ITUPublications

International Telecommunication Union

Global Economic Model and Study (GEMS) Tool

for Digital Infrastructure Deployment

May 2026

Acknowledgements

The **Global Economic Model and Study (GEMS) Tool for Digital Infrastructure Deployment** is an ITU initiative developed through a landmark partnership with the Communications, Space and Technology Commission (CST) of the Kingdom of Saudi Arabia.

The ITU extends its sincere appreciation to the **GEMS Advisory Team** for their invaluable guidance and expertise. Their strategic insights and thorough review have significantly strengthened the Global Economic Model and Study, ensuring its methodological robustness and enhancing its global credibility. Thanks to their dedication, GEMS serves as a trusted resource for evidence-based policymaking and for advancing inclusive digital development worldwide.

The **GEMS report builds on findings** from ITU research on the economic contribution of broadband, digitization, and ICT regulation. It is also based on an extensive compilation and analysis of statistical data from national and international sources, as well as data from the ITU DataHub, the ITU ICT Regulatory Tracker and the Digital Development Index developed by the Asia Development Bank and the Digital Ecosystem Development Index by the Development Bank of Latin America (CAF).

The GEMS report and analytical tool were prepared by ITU experts Dr Raul Katz and Dr Juan Jung from Telecom Advisory Services (Teleadvs), in collaboration with experts from the ITU Telecommunication Development Bureau (BDT). The lead author of the study is **Dr Raul Katz**, who holds a PhD in Political Science and Management Science and an MS in Communications Technology and Policy from the Massachusetts Institute of Technology (United States). He also earned a *Maîtrise* and *Licence* in Communication Sciences from the University of Paris, as well as a *Maîtrise* in Political Science from the University of Paris–Sorbonne (France). **Dr Juan Jung**, holds a PhD and an MA in Economics from the University of Barcelona (Spain) and a BA in Economics from the University of the Republic (Uruguay). Dr Jung is a Senior Economist at Telecom Advisory Services, specializing in the telecommunications and digital industries, with extensive experience in economic impact analysis and regulatory assessment in the telecommunications sector.

Disclaimer

ISBN

978-92-61-42251-6 (PDF version)
978-92-61-42261-5 (EPUB version)

Please consider the environment before printing this report.

Global Economic Model and Study (GEMS) Tool

for Digital Infrastructure Deployment

May 2026

Table of contents

List of figures and tables

Figures

Tables

Foreword

Achieving universal and meaningful connectivity remains one of the defining challenges of our time. While significant progress has been made in expanding access to digital technologies, billions of people remain unconnected or underserved, particularly in rural and remote areas. Bridging this divide is not only a technological imperative, but also a socio-economic necessity, one that underpins inclusive growth, innovation, and the realization of socio-economic development for all.

The Global Economic Model and Study (GEMS) Tool for Digital Infrastructure Deployment has been developed in response to this challenge. It reflects a shared commitment to move beyond aspirations and toward actionable, evidence-based solutions.

This publication introduces both a comprehensive methodological framework and an analytical econometric tool designed to support policymakers, regulators, operators, and industry stakeholders. By integrating econometric modelling with real-world data, GEMS enables users to assess investment needs, evaluate commercial viability, and quantify broader socio-economic impacts. It also provides a platform to test policy and regulatory scenarios, helping to identify pathways that can make connectivity investments both sustainable and inclusive.

What distinguishes GEMS is its holistic perspective. It brings together the roles of government, the private sector, and development partners into a single analytical environment. In doing so, it facilitates informed dialogue, supports strategic decision-making, and strengthens the case for coordinated action.

I hope that this publication, together with the GEMS economic tool, will serve not only as a contribution to ongoing global efforts, but also as a practical instrument to support country-level action. By fostering collaboration among policymakers, regulators, investors, and development institutions, it aims to help translate ambition into implementation. Through such collective efforts, we can accelerate progress toward a more connected, inclusive, and resilient digital future.

Dr Cosmas Luckyson Zavazava
Director of the Telecommunication Development Bureau
International Telecommunication Union

Executive summary

Globally, an estimated 6 billion people, around three-quarters of the world's population, were using the Internet in 2025, up from a revised estimate of 5.8 billion in 2024. At the same time, 2.2 billion people remain offline, a modest decline from 2.3 billion the previous year. The report underscores the enduring digital divide, particularly between urban and rural areas: worldwide, 85 per cent of urban residents are online, compared with just 58 per cent in rural areas.

The world's online population grew by more than 240 million people in 2025, according to *Facts and Figures 2025*[1] released by the International Telecommunication Union (ITU). The new estimates confirm continued progress in expanding digital connectivity, while also highlighting persistent disparities in the quality of access that affect how individuals benefit from Internet use.

To help address these connectivity challenges, the Global Economic Model and Study (GEMS) Tool for Digital Infrastructure Deployment is an initiative of the International Telecommunication Union (ITU) sponsored by the Communication, Space and Technology Commission (CST) of the Kingdom of Saudi Arabia that aims to leverage digital technologies for realizing the Sustainable Development Goals, through closing the digital divide and connecting the unconnected.

The purpose of this effort is to develop a comprehensive collaborative model to address the economic and financial challenges faced by telecommunication/ICT network operators when deploying infrastructure, especially in rural and remote areas. The GEMS culminates in the development of a tool that integrates an economic and financial assessment using econometric modelling to measure the impact of digital and telecommunication infrastructure on the economy.[2] The aim is to guide policy-makers, regulators, service providers, and funding institutions for conducting and supporting investment decisions, and in the application of regulatory practices aimed at mitigating the investment effort. Along these lines, more than a tool, the GEMS is positioned as a whole-of-government strategic platform supporting fiscal planning, cross-industry coordination, and structured engagement with development partners. This initiative is consistent with the ITU Digital Regulation Handbook, which emphasizes evidence-based policy-making and multistakeholder cooperation as approaches to meet the connectivity challenge. Along these lines, GEMS is conceived as a strategic enabler focused on addressing the coordination needs among governments, private sector, multilateral institutions, and civil society at large to tackle the connectivity needs:

- Positioned as a "diplomatic instrument" to help policy makers negotiate with multilateral development banks, sovereign funds, private investors, and other sectors ministries (e.g. finance, health, education, etc.) and agencies (innovation, technology competitiveness, etc.).
- Promoted as an advocacy platform that can help regulators promote the idea of collaborative digital investment to other sectors of the economy.
- Help the private sector with access to capital.
- Stimulate awareness in other government agencies regarding the connectivity challenge.

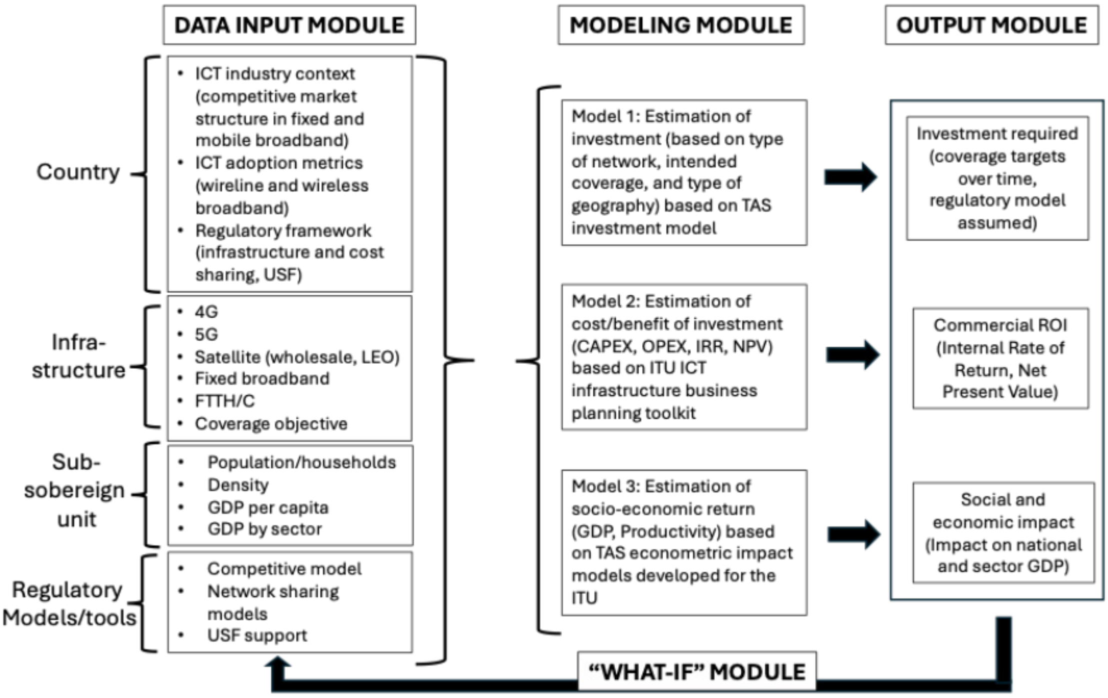
---

[1] ITU [Facts and Figures 2025]

[2] It leverages the ITU Business Panning for Infrastructure development Toolkit and the Economic Impact of Broadband, Digitization and ICT Regulation series of publications.

The output delivered by the tool is designed to be tailored to the context of each country and its regions (urban, suburban and rural), estimating investment requirements and resulting broadband adoption and speed gains, and potential private and social returns on such investments, allowing for the test of the impact of regulatory and funding mechanisms in mitigating the investment effort. The tool is conceptually structured around four modules (see Figure A).

Figure A: Conceptual Structure of GEMS tool



Source: Telecom Advisory Services analysis

The conceptual structure of the GEMS tool is based on three main modules: 1) Data Input Module: it describes the list of data inputs from a point of view of a Country, infrastructure, sub-sovereign unit and regulatory models/tools applied; 2) Modelling Module: it describes the estimation of investment based on Telecom Advisory Services (TAS) investment models; and 3) Output Module: it describes the results in terms of investment required, commercial return on investment (ROI) and social and economic impact.

The first module (Data Input) captures the country economic and technology conditions as well as targets for broadband network deployment under technology neutrality assumptions, considering 4G, 5G, fibre to the home (FTTH), and satellite (both under wholesale and retail low Earth orbit (LEO) business models). The second module (Modelling) is composed of a set of econometric models aimed at measuring the impact on the return on investment of operators (ROI) and on the economy as a whole in terms of gross domestic product (GDP) contribution. The third module (Output) estimates the results at the social and private level of the deployment of network technologies.[3]

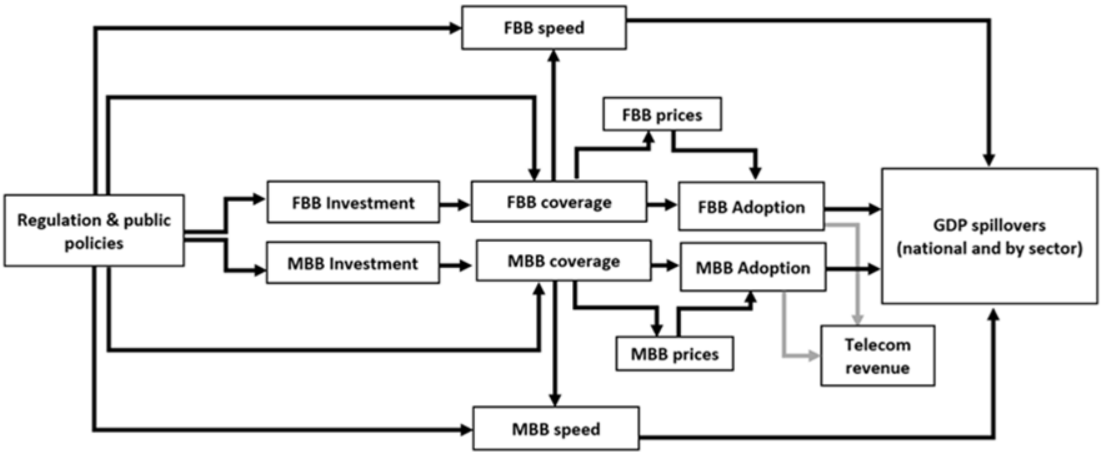
---

[3] The "social" return of connectivity addressed in GEMS is somewhat restrictive, insofar that it reduces it primarily to a macroeconomic metric of GDP per capita. It should be noted that, while important, this approach does not capture wider societal benefits of connectivity such as improved access to education, healthcare, financial inclusion, and public services delivery.

The data input module accounts for regulatory conditions underlying a connectivity plan, such as spectrum assignment predictability, licensing timelines, and infrastructure sharing conditions.[4]

The econometric models underlying the second module (fixed broadband (FBB) and mobile broadband (MBB)) are designed around a series of causal flows that link the successive chains in the dynamic process that goes from regulation and policy to investment and ends in economic impact across society and the return on investment for the operator (Figure B). As can be seen in Figure B, this requires estimating the impact of the investment on broadband coverage, speed levels, and adoption. These econometric models were estimated for a sample of 109 countries worldwide.

Figure B: Diagram of causal flows to be estimated



Source: Telecom Advisory Services analysis

The "what if" module shows the relationship among the Modelling module (defined by 3 models (model 1: Estimation of investment); model 2 Estimation of cost/benefit; model 3: Estimation of socio-economic return), the Output module (Investment required, Commercial ROI, Social and economic impact) and the Data Input module based on Country, Infrastructure, Sub-sovereign unit and Regulatory Models/tools). It allows testing different planning conditions and assumptions.

In sum, the tool serves as a platform to test the private (operators) and social returns of an infrastructure plan aimed at addressing digital connectivity challenges of any country. It has the flexibility to accommodate varying planning horizons (common in medium-term infrastructure plans) and data availability, allowing proxy values when detailed datasets are unavailable. In doing so, it integrates demand-side factors such as affordability, and device access, to estimate GDP impact resulting from broadband adoption.

Several pilot cases were developed to calibrate the tool and test its results and capability. This document presents the case studies of Ghana, Guatemala and Saudi Arabia.

---

[4] It should be stated that many countries face significant data gaps or where data collection mechanisms are still evolving. A separate "How-To" user manual has been developed separately, which jointly with regional training programmes, it will include practical training workshops and tutorials, will provide clear guidance on how to address incomplete datasets, including the use of proxies, default values, or interpolation techniques.

Ghana, for example, is a country that currently has limited coverage of 5G (13.6% of the population)[5] and FTTH (3.9% of households passed)[6], while 4G has reached almost universal deployment (99.3% of the population)[7]. The project simulated consists in expanding the footprint for 5G and FTTH, to cover the entire population and households located in urban and suburban areas. For 5G a timeframe of 5 years to reach the goal is established, while in the case of FTTH the timeframe is expanded to 8 years, given that the starting point is much lower. Considering that there is still 1.8 per cent per cent of people living in rural areas out of the reach of 4G networks, the simulation also includes a demand stimulus applicable to the purchasing devices and connectivity from LEO satellite broadband services that are currently covering the country.

