business decisions, establish feasible ownership and implementation sequencing, and evaluate interventions against independently verifiable outcomes rather than national subscription counts alone.

15. Data Limitations and Editorial Integrity

- Recent-year country coverage is incomplete; the historical panel is a source-observation framework rather than a full 2025 national series.
- Demographic context from 2025 is combined with telecom observations from 2024 for screening, not same-year inference.
- Some GDP per capita figures carry “latest available” rather than an exact observation year; rankings must be qualified.
- Manufacturer shipment histories vary in tracker coverage, product scope and observed years.
- Operator group revenues/profits do not necessarily represent mobile-service financial results.
- The present datasets do not provide national annual handset purchases, unique smartphone ownership, country package prices or company-specific obtainable-market shares.
- No statistical correlation presented here should be treated as causal without temporal controls and sensitivity assessment.

Limitations: Pakistan Economic Survey 2024–25 reports estimates of 91% population coverage by cellular service, over 81% 3G/4G signal reach and 147.2 million broadband subscriptions; these indicators differ from the 2024 international Internet-use measure.

The global GDP model and the selected-country nominal-dollar scatter use different income definitions and comparison samples. Exact source vintages and matched data coverage vary by year and metric. The paper does not contain operator-level prices, profitability, unique device ownership or verified market-size estimates, and prediction-interval analysis prediction-interval calibration and naive/drift forecast benchmarking have not been completed. These limits qualify interpretation without erasing the included evidence.

Exhibit status: The international histories, model estimates, convergence diagnostics, forecasts and Pakistan peer comparisons are presented with their respective data and interpretation limitations.

Operator relevance: Section 13.1 translates the Pakistan peer findings and the companion strategy draft into three practical, testable pathways: first-time meaningful access, upgrading and deeper usage. The 2024 gaps justify investigation; neither they nor 2025 coverage figures establish obtainable customers, current 2026 market share or commercial returns.

Publication and transfer-to-strategy verification gate: Before the empirical gaps are used as market-capture assumptions, confirm (1) the source and revision date for each 2024 Pakistan/peer observation, (2) matched-country n for Figures 9-3 and 9-4, (3) the simple forecasting baselines and Pakistan holdout coverage, (4) compatible indicator years and units in Figures 5-3a–5-3b and (5) active unique-user and operator-level affordability, retention and margin evidence. Until those checks are complete, results should be labelled opportunity-screening evidence rather than investment appraisal.

15.1 Verification, Corrections and Author Responsibility

The author has made best efforts to obtain, cross-check and verify information against the publicly available source disclosures, international statistical series and historical evidence registers used in this synthesis. Despite due care, inadvertent omissions, transcription mistakes, differences in reporting definitions, subsequent source revisions or other human oversights remain possible. Readers are invited to communicate potential inaccuracies and supporting evidence to the author; substantiated corrections and clarifications will be reviewed and, where appropriate, incorporated into a revised edition. This is an independent public-data review, not an audit, endorsement, criticism of undisclosed corporate practices, or financial advice.

Declarations

Funding: The authors report that this research was undertaken independently and did not receive an external research grant or commissioned funding. The author is responsible for confirming the funding statement immediately before submission.

Authors' contributions: Khan Arshad solely conceptualized the study, with research design, source selection, country-year data integration, statistical and econometric analysis, visual interpretation, and manuscript preparation.

Use of analytical tools: Brill-Viz workflows supported data preparation, analytical calculations, statistical visualization, figure design and reporting. Model specifications, numeric results, spatial accuracy and final interpretation remain the authors' responsibility.

About the Author



Khan Arshad is a petroleum geologist, exploration professional, independent researcher and developer of scientific data-analytics and visualization tools, with nearly three decades of professional experience in oil and gas exploration, regional geological studies, petroleum-system analysis, prospect evaluation, petroleum economics and exploration-project management. He holds an M.Sc. in Petroleum Geology from the University of Aberdeen, United Kingdom, and an M.Sc. in Geology from the University of Karachi, Pakistan.

His professional career has included technical and managerial assignments in Pakistan with Baker Hughes INTEQ, OMV, PETRONAS, MND, Eni and Dewan Petroleum. His experience encompasses wellsite and operations geology, seismic and petrophysical interpretation, sequence stratigraphy, regional basin analysis, new ventures, prospect generation, exploration-risk and reserves assessment, exploration-team leadership and major exploration-project management.

A substantial part of his career has involved multidisciplinary integration of geological, geophysical, petrophysical, geochemical and economic evidence. His regional work has covered major sedimentary basins and tectonic provinces of Pakistan, including the Middle and Lower Indus basins, Kirthar and Sulaiman fold belts, Potwar Basin and Punjab Platform. This background has contributed to a broader interest in how complex natural-resource systems can be evaluated through integrated data, quantitative analysis and transparent visualization.

He is the founder of **enerbrill**, where he combines geoscience, energy-sector experience, data analytics, scientific visualization and software development. He has independently developed **Brill-Viz**, an integrated analytical and visualization platform, together with specialized applications for probabilistic volumetrics, geological chance-of-success assessment, petrophysical evaluation, Total Organic Carbon estimation, decision analysis, mind mapping, research synthesis and AI-assisted document intelligence.

His independent research has expanded beyond petroleum and energy systems into water security, agricultural productivity, food security, climate, demography, international trade, infrastructure, telecommunications, digital transformation and economic resilience. His particular interest lies in integrating heterogeneous datasets into transparent analytical frameworks that distinguish observed evidence, statistical relationships, derived indicators, uncertainty and interpretation.

In the present research on the global mobile communications industry, Khan Arshad examines the historical transformation from fixed-line telecommunications to cellular connectivity, mobile broadband and widespread Internet adoption. The study integrates developments in mobile devices and manufacturers, telecommunications networks, demographic and economic conditions, digital participation, technological diffusion and international market dynamics. It considers how these interconnected developments have reshaped communications access and created new economic and strategic opportunities across countries at different stages of development.

As the independent researcher, he has undertaken its research conception, analytical framework, data integration, comparative-country assessment, statistical and econometric evaluation, forecasting, interpretation and visualization. His principal contributions include integrating international telecommunications, demographic and macroeconomic datasets; examining relationships between mobile-cellular subscriptions, Internet adoption and economic development; assessing digital convergence and disparities; and evaluating Pakistan's position relative to selected regional and international benchmarks.

Through this research, he seeks to demonstrate how multidisciplinary data analytics and scientific visualization can support a deeper understanding of telecommunications development, digital inclusion, market transformation and evidence-based strategic decision-making. The study also illustrates the application of **Brill-Viz** as an independent analytical platform for transforming complex public datasets into reproducible research findings, comparative intelligence and accessible visual evidence.

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