If this project is completed in time, both fixed and mobile broadband adoption and respective broadband speeds will increase considerably. Fixed broadband adoption is expected to reach 41 per cent of households in eight years, while mobile Internet unique subscribers will account for nearly 40 per cent of the population by the fifth year (these estimations are largely conservative as they do not consider the natural growth trends in adoption for both technologies). In addition, users of LEO satellite broadband will reach more than 17 000 subscribers, which will increase the connectivity in zones out of reach of conventional fixed and mobile broadband. The average fixed broadband speed will reach 885 Mbit/s (from 50.42 right now according to Ookla), while the average for mobile broadband will grow to 70 Mbit/s (from 21.20 currently achieved by MTN according to Speedgeo). All these effects will yield important economic spillovers[8], both in the aggregate (GDP growth of 1.40%) and for different sectors (primarily, wholesale and retail trade, manufacturing, IT and financial services). However, while generating a substantial economic impact, the project under current regulatory conditions yields a negative return on investment for telecommunication operators.

Consequently, the investment effort will only be profitable for telecommunication operators if deep regulatory reforms and policies are implemented. The first action aimed at mitigating this negative returns would be for the regulatory agency to implement some regulatory reforms. Two initiatives have been identified that could have a positive mitigating impact on the investment business case:

- Allowance of spectrum secondary trading, defined as the option to trade spectrum rights or licences directly between original licensed holders and buyers or leasers. Ghana is not currently allowing this practice.
- Foster infrastructure sharing obligation, which addresses the mandate to share towers, base stations, posts, ducts or granting its access and use of public telecommunication networks (e.g., optical fibre, wireless) required by monopoly or dominant operators. Currently, the country is not implementing this measure.

Yet, even under these new conditions, while the rate of return improves, the initiative requires additional funding support. Considering the project's social desirability, the government should also make some funding contribution:

- Universal service must contribute to financing an important percentage of the required investments (30% of total investment).

---

[5] Source: GSMA.

[6] Source: National Communications Authority of Ghana (NCA).

[7] Source: GSMA.

[8] Economic spillover is defined as an indirect impact that an economic event, activity, or policy in one area (like a region, country, or sector) has on another one. These effects are also known as economic externalities.

- Create subsidies to stimulate demand. This is critical as affordability problems are limiting the access to digital services of important segments of the population. More demand will mean more revenue for the operators (then contributing to making the deployments profitable) and also larger economic impact through spillovers across the economy. It is assumed that the economically disadvantaged 50 per cent of the population will benefit from a reduced price by 40 per cent, while users of LEO broadband will see their monthly fee reduced by 50 per cent and the hardware kit subsidized by the government.

Finally, to improve the project financial profile, another policy strategy is proposed, which consists in making other national sectors of the economy, such as wholesale and retail trade and financial services contribute to network deployments. In this case, an overall 0.1 per cent fee was charged on each sector revenues, which is more than enough to make these investments profitable and thus, for the operators to have incentives to deploy the necessary infrastructure.

As briefly explained in the Ghana pilot case study, the GEMS tool demonstrates that ambitious connectivity goals, while being hugely beneficial to a nation's economy, are often commercially unviable under current regulatory models. GEMS provides a clear roadmap to bridge this gap by identifying specific, quantifiable policy levers. It also allows to test basic regulatory and funding assumptions, based on research evidence and econometric analysis, influencing the deployment of broadband technologies.

In summary, this first version of GEMS (1.0) represents the first output of the development effort. A future next-generation version is envisioned for development, containing expanded analytical capabilities, improved modelling flexibility and additional indicators. As such, the tool will continue evolving over time alongside technological and policy developments.

Acronyms

ADSL	Asymmetric Digital Subscriber Line
CAPEX	Capital Expenditure
CPP	Connectivity Planning Platform
FBB	Fixed Broadband
FTTH	Fiber to the Home
FWA	Fixed Wireless Access
GDP	Gross Domestic Product
GEMS	Global Economic Model and Study
GSMA	Global System for Mobile Communications Association
HHI	Herfindahl-Hirschman Index
ICT	Information and Communication Technologies
IMF	International Monetary Fund
IoT	Internet of Things
ITU	International Telecommunication Union
LEO	Low Earth Orbit
MBB	Mobile Broadband
MDB	Multilateral Development Bank
MVNO	Mobile Virtual Network Operator
OECD	Organisation for Economic Co-operation and Development
OTT	Over-the-Top
QoS	Quality of Service
RIO	Reference Interconnection Offer
ROI	Return on Investment
SDG	Sustainable Development Goals
SME	Small and Medium-sized Enterprise
TAS	Telecom Advisory Services
USF	Universal Service Fund(s)
VoIP	Voice over Internet Protocol
WACC	Weighted Average Cost of Capital
WB	World Bank
xDSL	Digital Subscriber Line

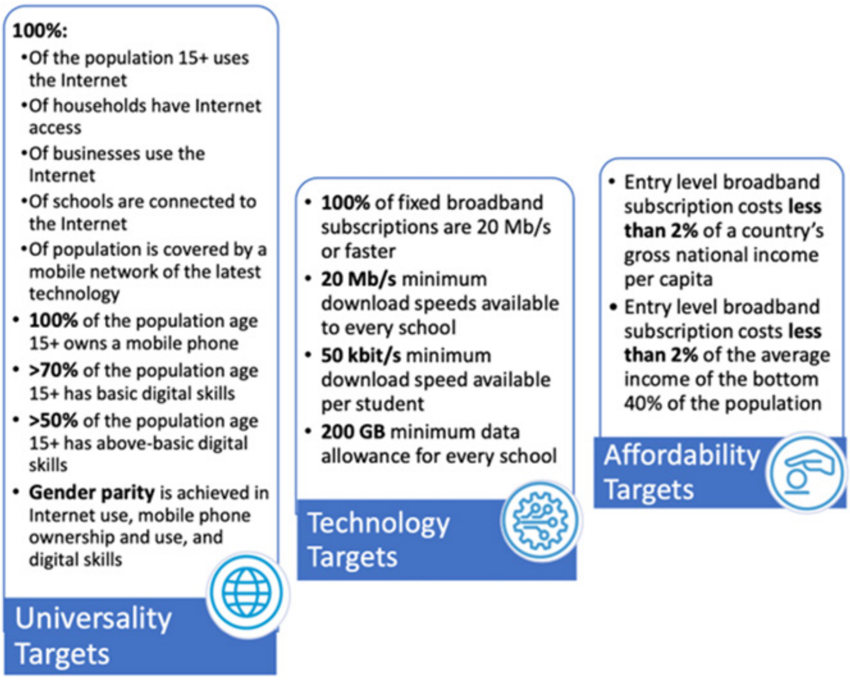
1 Introduction

An estimated 6 billion people – around three-quarters of the world's population – were using the Internet in 2025, up from a revised estimate of 5.8 billion in 2024. At the same time, 2.2 billion people remain offline, a modest decline from 2.3 billion the previous year. The report underscores the enduring digital divide, particularly between urban and rural areas: worldwide, 85 per cent of urban residents are online, compared with just 58 per cent in rural areas.

The world's online population grew by more than 240 million people in 2025, according to *Facts and Figures 2025*[9] released by the International Telecommunication Union (ITU). The new estimates confirm continued progress in expanding digital connectivity, while also highlighting persistent disparities in the quality of access that affect how individuals benefit from Internet use.

Reflecting these conditions, the International Telecommunication Union (ITU) published in 2020 the *Connecting Humanity by 2030* report, which established the goal of achieving universal, affordable broadband Internet connectivity by the end of the decade. This goal was predicated on a set of aspirational targets[10] (see Figure 1-1).

Figure 1-1: Aspirational targets for 2030



100%:

- Of the population 15+ uses the Internet
- Of households have Internet access
- Of businesses use the Internet
- Of schools are connected to the Internet
- Of population is covered by a mobile network of the latest technology
- **100%** of the population age 15+ owns a mobile phone
- **>70%** of the population age 15+ has basic digital skills
- **>50%** of the population age 15+ has above-basic digital skills
- **Gender parity** is achieved in Internet use, mobile phone ownership and use, and digital skills

Universality Targets

- **100%** of fixed broadband subscriptions are 20 Mb/s or faster
- **20 Mb/s** minimum download speeds available to every school
- **50 kbit/s** minimum download speed available per student
- **200 GB** minimum data allowance for every school

Technology Targets

- Entry level broadband subscription costs **less than 2%** of a country's gross national income per capita
- Entry level broadband subscription costs **less than 2%** of the average income of the bottom 40% of the population

Affordability Targets

Source: International Telecommunication Union. "Aspirational targets for 2030." April 2022. Available at: https://www.itu.int/itu-d/meetings/statistics/umc2030/.

In this context, the ITU released in 2025 an *Action Blueprint* aimed at fulfilling the aspirational targets through sustainable, affordable, and innovative solutions, which determined that universal, meaningful connectivity will require an investment ranging between USD 2.6 and 2.8 trillion.[11]

---

[9] ITU Facts and Figures 2025

[10] International Telecommunication Union. "Aspirational targets for 2030." April 2022. Available at: https://www.itu.int/itu-d/meetings/statistics/umc2030/.

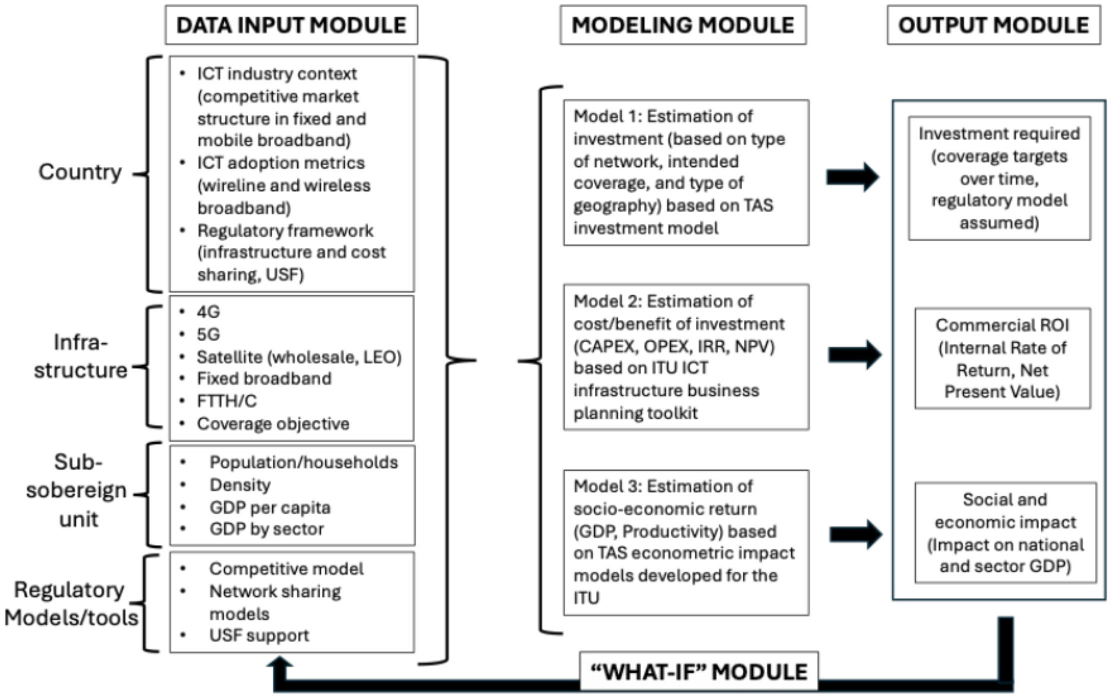
[11] International Telecommunication Union (2025). *Connecting Humanity through sustainable, affordable, and innovative solutions: Action Blueprint.*

The current project was conceived to help to address these actions at the national level. This Global Economic Model and Study (GEMS) Tool for Digital Infrastructure Deployment is an ITU initiative sponsored by the Communication, Space and Technology Commission (CST) of Saudi Arabia aimed at developing a comprehensive collaborative model to address the economic and financial challenges faced by telecommunication/ICT network operators when developing infrastructure, not only in high density urban concentrations but also in rural and remote areas. To enable the evaluation of the investment impact, the underlying tool of GEMS integrates a socio-economic assessment using econometric modelling to measure the impact of digital and telecommunication infrastructure development on the economy. In addition, the tools provide a framework to estimate the return on investment for telecommunication operators responsible for deploying such infrastructure.

As such, the GEMS platform is designed to guide policymakers, regulators in the application of regulatory practices and telecommunication operators on investment decisions, thereby promoting sustainable economic growth and innovation.

At a more concrete level, the GEMS tool represents an analytical platform that allows policymakers to estimate the investment required to achieve full connectivity in a country, disaggregated by urban, suburban and rural contexts. Its starting point is the current state of coverage of fibre to the home (FTTH), 5G and 4G mobile networks. From the current situation, it estimates the investment required to complete connectivity, assessing the potential returns on such investment, and stipulating business opportunities and business models. In addition, by factoring in market maturity, and the policy and regulatory environment, the GEMS tool has the capability of assessing the impact of changes in regulation and/or implementation of funding initiatives to improve the social and private return on investment. The tool is conceptually structured and described in Figure 1-2.

Figure 1-2: Conceptual structure of the GEMS tool



Source: International Telecommunication Union

The conceptual structure of the GEMS tool is based on four main modules: 1) Data Input Module: it describes the list of data inputs from a point of view of a Country, infrastructure, sub-sovereign unit and regulatory models/tools applied; 2) Modelling Module: it describes the estimation of investment based on Telecom Advisory Services (TAS) investment models; and 3) Output Module: it describe the results in terms of investment required, commercial ROI and social and economic impact; and last one is the "What if" Module. All these are described in the text below. Following the diagram in Figure 1-2, the tool is constructed around four modules:

- Data input module, where the user inputs information into four components which drive investment and returns:
    - The overall country context where the infrastructure will be deployed; the variables of ICT industry context, service adoption, and regulatory framework are critical influencing patterns on the level of ICT infrastructure investment and economic impact.
    - Type of infrastructure (4G, 5G, FTTH, satellite) targeted for deployment and the coverage objective, given that investment levels vary by technology. It should be clarified that GEMS considers not only low-earth orbital (LEO) services but also geostationary orbit satellites offering service on a wholesale basis.
    - Characteristics of the sub-sovereign unit: data at sub-national level is required considering that the tools are intended to provide analysis at the regional level (e.g. urban versus rural), that investment in infrastructure varies widely by type of geography, while that the economic impact is intended to be calculated by sector of the economy.
    - Regulatory models and tools: the return of investment in network infrastructure is directly dependent upon the level of competition and more importantly, network sharing agreements that are conducive to reducing the investment per operator. There are cases that even under the prior conditions, the contribution of a universal service fund will be required.
    - It should be stated that many countries face significant data gaps or where data collection mechanisms are still evolving. A separate "How-To" user manual has been developed separately, which jointly with regional training programmes will provide clear guidance on how to address incomplete datasets, including the use of proxies, default values, or interpolation techniques. Along these lines, users should be cautioned against using average coefficients across countries since this may limit the precision of final GEMS results. A "one-size-fits-all" approach could therefore lead to misleading conclusions or reduce GEMS validity.
- Modelling modules: once the data is entered in the first module, it is used as inputs in three models:
    - Model 1: estimation of investment required. For this model, the tool relies on econometric models developed to estimate the impact of investment required to achieve coverage for different types of networks. While a primary emphasis of the investment required is on the last mile, the estimates include prorated costs of middle-mile infrastructure (transport and backbone) since these elements are critical for network performance, cost efficiency and scalability. Additionally, the models are indirectly validated by the Connectivity Planning Platform (CPP)[12] developed in the context of the Last Mile Connectivity model.[13]

---

[12] See ITU (2025) Connectivity Planning Platform (CPP) at https://www.itu.int/itu-d/sites/cpp/#event-cpp-version-200-brto-be-released-by-30012027

[13] See International Telecommunication Union (2025). Last Mile Connectivity Solutions Guide: Practical Strategies for Sustainable Expansion. Available at: https://www.itu.int/en/ITU-D/Technology/Pages/Connectivity.aspx

  - Model 2: estimation of cost/benefit of investment. For this purpose, the ITU *ICT infrastructure business planning toolkit*[14] together with the ITU Connectivity Planning Platform (CPP) is used as the framework to build a return on investment (ROI) model for assessing the financial return of network deployments.
  - Model 3: estimation of socio-economic return of the investment. In addition to the financial assessment of model 2, this model will estimate the economic impact (GDP) both at the national and sector level of investment. It is based on the econometric models developed for the *Economic Impact of Broadband, Digitization and ICT Regulation* series published by ITU. This research quantifies the positive impact of broadband, digital transformation, and the interplay of ICT regulation on national economies by applying econometric modelling techniques at regional and global level. The "social" return of connectivity addressed in GEMS is somewhat restrictive, insofar that it reduces primarily with a macroeconomic metric of GDP per capita. It should be noted that, while important, this approach does not capture wider societal benefits of connectivity such as improved access to education, healthcare, financial inclusion, and public services delivery.
- Output modules: the three sets of models of the modelling module will generate the results in the three assessment areas: level of investment, commercial return on investment, and socio-economic impact.
- "What if" module: as the practice in project finance indicates, it might very well happen that, while the socio-economic impact is positive, the financial return of an infrastructure project is not viable (e.g. negative rate of return), especially in rural areas. Under these conditions, a feedback loop is constructed in the tool to be able to re-estimate the results under different regulatory models and/or remedies (e.g. promote network sharing agreements, provide universal service fund contribution, etc.).

The tool considers the capabilities of each country and each region within a country, in order to assess the potential for generating revenue and economic growth. Moreover, by implementing policies and regulations that promote the ongoing modernization of networks and ensuring compliance with national goals and aspirations of the government, and public-sector requirements for higher capacity and speed, government actions can help align the infrastructure with both economic development goals and the evolving needs of government entities.

The rest of the document provides the underlying concepts and methodology, theoretical framework, and operating structure of the GEMS tool. Chapter 2 describes the relevance of this initiative. In Chapter 3 provides the theoretical framework of causal links that take place from the investment decision to the economic impact, presenting the empirical analysis obtained. Chapters 4 through 6 present five pilot case studies to demonstrate the capability and underlying functionality of the GEMS tool.

How to use GEMS to negotiate?

The GEMS tool is a platform used to test the private (operators) and social returns of an infrastructure plan aimed at addressing digital connectivity challenges of any country. It has the

---

[14] International Telecommunication Union (2023). *ICT infrastructure business planning toolkit*. Available at: https://www.itu.int/pub/D-PREF-EF.ICT_STRUCT_KIT-2023. This toolkit offers regulators and policy-makers a clear and practical methodology for the accurate economic evaluation of broadband infrastructure deployment plans for 5G networks and satellite solutions. This toolkit serves as a practical resource designed to facilitate the economic quantification and evaluation of ICT infrastructure deployment plans. It provides both theoretical principles and practical guidelines for estimating the net present value (NPV) of a project. Specifically, the toolkit outlines mechanisms for assessing project demand, operating and maintenance costs, expected revenues, required investments, and capital costs.

flexibility to accommodate varying planning horizons (common in medium-term infrastructure plans) and data availability, allowing proxy values when detailed datasets are unavailable. In doing so, it integrates demand-side factors such as affordability, and device access to estimate the GDP impact resulting from broadband adoption.

By estimating alternative scenarios to fulfil national connectivity infrastructure plans, GEMS can support policy-makers, regulators, and private operators in their dialogues with ministries of finance, multilateral development banks and other sector ministries and agencies around funding and policy negotiations. As such, it is an evidence-based tool that estimates programme financial viability and provides a backdrop against which all parties can negotiate their respective contributions.

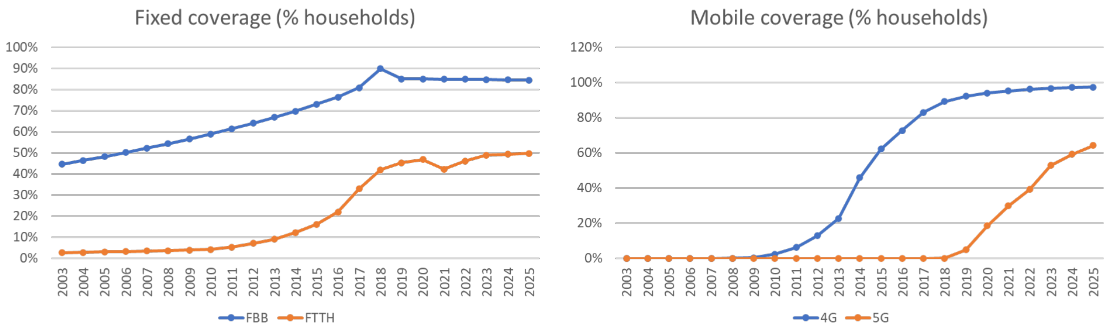
2 Relevance of the GEMS (Global Economic Model and Study) initiative

2.1 Why is a GEMS tool needed?

Despite important advances in the past decade, the digital divide remains a critical gap in the provision of universal connectivity to the world population. In 2024 alone, 227 million new people connected to the Internet for the first time, bringing the total number of connected people to 5.5 billion (or 68% of the global population). That being said, 2.6 billion remain offline as of the end of 2024.[15]

As it has been studied in prior research, the divide is driven by a combination of supply side and demand factors.[16] Supply side is typically measured by network coverage, although it can also include metrics such as quality of service. As reflected in Figure 2-1, while fixed broadband world coverage has reached 85 per cent of the households passed and 4G has reached almost universal service footprint, there is still an important gap to bridge regarding new generation technologies: FTTH and 5G networks currently cover approximately 50 and 60 per cent of the households and people respectively.

Figure 2-1: World: broadband coverage evolution



Sources: ITU; IDATE; OECD; GSMA; regulatory agencies; Telecom Advisory Services analysis

---

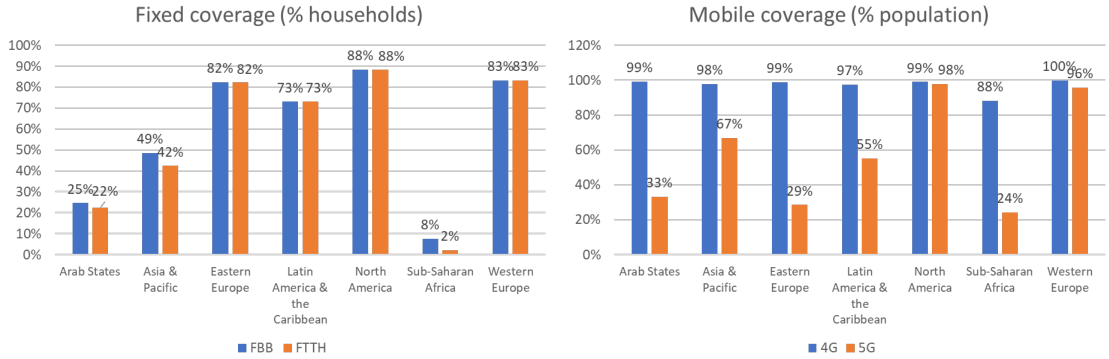
[15] International Telecommunication Union (2024). *Measuring digital development: Facts and figures 2024*. Available in: https://www.itu.int/en/ITU-D/Statistics/pages/facts/default.aspx

[16] See Katz, R. and Berry, T. (2015). *Driving demand of broadband network and services*. London: Springer.

Region-level analysis provides some important nuances to be considered in these statistics. Fixed broadband technologies have reached more than 90 per cent of households passed in the Americas, Europe, and Arab States regions, but it remains very limited in sub-Sahara Africa. Furthermore, the Asia-Pacific and Arab States regions still have most of the households without being passed by FTTH, while in sub-Sahara Africa this technology is almost non-existent. While 4G is widely deployed in most regions of the world, its coverage level in Sub-Sahara Africa reaches 88 per cent of the population.

In turn, 5G has reached 98 per cent coverage in North America and 96 per cent in Western Europe but is in its early deployment in Sub-Sahara Africa (24%), Eastern Europe (29%) and Arab States (33%), and is still lagging in Latin America and the Asia-Pacific (Figure 2-2).

Figure 2-2: Broadband coverage by region (2025)



The differences in coverage have a second explanatory dimension: the gap between urban and rural dwellers. Of the 2.6 million people who remain unconnected, 1.8 billion live in rural areas. Beyond coverage, the demand side gap is explained by variables including affordability of service, digital literacy and relevance of cultural content.[17] While service affordability has been improving around the world, the cost of fixed broadband in low-income countries is still roughly a third of average monthly income, much higher than the aspirational target of 2 per cent stipulated by the ITU/UNESCO Broadband Commission for Sustainable Development.

This descriptive evidence suggests that important efforts are needed by global and national stakeholders to accelerate the process of closing the digital divide. On the supply side, the deployments have not been fast enough due to high costs and economic barriers, while on the demand side, cognizant of the telecommunication operators economic constraints, additional initiatives on service and device pricing are required to be put in play.

In this context, the GEMS platform is a critical contribution for analysing new economic models and revenue streams, while recognizing potential roles of related stakeholders for infrastructure development with suggested recommendations. These models consider the conditions and capabilities of each country and each region within them, to assess the potential for generating revenue for telecommunication operators and fulfilling derived economic growth.

This is a relevant tool to support ICT policy-makers, regulators and other stakeholders to understand and apply economic evaluations by relying on economic evidence generated by prior empirical research and supported by econometric models. The tool is an input that will

---

[17] See Katz, R. and Berry, T. (2015). *Driving demand of broadband networks and services*. London: Springer.

help public authorities promote equitable access to digital services across different regions of countries, and to facilitate the development of collaborative investments from various entities/resources, including universal service financing, and, potentially, contributions of other national government sectors and stakeholders.

2.2 The GEMS tool provides results by type of networking technology and country

GEMS addresses deployment strategies of four types of networking technologies: Fibre to the home (FTTH) for fixed broadband, 4G, 5G, and satellite. While recognizing that fixed broadband can be supported by other technologies (ADSL, xDSL, hybrid fibre coaxial), it assumes that FTTH is the sole technology capable of supporting current and, more importantly, future last-mile data transport needs in urban and suburban areas. In the case of wireless broadband, 4G is considered to be the most economic technology to provide connectivity in rural areas, while 5G remains the most suited for last mile in urban and suburban areas. Finally, satellite technology is considered as the only infrastructure capable of supporting access at extremely low-density geographies.[18]

Considering these technological assumptions, the tool addresses connectivity needs in three country segments based on the development of FTTH, 4G,5G and satellite:

- Advanced development (countries with advanced development of two of the four technologies under consideration, but with some potential progress to be made in one of them to reach universalization).
- Intermediate development (Countries where at least one of four technologies is significantly underdeveloped).
- Limited development (Countries depicting a significant delay in at least two out of four technologies).

The tool is applicable for each of the three countries' segments. Limited development countries can fully exploit the capabilities of the tool, by conducting simulations for deployment of two or three technologies in simultaneous mode, incorporating cross efficiencies and potential synergies into the analysis.

That said, the tool is also designed for situations in which simulation and calculations address one of the four technologies, thus being accurate for situations such as that of intermediate and advanced economies that typically have already made important progress to reach universalization.

Why Fixed Wireless Access (FWA) and satellite matter?

The GEMS tool serves as a platform to test the private (operators) and social returns of an infrastructure plan aimed at addressing digital connectivity challenges of any country. Along these lines, it considers Fixed Wireless Access (in the scope of 5G connectivity) and satellite technology (under a wholesale mode where a telecommunication operator purchases satellite backhaul as a service to serve rural areas, or where individual consumers purchase retail LEO service from an operator). Both Wireless technologies are key contributors to achieve full

---

[18] In this sense, the technology assumptions somewhat differ from the *Action Blueprint* which states that urban areas are to be served by optical fibre, locations between 300 and 1 person per square km should be served by 4G terrestrial networks, and locations under one person per square km are to be served by satellite.

connectivity needs considering limited fixed broadband or wireless connectivity, a condition prevalent in many developing regions. Fixed Wireless Access can provide broadband connectivity in countries with low fixed broadband deployment while satellite technology is considered as the only infrastructure capable of supporting access at extremely low-density geographies.

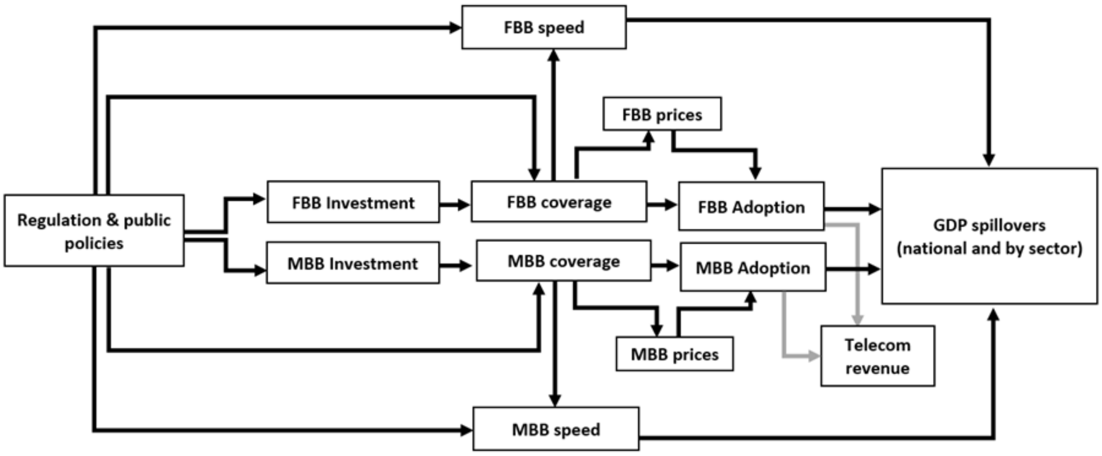
3 Theoretical and empirical frameworks of the GEMS tool: overview of the causal flows

As stated in the introduction, the data to be inputted by the GEMS user is of two types:

- Country conditions (Fixed and mobile broadband indicators such as current investment, coverage, download speed, revenues, and adoption, features of current regulatory framework as defined in the ITU ICT Regulatory Tracker, and socio-economic indicators such as GDP, population, households, and distribution by urban, suburban, and rural).
- Simulation targets (future coverage by year by urban, suburban and rural regions for different technologies, potential regulatory reforms to mitigate investment hurdles, and potential subsidies to be considered for either demand stimulation or investment).

Based on these data inputs, the tool estimates the investment required, funding mechanisms, socio-economic impact (for the economy as a whole and by sector) and rate of the return for the operators responsible of deploying the infrastructure. The estimation of all these variables is conducted through a series of causal flows linking each pair of variables (see Figure 3-1).

Figure 3-1: Diagram of causal flows to be estimated



Source: Telecom Advisory Services analysis

This chapter presents the underlying econometrically derived coefficients of each causal link, including the research literature associated with each of them, the empirical strategy to model them econometrically, and the main results obtained. All variables used in the empirical analysis are presented in Appendix A.1, including their source, description and main descriptive statistics.

3.1 Initial conditions of investment

3.1.1 Social and economic context

The internal conditions of the country to be analysed are crucial inputs that condition the results of the analysis. For this purpose, the user must compile data regarding the macroeconomic and demographic context of the country.

First, the latest GDP datapoint of the country (in USD billion) must be entered in the tool (sources for this data can be the International Monetary Fund (IMF), the World Bank (WB), or national statistical authorities[19]). In addition, the user will have to specify the weight (in %) of each of the following economic sectors in the country GDP:

- Administration and Support
- Construction
- Information and Communication Technologies
- Manufacturing
- Transportation and Storage
- Wholesale and Retail Trade
- Financial and Insurance
- Professional, Scientific and Technical services
- Health services

The statistics for all these sectors can be found in the country's national accounts, as reported by local statistic offices. It should not be a matter of concern if the latest data available is not from the current or past year, as the sectoral structure of the economy varies little over time. In addition, the tool will automatically calculate an additional sectoral category, labeled as 'others', which will capture all the remaining economic activities not included above.[20]

Required social and demographic inputs.

First, the latest figure of total population must be added, along with an estimation of the number of households. Population data is available in either the national statistics agency, or in international data sources such as the World Bank. The estimations of households by country are reported in the ITU DataHub[21] and should also be available in local data sources.

A critical input that must be provided next is the one referred to the breakdown of country population by urban, suburban and rural areas. In case the data is not readily available, the user can split countries into three areas, from those with the largest population density to those with the lowest. Based on this criterion, the three regions considered by country are assumed to be 'urban', 'suburban' and 'rural'. For each of them, the user must enter the share of national population living there, as well as the population density in each of them.

In general, this type of information is not directly available, which means that it will have to be estimated by the user relying on secondary sources. It is worth noting that each of these

---

[19] In case the data is compiled from national authorities it will have to be converted to USD since the tool uses this currency denomination for all calculations.

[20] This is because the data used for calculating the sector impact includes only a limited number of sectors.

[21] The world's richest source of ICT statistics and regulatory information-ITU DataHub(https://datahub.itu.int/)

areas does not need to be contiguous territories as is the case with administrative regions (such as departments or provinces). In fact, the urban area can be formed by all cities (or metropolitan areas) with more than a certain population threshold (for example, cities with more than 500 000 inhabitants). By adding the population and the area extension of each of them, data for urban centres is obtained. The second area may refer to the sum of all secondary or minor cities or towns (e.g.: cities with 50 000 to 500 000 inhabitants) and should be calculated in a similar manner. The remaining areas can be considered to be rural ones, typically reaching a population density of 100 inhabitants per square km.

3.1.2 Technology context

Following the socio-economic data, input must be provided for various indicators of wireline and wireless technologies. These figures must refer to current values, or to the latest available one, for the following variables:

- Telecommunication capital investment (capex) per capita (USD/year), for both mobile and fixed networks[22]
- Fixed broadband coverage (% households)
- FTTH coverage (% households)
- 4G coverage (% population)
- 5G coverage (% population)[23]
- Satellite coverage (considering both availability for wholesale service provisioning and LEO operations)
- Average downloading speed (Mbit/s), for both mobile and fixed networks
- Price (USD/month), for both mobile and fixed Internet representative commercial plans
- Fixed broadband adoption (% households)
- Mobile Internet unique subscribers (% population)
- Revenue (USD million/year), from both mobile and fixed services

Most of these data can be obtained or calculated from ITU DataHub the GSMA public site, or from the local regulatory authority. Coverage for fixed broadband can be more challenging to obtain, requiring relying either on local sources, such as data from local operators, or industry analyst data bases (such as IDATE for FTTH or OMDIA for fixed broadband). Satellite availability can be found either on the country regulator website, or in the case of LEOs by consulting operator coverage maps and pricing website.

Another important input refers to the current regulatory framework. For each country, the user must enter whether the following regulatory measures have been implemented in the country. This information can be easily compiled from the ITU ICT Regulatory Tracker:

- Types of licences provided
- Licence exempt
- Operators required to publish Reference Interconnection Offer (RIO)

---

[22] CAPEX is the primary value used since it remains the key determinant in understanding the return on investment.

[23] While GEMS does not address Fixed Wireless Access as an alternative technology due to the lack of data to estimate its social and economic return, the extensive 5G coverage provides an appropriate substitute.

- Interconnection prices made public
- Quality of service monitoring required
- Infrastructure sharing for mobile operators permitted
- Infrastructure sharing mandated
- Co-location/site sharing mandated
- Unbundled access to the local loop required
- Secondary trading allowed
- Band migration allowed
- Number portability available to consumers
- Individual users allowed to use VoIP
- National plan that involves broadband
- Legal concept of dominance or Significant Market Power

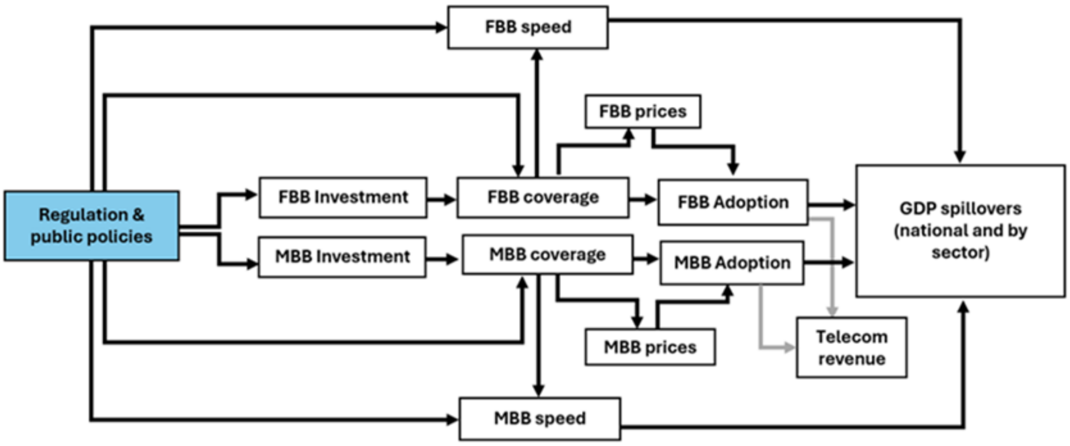
On a cautionary note, it is important to recognize that some of the identified macro sectors might include subsectors with different, maybe even contrasting, effects on spillovers, hence the need to focus on the right level of disaggregation. However, at this point, considering the limited availability it was decided to estimate effects at this level of aggregation.

Understanding the current regulatory framework is critical to know which areas must be changed to mitigate some of the investment burdens and allows estimating the economic impact associated with the implementation of the potential reforms.

3.1.3 Regulatory context

The research exploring the causal role of telecommunication/ICT sector regulation and policies points to their critical conditioning role in stimulating network deployment and migration to the latest technologies. Beyond specific policies, sector outcome is also expected to be influenced by the ICT institutional framework, as well as other contextual factors. Through its monitoring and enforcement capability, the ICT regulatory institutional framework intermediates the causality between policies and market outcomes. This is why the initial conditions of investment need to consider the current regulatory framework and policies (see Figure 3-2).

Figure 3-2: Causal link between regulation, investment and network performance



Source: Telecom Advisory Services analysis

From a wider perspective, Alesina et al (2005) estimated the effect of overall regulation pressure in several sectors, including telecommunications, for a sample of OECD countries from 1975 to 1998, identifying a relevant role of regulatory reforms. More recently, Arezki et al (2021) analysed the pace of technology adoption in the telecommunication sector, finding evidence of the role of market liberalization and a capable regulatory authority as driving factors behind a sustained pace of technology adoption.

In a similar vein, technology neutrality, a policy that allows the use of any technology supported by the deployed infrastructures, is supposed to encourage innovation and promote competition, allowing markets to determine which technologies will succeed. This is particularly important as the rapid pace of innovation advances make it necessary to have flexible mechanisms in place to migrate to newer technologies.

Another body of research has focused specifically on the role of spectrum management. The research literature tends to support the importance of spectrum management for the development of wireless communications. A consensus exists that to encourage substantial investment and innovation in mobile services, it is important to have a transparent, long-term plan that includes a strategy for making sufficient spectrum available under appropriate conditions. Considering this premise, spectrum management, its pricing, and the imposition (or absence) of associated obligations can have a significant impact on capital investment and innovation. This is generally supported by empirical evidence (see for instance, Bahia and Castells, 2021).

An additional regulatory factor promoting network deployment is the promotion of a flexible approach towards spectrum use by telecommunication operators. For example, spectrum secondary trading consists of a mechanism by which licence holders can transfer spectrum-usage rights on a voluntary commercial basis to other operators. This may result in more efficient use of the limited spectrum, ensuring that this resource does not lie fallow, but instead is used to deliver valuable services. It also adds flexibility to business planning for mobile operators.

Finally, the growth in data traffic means mobile operators must gain access to increasing amounts of spectrum to meet demand. When clearing new frequency bands for mobile use is not possible, spectrum sharing can offer a way to help by enabling mobile access to additional bands in areas, and at times, when other services or providers are not using them.

Beyond being affected by investment levels, coverage may also be influenced by regulatory measures, as operators may react to incentives in policies such as network sharing (Jung and Katz, 2023).

3.2 Investment and coverage: the key role of population density

Once the context variables of economic, technology and regulatory factors are entered in the tool, the first step in the causal modelling is the estimation of impact of these variables on capital investment (capex) and consequently, coverage. This indicator refers to capital spending in fixed assets (acquiring and upgrading property and networks) related to the infrastructure required to deliver services. It includes investments made for fixed and mobile-broadband services, such as information technology infrastructure and broadband networks.

The empirical equations that are econometrically relied upon in tool are described as follows:

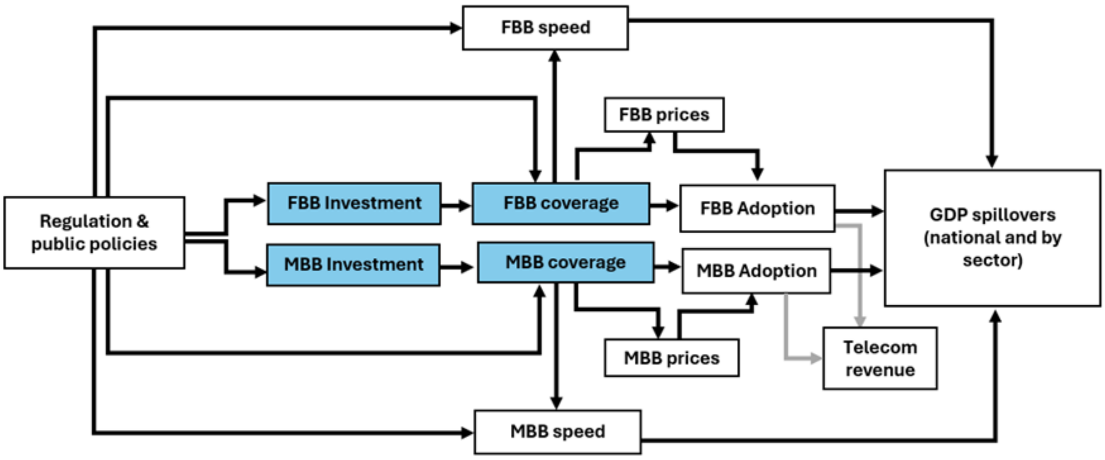
$$\log(MCapex\ pc)_{it} = \alpha_i^{MC} + \delta_t^{MC} + \beta^{MC}\log\left(MCapex\right)_{it-1} + \theta^{MC}Regulation_{it} + \gamma^{MC}X_{it} + \varepsilon_{it}^{MC}$$
$$\log(FCapex\ pc)_{it} = \alpha_i^{FC} + \delta_t^{FC} + \beta^{FC}\log\left(FCapex\right)_{it-1} + \theta^{FC}Regulation_{it} + \gamma^{FC}X_{it} + \varepsilon_{it}^{FC}$$

Where and represent country and year fixed effects, respectively, while *X* is a vector of controls (competition, urbanism, lagged revenues, and lagged GDP per capita). *MCapex pc* and *FCapex pc* refer to mobile and fixed investment per capita, respectively. The empirical specification used is roughly similar to the one implemented by Kim et al (2011).

The estimation of investment amount depends on past capex values. Given the conventional breakdown of capex in terms of non-discretionary spending and modernization investment, it is reasonable to consider the prior year capex as a valid variable. This has been proven empirically: a 1 per cent increase in past-year capex will raise current years in 0.86 per cent for the case of mobile networks, and 0.59 per cent in the case of fixed ones (Table A-5 in Appendix). This is a key point of departure from other conventional ways of estimating capex requirement: rather than focusing on how much investment is required to fulfil a certain deployment, a realistic level is defined, which is driven by historical investment levels.

However, it is important to consider that beyond the historical capex levels, the amount of future capex is expected to be influenced by other variables, such as competition intensity[24] (Genakos et al., 2018; Kim et al, 2011), regulatory conditions[25] (Alesina et al, 2005; Kim et al, 2011), and urbanization level (Katz and Jung, 2023). On the other hand, there is additional research that highlights how macroeconomic factors can affect investment levels (see for example Shaalan, 1990), therefore controlling by variations on the economic cycle is relevant (e.g.: GDP per capita) (see Figure 3-3).

Figure 3-3: Causal link between capex and coverage



Source: Telecom Advisory Services analysis

---

[24] We measure this indicator through market concentration metric of Herfindahl-Hirschman Index (HHI). This is measured by squaring the market shares of market participants. Lower levels of this indicator are associated with higher competition intensity, which is expected to drive price competition by creating incentives to reduce them.

[25] Refers to public policies and norms adopted by sector regulators that can potentially affect deployment costs and stimulate or discourage investments. Examples can be infrastructure sharing, spectrum trading in secondary markets, and technological neutral spectrum licensing.

Having formalized the future capex level based on historical, regulatory and economic variables, the next step in the diagram concerns the coverage of networks. Coverage refers to the extent of network deployment across the country, measured as a share of the population (or share of households) that can potentially access the service. From a perspective of economic causality, it is the investment that drives coverage enhancements (Katz and Jung, 2023). This is also associated with a year lag established between investment and coverage expansion in the econometric analysis, as there are construction and bureaucratic process that take some time to materialize. This means that, through the econometric results, next year coverage can be determined if current capex is increased by a certain level. However, the aim is to use these results to answer the inverse question by applying a reverse approach: how much capex is required to reach certain coverage levels in the future?

Relevant research on estimating telecommunication deployment investment was conducted in 2019 by Cartesian for the Fiber Broadband Association, that carried out a study to estimate the cost of deploying FTTH in the United States of America with the purpose of supporting the discussion of public policies related to fulfilling ultra-fast broadband coverage options. The estimation of the costs of using optical fibre for fixed network distribution considers population density as a determining economic factor, since the amount of investment tends to increase with a lower density. Cartesian (2019) segmented the uncovered territory according to population density and created groups to calculate the deployment cost for each group based on operator experiences and benchmarks. Based on these observations, the cost per household for deployment in each area can be calculated. This model estimated that the cost per household passed by FTTH in urban areas is approximately USD 700-1 500, while, in rural areas, it ranges between USD 3 000 and USD 6 000, depending on population density.[26] Beyond the increase in cost per household passed as density decreases and topography becomes more complex; the study concludes that FTTH deployment in low-density rural areas is not economically feasible. In contrast, this area should be served by wireless technology.

As for 5G deployments, a report submitted to the European Commission by a consortium made up of Tech4i2, Real Wireless, Trinity College, Interdigital (2016), considers that the cost of 5G deployment per subscriber will follow an extrapolation of the investment costs for each previous generation of wireless technology. Thus, the authors project the cost per user for 5G in a linear manner based on 2G, 3G, and 4G costs derived from Selian (2001). The cost per subscriber estimated in this highly qualitative study includes, according to analysts, radio and backhaul equipment costs, excluding maintenance, sales, marketing, billing, and administrative costs.

A more rigorous study developed by Oughton and Frias (2018) estimated the costs for 5G rollout in Great Britain. The analysis is based on building technology architectures based on traffic models, mobile broadband adoption, and population density. Each postcode in the country is categorized according to antenna density, extrapolating 4G site deployment and future 5G needs. The study defines scenarios based on alternative models of infrastructure sharing and quality of service by region. The urban-suburban scenario defined by the authors stipulates that deployment is carried out in all the areas corresponding to first and second level metropolitan centres. This strategy is similar to most of the 5G deployment plans formulated by operators in advanced economies, where the uniform speed to be offered is symmetrical 50 Mbit/s. After

---

[26] Studies conducted for other countries usually estimate lower costs per household. This can be related to more expensive costs being faced in the United States in comparison to other economies. For example, the FTTH Council Europe (2012) estimated a cost for densely populated European areas to be close to 400 euros per household.

this first scenario, further possibilities are considered to expand the simulation to rural areas. Each scenario requires different levels of investment, but they can be disaggregated in terms of investment by geography. Derived from the authors' findings, investment per population in cities with over 1 million inhabitants accounts to USD 45.71 per pop, increasing in suburban areas to USD 197.16 per pop, and in rural areas to USD 3 981.22 per pop. [27]

Considering the surveyed literature, the estimates were made incorporating population density as a moderating factor between investment and coverage. This requires introducing as a regressor to explain coverage, the population density in interaction with capex. The empirical equations that are econometrically estimated are described below:

$$4G\ coverage_{it} = \alpha_i^{4G} + \delta_t^{4G} + \beta^{4G}\log(MCapex)_{it-1} * Pop\ density_{it} + \theta^{4G}\log(MCapex)_{it-1} * Regulation_{it} + \gamma^{4G}X_{it} + \varepsilon_{it}^{4G}$$

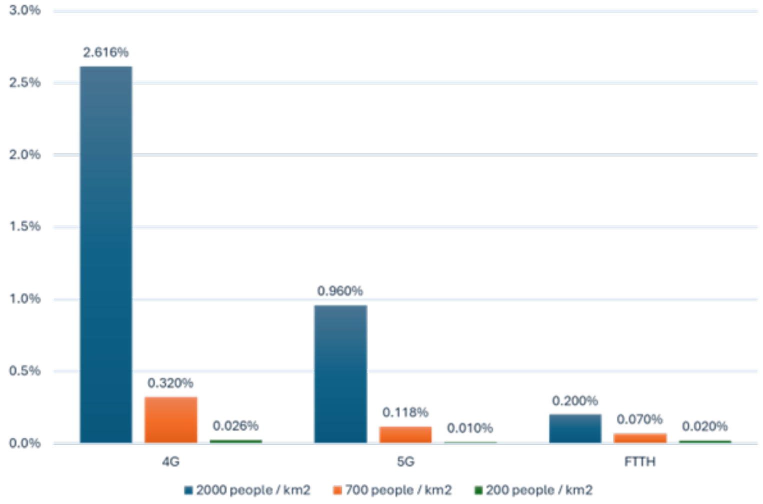
$$5G\ coverage_{it} = \alpha_i^{5G} + \delta_t^{5G} + \beta^{5G}\log(MCapex)_{it-1} * Pop\ density_{it} + \theta^{5G}\log(MCapex)_{it-1} * Regulation_{it} + \gamma^{5G}X_{it} + \varepsilon_{it}^{5G}$$

$$FTTH\ coverage_{it} = \alpha_i^{FTTH} + \delta_t^{FTTH} + \beta^{FTTH}\log(FCapex)_{it-1} * Pop\ density_{it} + \theta^{FTTH}\log(FCapex)_{it-1} * Regulation_{it} + \gamma^{FTTH}X_{it} + \varepsilon_{it}^{FTTH}$$

Where and represent country and year fixed effects, respectively, while *X* is a vector of controls (population density, competition indicators, legacy technology coverage).

The model results presented in Table A-6 in the Appendix indicate that population density has a critical role in determining the investment needed to reach certain coverage targets. This is because the investment will have a very different impact on coverage depending on the level of population density. As can be appreciated next in Figure 3-4, if investment increases 1 per cent, the effects over coverage will be much larger the more densely populated the area is.

Figure 3-4: Increase in percentage points of coverage after a 1 per cent increase in investment



Note: sample average values for 2024 taken as reference for calculations.

---

[27] Another component of network architectures that could drive a reduction in service costs, thereby increasing affordability, is the deployment of IXPs (interconnection points). While out of scope in the current GEMS, it could be considered in future tool upgrades.

From Figure 3-4, it can be appreciated that, as expected, wireless is the least expensive technology to deploy among the three technologies: 4G is the one that requires less capital investment, while on the other hand, 5G is more expensive, as it requires a higher level of cell densification.

This can be appreciated in Table 3-1 below, where costs per person (for the case of wireless technologies) and costs per household (for the case of FTTH) covered are detailed for different areas depending on population density.

Table 3-1: Average cost per person covered (4G, 5G) / household passed (FTTH)

Cost per person covered / household passed		4G (cost per person covered USD)	5G (cost per person covered USD)	FTTH (cost per household passed USD)
Area (people / km^2):	2000	USD 18.9	USD51.4	USD311.6
Area (people / km^2):	700	USD154.0	USD419.6	USD890.4
Area (people / km^2):	200	USD1 886.1	USD5 139.6	USD3 116.3

Note: sample average values taken as reference for calculations.
Source: Telecom Advisory Services analysis

For example, in an urban area (with 2 000 people per square kilometre), each household passed requires an investment of USD 312 (below the levels estimates by Cartesian for the United States, although closer to the estimates of FTTH Council Europe), however, in suburban regions (with 700 people per square kilometre) the cost increases to USD 890, while in a rural area (200 people per square kilometre) it augments considerably, to USD 3 316.

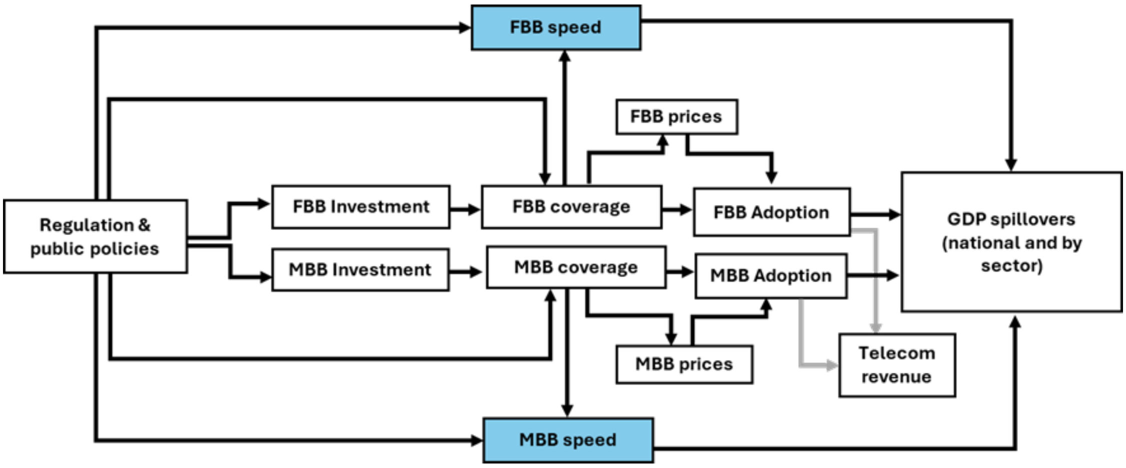
As for wireless networks, 5G is considerably more expensive than 4G. In the urban area, the cost per person covered with 5G is USD 51, increasing to USD 420 and USD 5 140 in suburban and rural areas respectively. These estimates are similar to those calculated by Oughton and Frias (2018). Overall, these results suggest that in rural areas, 4G should be the technology deployed to minimize such costs.

A final word of caution regarding these estimates. While it is reasonable to initially rely on econometric modelling to estimate the relationship between investment and network coverage, the results are based on average links which might not be realistic for the realities of individual countries. In a complementary fashion, the Connectivity Planning Platform, which addresses investment quantification, disaggregating between middled and last mile and relying on sites or backhaul length can provide a point of validation to the estimates based on the econometric model.

3.3 Enhancing broadband performance: speed drivers

Next step in the diagram of causal flows is related to network performance, usually measured through speed indicators (download and upload) as well as other metrics such as latency (see Figure 3-5).

Figure 3-5: Causal link between broadband coverage and speed



Source: Telecom Advisory Services analysis

The empirical equations that are econometrically estimated in this case are described below:

$$\log(MBB\ speed)_{it} = \alpha_i^{MS} + \delta_t^{MS} + \beta^{MS} MBB\ Coverage_{it} + \theta^{MS} 5G\ share_{it} + \lambda^{MS} Regulation_{it} + \gamma^{MS} X_{it} + \varepsilon_{it}^{MS}$$

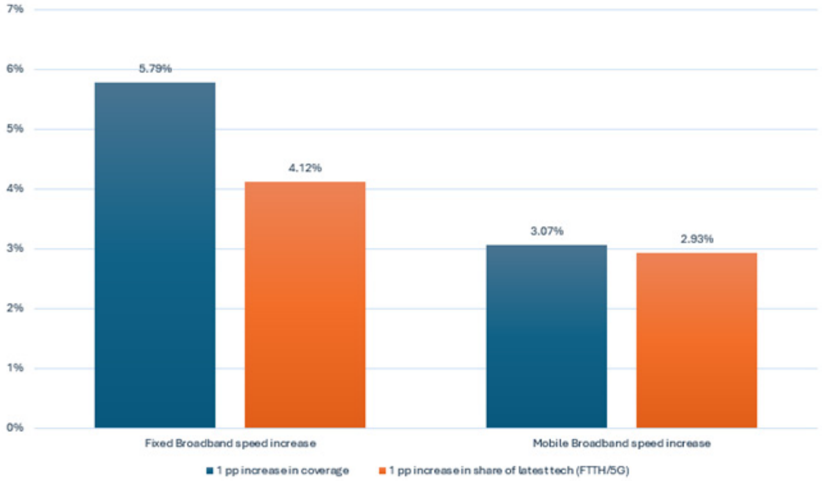
$$\log(FBB\ speed)_{it} = \alpha_i^{FS} + \delta_t^{FS} + \beta^{FS} FBB\ Coverage_{it} + \theta^{FS} FTTH\ share_{it} + \lambda^{FS} Regulation_{it} + \gamma^{FS} X_{it} + \varepsilon_{it}^{FS}$$

Where and represent country and year fixed effects, respectively, while *X* is a vector of controls (competition, population density, access to electricity, international bandwidth). Through econometric models presented in Table A-7 in the Appendix, the results for both fixed and mobile broadband speed equations are provided.

Coverage increases of the latest technologies will contribute to increasing average speeds. Each new generation of broadband technology produced significant quantum changes in terms of service quality, meaning that the distribution of local connections across these standards should be relevant to explain overall performance metrics. For example, 5G coverage expansion will mean that the share of this technology over all wireless connections will increase, leading to faster average mobile speeds. A similar situation occurs with FTTH expansion and overall fixed broadband speeds.

As reflected in Figure 3-6, increasing fixed broadband coverage by one percentage point will raise average speeds by 5.79 per cent, while a similar increase in 4G (or higher standard) broadband coverage will make wireless average speeds increase in 3.07 per cent. This is because the expansion of coverage is usually achieved by replacing older standards (hybrid fibre coaxial in the case of fixed broadband, 3G in the case of mobile broadband) with newer technologies. Similarly, every percentage point increase in the share of fixed broadband services delivered through FTTH (rather than copper or HFC) will raise average wired speeds by 4.12 per cent, while the similar effect for mobile regarding the share of 5G will yield a 2.93 per cent improvement.

Figure 3-6: Drivers of broadband speed



Source: Telecom Advisory Services analysis

In this analysis, other control variables that may explain speed disparities across countries are considered, such as measures of market concentration (Herfindahl-Hirschman Index) to capture the impact of competition intensity on performance metrics. International bandwidth per Internet user, a measure that reflects the connectivity capacity of a country with other countries and regions was also found to be relevant. As expected, higher international bandwidth yields improved service performance metrics. Also, electricity infrastructure is also relevant to ensure speed increases, through the coverage of the electricity network as a share of the population. Population density was also included as a control variable.[28]

In addition, the effect that QoS regulations have on the quality performance metrics was also checked but found no significant effects. However, allowing for spectrum refarming / in-band migration proved to be significant to enhance mobile broadband speeds (the impact of regulatory measures is analysed separately in section 3.4 below).

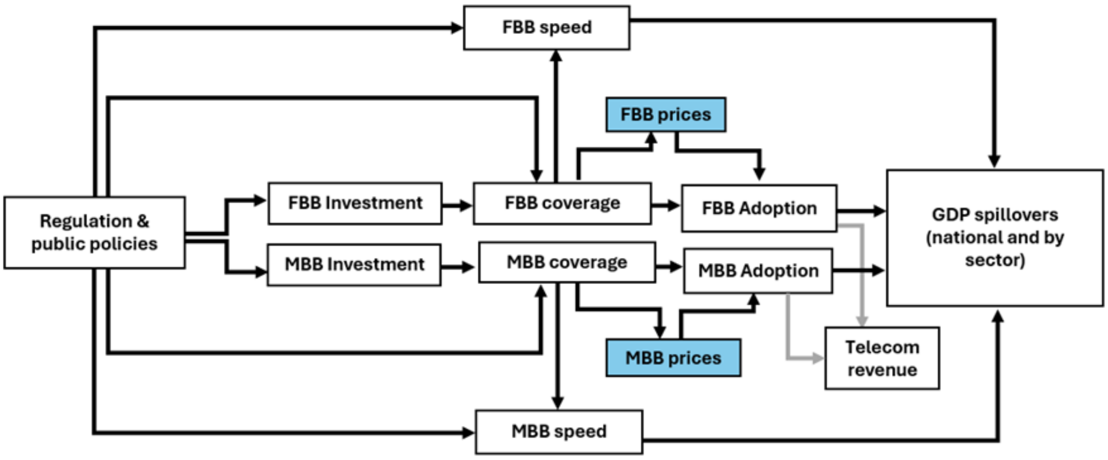
3.4 Increasing broadband affordability: price drivers

Once network coverage is estimated, the focus is on estimating its impact on broadband prices, a variable that drives adoption through elasticity (see Figure 3-7).

---

[28] Another relevant indicator for the case of mobile broadband speeds can be the level of spectrum holdings, by frequency band characteristics. Ensuring enough quantities of spectrum has long been considered central to the delivery of high-quality mobile broadband services. Unfortunately, there is not a public dataset on spectrum allocated to IMT by country and year.

Figure 3-7: Causal link between broadband coverage and pricing



Source: Telecom Advisory Services analysis

The empirical equations that are econometrically estimated are described below:

$$\log{(MBB\ price)_{it}} = \alpha_i^{MP} + \delta_t^{MP} + \beta^{MP}\log{(MBB\ Coverage)_{it}} + \lambda^{MP}Regulation_{it} + \gamma^{MP}X_{it} + \varepsilon_{it}^{MP}$$

$$\log{(FBB\ price)_{it}} = \alpha_i^{FP} + \delta_t^{FP} + \beta^{FP}\log{(FTTH\ Coverage)_{it}} + \lambda^{FP}Regulation_{it} + \gamma^{FP}X_{it} + \varepsilon_{it}^{FP}$$

Where and represent country and year fixed effects, respectively, while *X* is a vector of controls (competition, education).

Coverage improvements resulting from past investments contribute to reducing prices, as the supply curve of the telecommunication operators shifts to the right: for each price level, operators will be willing to supply connectivity to more consumers. Coverage gains can also be interpreted as the result of technological improvements, which from a dynamic perspective, usually translate into lower prices (as denoted by Moore's Law). Our results, presented in Table A-8 in the Appendix, suggest that 1 per cent increase in FTTH coverage will reduce fixed broadband prices by 0.112 per cent, while on the other hand, 1 per cent reduction in 4G (or higher standard) coverage will reduce mobile broadband prices in 0.454 per cent.

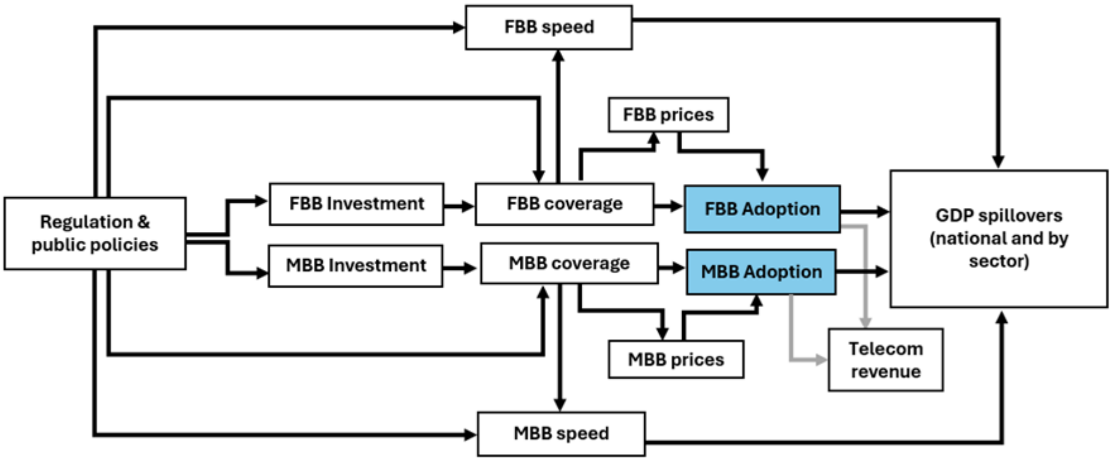
End-user prices are also assumed to depend on competition intensity, as measured through the Herfindahl-Hirschman Index (HHI) for both mobile and fixed broadband markets. Evidence from the estimates suggests that, all things being equal, the more concentrated a market is, the higher the prices are. Therefore, ensuring a competitively dynamic market would, as expected, have a negative impact on pricing. Regulation may also affect prices directly, as highlighted by several authors for very diverse regulatory measures (Calzada and Martínez-Santos, 2014; Grechyn and McShane, 2016; Genakos et al., 2018; Lamont and Thaler, 2003). The significant-market power-related regulation was tested to see if it could drive prices down, although the results were not significant.

Demand-side indicators may also contribute to price disparities. As highlighted by Reddick et al. (2020), socioeconomic factors can be relevant in this respect. These factors were proxied by average education levels (average years of education for adult population by country). More educated population will result in higher demand for digital goods and services, pushing prices up: the results point to higher levels of education associated with higher prices.

3.5 Broadband adoption: connecting the unconnected

Following the price equation, pricing will be a determinant for service adoption, as measured by unique subscribers of mobile Internet (as a share of population) while fixed broadband adoption is measured by fixed broadband lines as a share of households (see Figure 3-8).

Figure 3-8: Causal link between pricing and adoption



Source: Telecom Advisory Services analysis

The empirical equations that are econometrically estimated are described below:

$$\begin{gathered}\log(MBB\ adoption)_{it} = \alpha_i^{MA} + \delta_t^{MA} + \beta^{MA}\log(MBB\ price)_{it} + \lambda^{MA}\mathrm{Log}(MBB\ Coverage)_{it} \\ +\theta^{MA}5G\ share_{it} + \gamma^{MA}X_{it} + \varepsilon_{it}^{MA}\end{gathered}$$

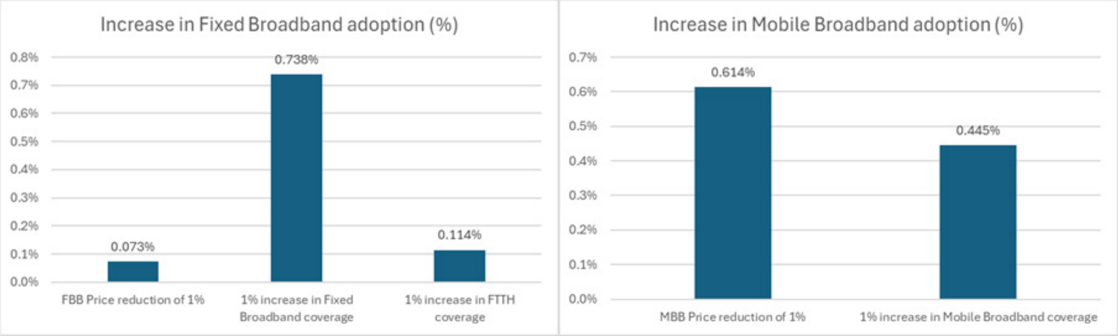
$$\begin{gathered}\log(FBB\ adoption)_{it} = \alpha_i^{FA} + \delta_t^{FA} + \beta^{FA}\log(FBB\ price)_{it} + \lambda^{FA}\mathrm{Log}(FBB\ Coverage)_{it} \\ +\theta^{FA}\log(FTTH\ Coverage)_{it} + \gamma^{FA}X_{it} + \varepsilon_{it}^{FA}\end{gathered}$$

Where and represent country and year fixed effects, respectively, while *X* is a vector of controls (education and income levels measured through lagged GDP per capita).

Naturally, higher prices should reduce demand. According to the estimations (Table A-9 in Appendix), the demand for both fixed and mobile broadband reaches levels below the unitary elasticity, with adoption being increased by 0.073 per cent and 0.614 per cent respectively, after a reduction of 1 per cent in service prices.

In addition, increases in coverage of the latest technological standards will drive up adoption, as broadband services supplied will now be much faster and therefore attractive for a wider range of uses. Our results suggest that an increase in 1 per cent of fixed broadband coverage increases adoption by 0.738 per cent, while the same variation in FTTH coverage will increase fixed broadband adoption by 0.114 per cent. In turn, a 1 per cent increase in mobile broadband coverage will raise mobile broadband adoption by 0.445 per cent (see Figure 3-9).

Figure 3-9: Drivers of broadband adoption



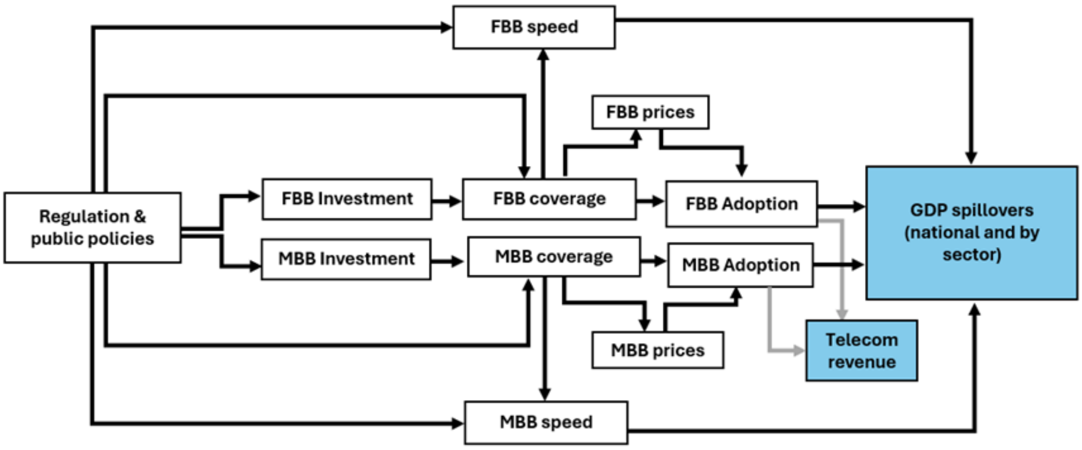
Source: Telecom Advisory Services analysis

From the demand-side, as reflected in the general literature explaining price differentials, personal income is expected to drive demand and to consequently affect prices (Grechyn and McShane, 2016; Genakos et al., 2018; Reddick et al., 2020; Weiss et al., 2015; Kravis and Lipsey, 1988; Lipsey and Swedenborg, 2010). Usually represented by GDP per capita, income levels represent the purchasing capacity of the population, which sets the maximum value of their willingness to pay for broadband services. Other personal characteristics may also affect prices through the demand side, such as education (Reddick et al., 2020). More educated people should be willing to pay more for mobile broadband services, thus contributing to higher prices. Our results suggest that education is a key driver of demand for both technologies, although the impact of income was verified as not significant in most of the estimates.

3.6 Economic impact of broadband deployment

The final causal link estimates the economic impact resulting from increases in broadband adoption and network speed (see Figure 3-10).

Figure 3-10: Causal link between broadband adoption and economic impact



Source: Telecom Advisory Services analysis

Causal links are of two types: (1) the return of the investment to telecommunication operators, and (2) the economic impact to society, as measured as GDP to the whole economy and by economic sectors.

3.6.1 Financial returns to the telecommunication operators

Telecommunication operators will deploy networks to grow their subscriber base, with the consequent increase in revenues. The return on investment (ROI) for the operator can be represented as:

$$ROI = \frac{Gross\ Return - Cost\ of\ investment}{Cost\ of\ investment}$$

Revenues and investments to be analysed will have to represent the revenues generated over the period analysed as well as the discount rate of predicted cash flows to calculate its present value[29]:

$$Gross\ Return = \sum_{t=0}^{n} \frac{Revenues_t}{(1+r)^t}$$

$$Cost\ of\ investment = \sum_{t=0}^{n} \frac{CAPEX_t}{(1+r)^t}$$

Where is the annual discount rate. The investment project will be attractive for the operators as long as . In turn, any regulatory reform that contributes to raising revenues or to reducing investment costs will increase the incentives for the operators to deploy the projects.

3.6.2 Economic benefits to society

A vast body of research has examined the socioeconomic impact of broadband. The role of telecommunication infrastructure in driving economic outcomes has been studied for more than two decades, beginning with the influential work of Röller and Waverman (2001). Authors such as Czernich et al. (2011) and Mack and Faggian (2013) have characterized broadband as a general-purpose technology, implying that its contribution to the economy surpasses that of traditional capital investments. High-speed Internet infrastructure, in particular, is regarded as fundamental for economic growth, as it enhances productivity, lowers transaction costs, and broadens access to knowledge and information. Empirical studies have verified this positive impact, both for global samples (Katz, 2020) and for regional analyses for the Americas (Katz and Callorda, 2019a), Africa (Katz and Callorda, 2019b), Europe (Katz and Callorda, 2020a), Commonwealth of Independent States (Katz and Callorda, 2020b), and Arab States (Katz and Callorda, 2020c).

Furthermore, many emerging technologies with substantial potential economic impact—such as big data, artificial intelligence, the Internet of Things (IoT), and cloud computing—are highly dependent on fast and reliable Internet networks. The expansion of FTTH and 5G networks represents a major improvement over older legacy connections and is expected to generate important additional economic benefits. The importance of broadband speed is critical, as suggested by empirical evidence. For example, Katz and Callorda (2020d) found that doubling download speeds above 40 Mbit/s resulted in a 0.73 per cent GDP gain.The empirical equation estimated econometrically is described as follows:

---

[29] The discount rate will have to be entered by the user based on particular conditions of the country under consideration.

$$\log(GDP)_{it} = \alpha_i^{GDP} + \delta_t^{GDP} + \beta^{GDP}\mathrm{BB}_{it} + \lambda^{GDP}\mathrm{Log}(K)_{it} + \theta^{GDP}\log(L)_{it} + \varepsilon_{it}^{GDP}$$

Where and represent country and year fixed effects. *K* and *L* denote physical capital stock and labour. *BB* is a construct built from principal component analysis applied to fixed broadband adoption, mobile broadband adoption, and average broadband speed (for both technologies). The use of constructs is desirable as these variables are highly correlated, thus being complicated to identify a specific effect for each of them as multicollinearity problems arise.

In addition to the aggregate social benefits, a universal connectivity strategy will have an impact on specific domains, such as education and health. For example, a full national connectivity strategy will include the provisioning of links to hospitals/clinics, schools, and anchor cultural institutions. The effect on these institutions should be estimated through the Connectivity Planning Platform (CPP), a data-driven tool also supported by ITU. The CPP tool could also support fulfilling connectivity within economic units located in low population density areas, such as ports, mining concerns, and other points of interest.

3.6.3 Economic spillovers for specific economic sectors

The increased broadband deployment and adoption performance should lead to a more productive use of digital tools by enterprises in different economic sectors. The literature outlines several paths through which broadband adoption can improve company performance: improved market access, lower communication costs, and internal operational improvements. However, different sectors may vary in the spillovers they gain from digital adoption and use. As argued by Mas and Quesada (2009), economic sectors can differ largely in their ICT usage intensity, thus expecting heterogeneous impacts. The empirical specification will be similar as that conducted at the national level but now using only sector-specific data.

The tool serves as a platform to test the private (operators) and social returns of an infrastructure plan aimed at addressing digital connectivity challenges of any country. It has the flexibility to accommodate varying planning horizons (common in medium-term infrastructure plans) and data availability, allowing proxy values when detailed datasets are unavailable. In doing so, it integrates demand-side factors such as affordability, and device access, to estimate GDP impact resulting from broadband adoption.[30]

Once private and social links are estimated along the causal chain, it is critical to model the impact of regulatory changes that can improve results, particularly under the likely scenario that the return of investment of telecommunication operators remains negative. Three levers are considered by the GEMS tool: changes in the regulatory framework, investment subsidization, and demand stimulation incentives.

---

[30] The assessment of economic impact of selected infrastructures is conducted through econometric analysis. While acknowledging that the use of input/output tables could represent and alternative approach, it would require gaining access to country specific tables and a solid understanding of intermediate inputs of each technology choices.

3.7 Regulatory good practices as variables to mitigate the investment burden

Changes in regulatory conditions defined in the initial causality framework can improve the returns of the investment in network deployment, as depicted in several econometric models (see Table 3-2).

Table 3-2: Impact of the specific regulatory measures

Regulatory measure	Identified effect
Spectrum secondary trading	Allowance of spectrum secondary trading can increase investment in mobile broadband by 3.2 per cent.
Band migration allowed	Allowance of spectrum in-band migration / refarming can increase investment in mobile broadband by 3.2 per cent and mobile broadband speeds by up to 76.4 per cent
Infrastructure sharing for mobile operators permitted	Allowing infrastructure sharing for mobile operators can increase investment in mobile broadband by 3.2 per cent. It can also result in a 10 per cent increase in investment to yield 1.4 (0.6) more percentage points in 4G (5G) coverage (than if done in absence of sharing).
Infrastructure sharing mandated	Mandating infrastructure sharing can drive effects such as a 10 per cent increase in fixed investment to yield 0.2 more percentage points in FTTH coverage (than if done in absence of sharing). It can also generate a 10 per cent increase in mobile investment to yield 1.4 (0.6) more percentage points in 4G (5G) coverage (than if done in the absence of mandated sharing).
Co-location/site sharing mandated	Passive infrastructure sharing can reduce costs, increasing coverage gains by unit of investment. It can also result in a 10 per cent increase in investment to yield 1.4 (0.6) more percentage points in 4G (5G) coverage (than if done in absence of sharing).

Source: Telecom Advisory Services analysis

Table 3-2 presents the regulatory measures found to have a significant impact across the diagram of causal flows. Regarding spectrum, one of the regulatory measures analysed is that of allowing secondary trading of this resource by mobile operators. Secondary trading promotes optimal allocation, thus more economically productive, use of spectrum. It also helps to create a self-regulating environment resulting in a more effective usage of the frequency bands, both by the new entrant and the network operator who already possesses the rights. It was found that the allowance of this practice to yield an increase in mobile capex of 3.2 per cent.

In addition, it was also found that allowing spectrum refarming (also called in-band migration) can be critical. This allows mobile operators to provide new services within their existing licences, which increases the incentives for innovation and more efficient use of the networks, as well as decreasing the cost of a new licence. In fact, it was found that the allowance of this practice yields an increase in mobile capex of 3.2 per cent, which is critical for mobile broadband speeds, increasing them up to 76.4 per cent.

In addition, the possibility of implementing sharing agreements allows maximizing the opportunities for operators to make investment profitable, thus creating incentives for network deployment. Network-sharing agreements can optimize the use of infrastructure, generally reducing costs, which is beneficial to both, service providers and consumers.[31] It can also serve as an incentive to stimulate network deployment. Infrastructure sharing between market operators or with other industries can decrease expenditures by the joint deployment and maintenance of facilities as well as increase the productivity of use of scarce resources.

It was also found that when infrastructure sharing is allowed between mobile operators to conduct MVNO agreements, investment rises by 3.2 per cent. In addition, it renders investments to be much more efficient in order to increase coverage levels. Specifically, it was found that this practice makes a 10 per cent increase in investment to yield 1.4 (0.6) more percentage points in 4G (5G) coverage (than if done in the absence of sharing). This effect on coverage was also found for the case of co-location/site sharing, and for mandates in infrastructure sharing[32] (e.g. towers, base stations, posts, ducts) or is granting of access and use to public telecommunication networks (e.g., optical fibre, wireless) required by monopoly or dominant operators. In this latest case, the impact is verified for both fixed and mobile investments.

It should be noted that other policy levers, not included in the list presented above, might also have a positive impact on investment. One of them is sector-specific tax reductions, an effect extensively studied by Katz and Jung (2023). A second one also studied is a reduction in spectrum costs. One of the reasons why these are not included in the list above is that they are not considered in the ITU Regulatory Tracker, which is the primary dataset used for the tool. These are factors to be considered in future versions of the GEMS tool.

3.8 Investment subsidization

The implementation of subsidies targeted for promoting the deployment of telecommunication infrastructure can be channelled from either public or private sources.

3.8.1 Government

The most common mechanisms through which governments promote financing of network deployment in areas that are not profitable is typically that of a universal service fund (USF). The concept of universal service, which seeks to ensure that all citizens have access to telecommunications has been motivated by both socio-political and economic reasons as a solution to the digital divide. Considering the potential negative ROI results of the deployment as estimated by the GEMS tool, USF contribution should be considered as a mitigating factor.

Universal service funds are typically provisioned by telecommunication companies, on the basis of a percentage of their revenues to contribute to financing access to telecommunication services in rural and disadvantaged areas. Public administrations recognize these areas and distribute resources through direct grants or competitive tenders for infrastructure projects. Ideally, the services should be self-sustaining after the initial investment, thus reducing the digital divide and ensuring equitable access to technology. This mechanism may also require government subsidies to incentivize companies to develop the necessary infrastructure, so universal access policies are key to meeting important government objectives.

---

[31] As defined in the ITU Regulatory Tracker, there is no distinction between discrimination or non discrimination: “Is infrastructure sharing mandated (e.g. towers, base stations, posts, ducts) or is granting of access and use to public telecommunication networks (e.g., fibre, wireless) required by monopoly or dominant operators?”

[32] It is important to acknowledge that some stakeholders and academic literature argues that infrastructure sharing should be voluntary rather than mandated, as the imposition of obligations may reduce incentives to invest. We were not able to verify this in the econometric model conducted for this study.

In practice, however, USFs have not necessarily proven to be an optimal solution in all cases. For example, an analysis carried out by the UN Economic and Social Commission for Asia and the Pacific (ESCAP) reveals that in some countries key problems emerged from its implementation, such as delays in disbursements, lack of transparency and market distortions. In many countries, funds are not distributed in time, delaying the deployment of telecommunication infrastructure in underserved areas. This is mainly because the administrative structures in charge of managing the USF are inefficient, and the procedures for allocating resources are poorly defined or overly bureaucratic. In addition, in some cases, countries do not publish clear reports on how funds are spent, leading to a lack of confidence in the management of resources. This lack of transparency has prevented USFs from meeting their objectives in a timely manner (ESCAP, 2017).

Another problem is that USFs can generate distortions in the market by offering permanent subsidies to certain operators, which may discourage competition. This occurs when companies that receive funding do not face enough competitive pressure to innovate or improve their services, as they are backed by ongoing subsidies, which prevent other companies from entering the market and offering better services or more competitive prices.

Despite these challenges, some countries such as India and Malaysia have made significant progress with the implementation of their USFs. In India, for example, the success of the USF is due to the 2006 modification of the policy to include broadband projects, which allowed the deployment of fibre optic networks and the expansion of rural Internet. This has connected hundreds of thousands of households in rural areas, especially through the fixed-line broadband scheme and agreements with operators. In Malaysia, USF success lies in the creation of Community Broadband Centers and the expansion of Wi-Fi networks in more than 400 rural villages, which has significantly improved connectivity (ESCAP, 2017). Finally, in Viet Nam, the USF contributed to important progress, although some implementation problems emerged, such as rural users abandoning their subscriptions when subsidies ended, reflecting the lack of sustainability of the model. In addition, oversight was inefficient, resulting in a doubling of funds in some cases. There was also no significant participation of the private sector or civil society, which limited competition and efficiency in the provision of services (Do et al., 2018). Universal service funds can represent a potential mitigating factor in cases where there is no financial return on the planned investment for telecommunication operators. The consideration of USFs, however, needs to be applied recognizing the potential implementation shortfalls highlighted so far.

GEMS addresses the USF contribution as a percentage of the total infrastructure investment required. This input does not consider USF implementation factors such as efficiency rate or disbursement lag of funding. While relevant in terms of measuring the true USF contribution, it lends itself to potential subjective assessment or lack of country specific data. Consequently, it was decided to exclude them from the platform.

Other instruments that could be applied for government subsidization are taxes earmarked for telecommunication infrastructure deployment funding or spectrum proceeds. Again, while potentially useful in subsidizing telecommunication infrastructure deployment, they have been excluded. Their applicability could be brought in the assessment if the USF contribution and other sector subsidies (see section 3.8.2. below) fail to address the need investment, yielding a positive private ROI.

“Pay or Play” mechanisms, whereby operators are given a choice to invest directly in infrastructure rather than contribute to the USF fund, has not been addressed in the GEMS platform. That said, since GEMS estimates the investment required via USF to fulfil the coverage objective, "pay or play" could be highlighted as potential alternative funding mechanism.

3.8.2 Additional supply subsidies

Complementing the contribution from USF, additional financing mechanisms could be implemented by the government, such as blended finance, which combines public and private funding to mobilize private capital flows towards specific projects that benefit society. By blending public finance with private investment, these mechanisms can help bridge the financing gap in telecommunications. As defined by the World Bank,

"Blended finance has become an essential tool for mobilizing private capital to support infrastructure development, particularly in emerging markets where financing gaps are most pronounced. By strategically using public or concessional funds, blended finance aims to attract private investment to projects that are deemed too risky or unprofitable and therefore not occur under normal market conditions. The key objective is to de-risk investments and catalyse private sector participation, often through the provision of financial protections such as concessional loans, risk guarantees, and equity contributions."[33]

Along these lines, blended finance could be used to reduce the weighted average cost of capital (WACC). Since the platform addresses the internal rate of return and return of investment and considers the WACC as an input, if blended finance were to be considered as a supply subsidy, this could be addressed by reducing the cost of capital to be agreed at time of input model variables.

3.8.3 Sector contributions

Another potential subsidization mechanism refers to the contributions to be made by other national economic sectors (public or private), as compensation for the benefit they receive from the economic impact of network deployments. So far, most of the debate of additional sector subsidization has been restricted to the "fair share" discussion, where telecommunication operators demand over-the-top (OTT) players to contribute to funding networks based on their utilization of networks in delivering services to consumers. While this debate is still inconclusive, the consensus remains that there is a need to rethink how to finance high-speed networks in unprofitable environments. The GEMS tool expands the scope of this analysis to other sectors of the economy (e.g., financial services, health sector, transportation and logistics, etc.) that benefit from the positive economic effects resulting from broadband deployments. As an example, an analysis of sectoral economic benefits generated by the deployment of telecommunication networks indicates that spillovers flow throughout firms generating improvements that could also be translated into contributions to network capital spending. For example, the deployment of 5G can result in significant improvement in operating performance of specific industries (see examples in Table 3-3).

---

[33] World Bank Group. *Public Private Partnerships Resource Center*. Available in: https://ppp.worldbank.org/blended-finance#:~:text=Blended%20finance%20is%20a%20strategic,providing%20financial%20returns%20to%20investors.

Table 3-3: 5G Use cases in specific industries

Sector	Country	Use case
Transportation and logistics	Peru	Multipurpose port in Chancay
	Germany	Hamburg port terminals
	Chile	Smart Square in Santiago
	Spain	Barcelona CityOS
	Guatemala	Red Civica Wayfree
	Finland	Kalasatama District (Helsinki)
	Dominican Republic	Colonial City of Santo Domingo
	United Kingdom	5G Smart Tourism Bath-Bristol
		ABP-Southampton Port
	Jamaica	Kingston Port
Mining	Peru	Copper mine in Toquepala
	Sweden	Kankberg Mine (Boliden)
	Chile	Codelco mines in Antofagasta
	Finland	Agnico Eagle - Mina Kittilä in gold mine
Health care	Peru	Remote MRI services
	Finland	Hola 5G in Oulu University Hospital

Source: Compilation by Telecom Advisory Services

Based on these examples, the contribution of other sectors of the economy could be considered as an approach to reduce the investment burden of telecommunication operators.

3.8.4 Demand stimulation mechanisms

Government subsidies for the demand side of broadband service can be important, especially in situations when expanding coverage may not be enough to substantially increase adoption levels. This type of intervention is critical as affordability barriers are limiting access to digital services of important segments of the population. In such cases, government contributions through subsidizing investment should be complemented with similar actions on the demand-side.

These demand stimulation mechanisms should be targeted at vulnerable groups, such as low-income households, people living in rural or remote areas, individuals with disabilities, or small and medium enterprises (SMEs) to help them in adopting high-speed Internet. This policy intervention will facilitate the access of these vulnerable groups to digital transformation opportunities, online education, telehealth, job recruitment processes, teleworking, and use of e-government services.

By subsidizing broadband this policy helps close the digital divide. Subsidies may take the form of vouchers targeted at certain socioeconomic segments, or providing discounts on the provision of devices, or specific programmes focusing on digital education or telehealth. Examples of this type of intervention can be found in Table 3-4.

Table 3-4: Examples of demand stimulus policies

Country	Policy
Colombia	Price subsidy aimed at increasing broadband connection among low-socioeconomic groups.[34]
Costa Rica	'Connected Homes' programme consisted of subsidies for Internet access, along with a laptop computer, provided to households based on their socioeconomic status. For the poorest quintile, the subsidy covers up to 80 per cent of the fees payable.[35]
Kenya	Plan to deliver 1.2 million laptops to students and classroom equipment to 23 000 schools in the country to stimulate digital learning solutions in targeted primary schools.[21]
Saint Vincent and the Grenadines	Subsidized Internet and SIM Card Initiative targeted at vulnerable households, funded by the USF.[22]
United Kingdom	Vouchers targeted at SMEs to cover the costs of installing faster broadband services.[36]

Source: Compilation by Telecom Advisory Services

As an additional benefit, more demand will mean more revenue for the operator (then contributing to making the deployments profitable) and also larger economic impact through spillovers across the economy. GEMS has the capability to test alternative demand side subsidies in terms of percentage support for wireline, wireless and LEO satellite service and user device.

While the demand side subsidies focus on the affordability barrier, other factors such as limited digital skills, are not addressed here since, while valid, they are considered to be a long-term programme variable and therefore, not subject to the variables addressed in GEMS.

3.9 Private and social rate of return

The GEMS platform estimates the return on connectivity infrastructure strategies, both for operators and for society (in terms of GDP contribution). As a refinement, GDP contribution is also estimated for different sectors of the economy. One could argue that the government could also benefit in terms of net fiscal balance; however, the estimation would require an additional analysis that exceeds the current scope of the platform.

---

[34] https://www.broadbandcommission.org/Documents/publications/WorkingGrouponDemand-2016.pdf

[35] https://ict-pulse.com/2021/03/subsidized-internet-what-can-we-learn-from-countries-that-offer-that-programme/

[36] https://www.gov.uk/government/news/small-businesses-given-big-boost-through-government-broadband-scheme

4 Case study pilot: Ghana[37]

The following case study of the country of Ghana is presented as an example of application of the GEMS tool to a real situation.

4.1 Starting point

Current telecommunication network coverage levels for Ghana are presented in Figure 4-1 for 4G, 5G and FTTH networks. According to the ITU DataHub and the GSMA public data, Ghana has a near universal coverage of 4G, reaching 99.3 per cent of total population. This means that all urban and suburban areas are completely served by this technology, while in rural areas 4G coverage reaches 98.2 per cent. On the other hand, according to the National Communications Authority, the country has limited coverage of 5G, as the network is available to only 13.6 per cent of the population. Our estimates indicate that while 93.4 per cent of the population of urban areas is covered by 5G, there is a lack of availability of this technology in suburban and rural areas. In addition, the country is completely covered by low Earth orbit (LEO) satellite broadband, after Starlink received the approval to operate by the National Communications Authority early in 2024.[38]

Regarding fixed broadband, this technology has very limited coverage (4.29% of households passed), as most of the connectivity is done through wireless networks. Consequently, FTTH coverage is very limited. Consistent with the deployment of fixed broadband in sub-Sahara Africa, only 3.87 per cent of households in the country are covered by this technology (26.6% of households located in urban areas).

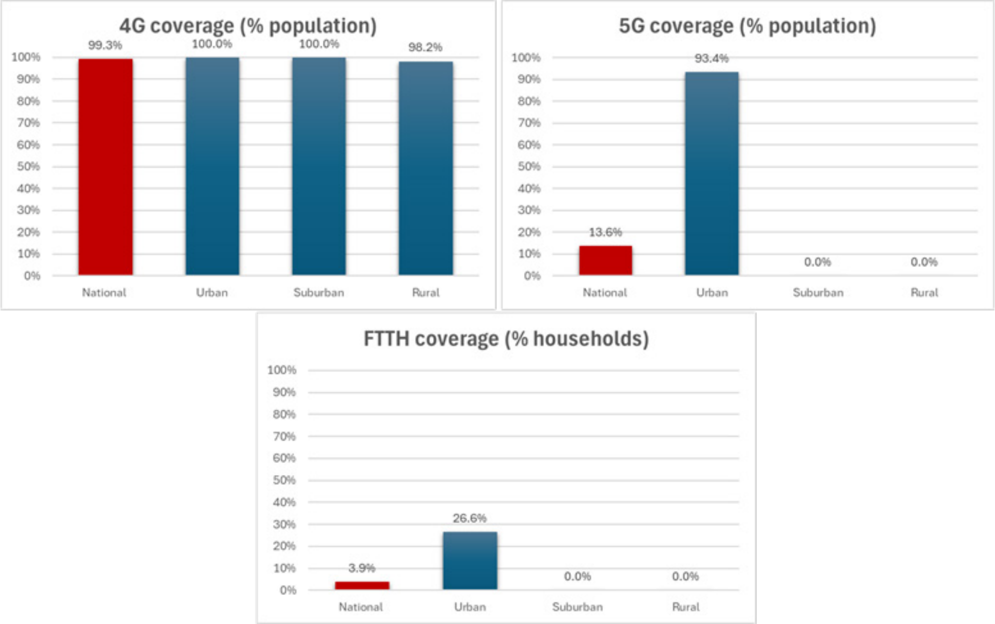
As a result of the supply situation, fixed broadband adoption levels are low: only 3.63 per cent of households have adopted fixed broadband, while the unique subscribers of mobile Internet account for 33.59 per cent of the population.

---

[37] This case study was conducted by relying on the following data sources: ITU DataHub, ITU Regulatory Tracker, ITU ICT Price Baskets, World Development Indicators from the World Bank, International Monetary Fund World Economic Outlook, IDATE Market Panorama, Ookla Speedtest, GSMA publicly available data, and additional local demographic sources.

[38] Broadcast Prome (2024): *"NCA approves Starlink to provide satellite internet services in Ghana"* (April 29th). Downloadable in: https://www.broadcastprome.com/news/satellite/nca-approves-starlink-to-provide-satellite-internet-services-in-ghana/

Figure 4-1: Ghana: Current coverage levels by technology and area



Source: Telecom Advisory Services analysis

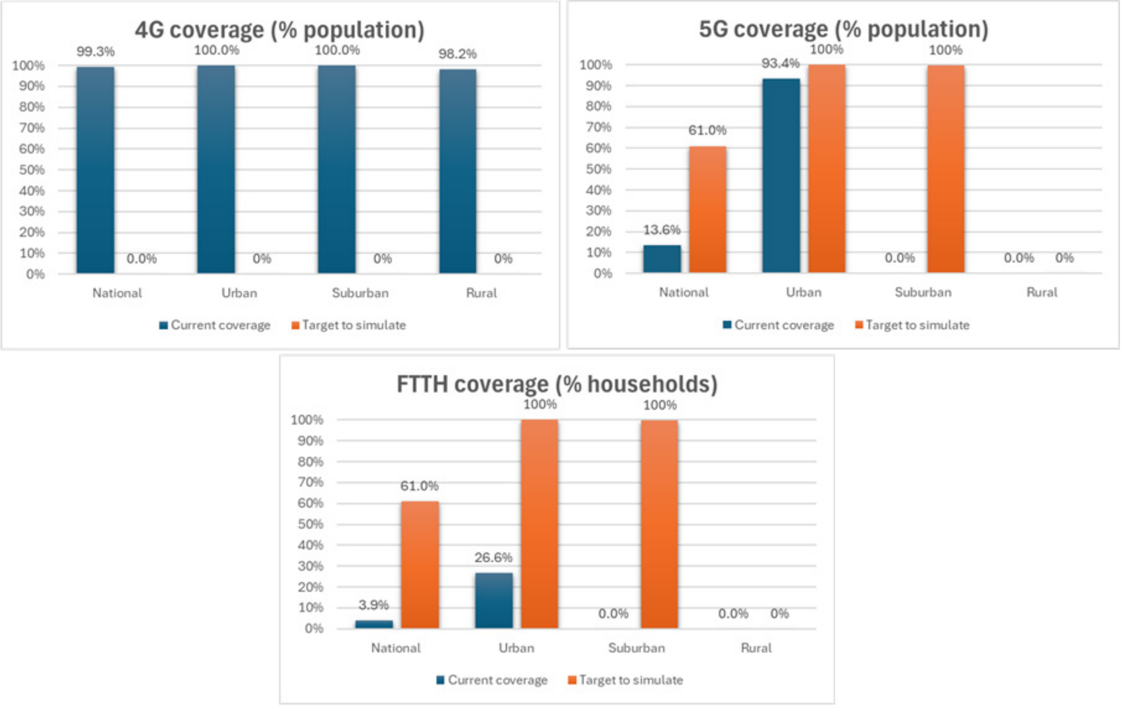
Based on this situation as the starting point, an estimation of future deployment was carried out, focusing only on accelerating roll-up of 5G and FTTH, since 4G is already nearly universal.

4.2 Targets

The purpose is to simulate an expansion of coverage footprint for 5G and FTTH. First, both technologies should reach coverage of the entire population and households located in urban and suburban areas. However, it is assumed that the expansion of these technologies into rural areas is not feasible economically.

Therefore, for the foreseeable future, 4G networks will fulfil the needs of the rural areas, at least in the mid-term (Figure 4-2). Considering that there is still 1.8 per cent per cent of people living in rural areas out of the reach of 4G networks, a demand stimulus applicable to the purchasing of LEO satellite broadband services that are currently covering the country was also included in the simulation.

Figure 4-2: Ghana: Coverage targets by technology and area



Source: Telecom Advisory Services analysis

Serving the entire urban and suburban population means expanding coverage of 5G to 61 per cent of the national population (or 61 per cent of households in the case of FTTH). This is an ambitious project, for which a period of 5 years is assumed for 5G and 8 years for FTTH deployments. As a result, 5G coverage will grow 4.5 times from current levels, while FTTH will increase by 16 times, which, in and of itself, remains a significant effort.

4.3 Social impact

If this project is completed in the required time, both fixed and mobile broadband adoption and respective broadband speeds will increase considerably. Fixed broadband adoption is expected to reach 41 per cent of households in the eighth year, while mobile Internet unique subscribers will account for nearly 40 per cent of the population by the fifth year (these estimations are largely conservative as they do not consider the natural growth trends in adoption for both technologies). In addition, users of LEO satellite broadband will increase in more than 17 000 subscribers, which will in turn augment the connectivity in zones out of reach of conventional fixed and mobile broadband.[39] A critical issue that cannot be addressed ex-ante is whether there would be enough satellite capacity to accommodate this demand.[40] The average fixed broadband speed will reach 885 Mbit/s (from 50.42 right now according to Ookla), while the average for mobile broadband will grow to 70 Mbit/s (from 21.20 registered by MTN according to Speedgeo). All these effects will yield important economic spillovers[41], both in the aggregate and for the different sectors.

---

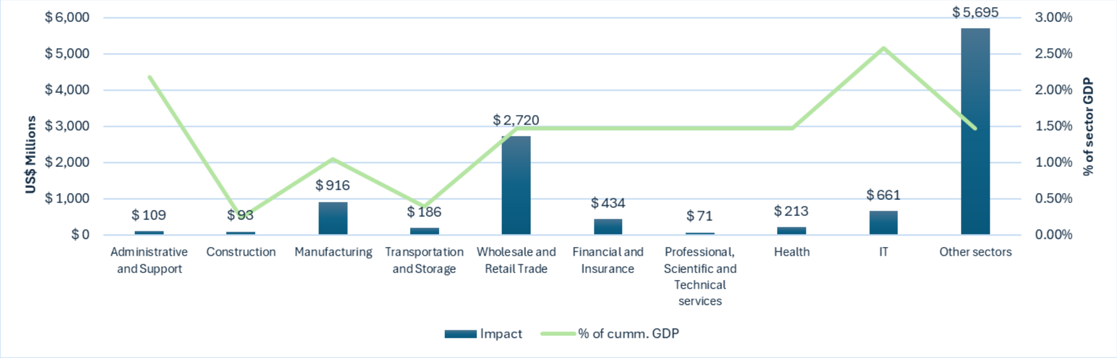
[39] This result depends on our assumption that there are currently 50 000 subscribers to LEO broadband in Ghana. While no official data regarding the quantity of subscriptions in the country is available, Idem Est reported 687 000 Starlink subscriptions across Africa by the end of 2025. Considering Ghana's population share within the countries that have allowed Starlink to operate, nearly 35 000 of those connections can be attributed to the country. Assuming the presence of other potential LEO providers, we round up the value to 50 000.

[40] High level estimates consider that while a single satellite is shared among many users, depending on usage levels, it can handle 1 000 users simultaneously.

[41] Economic spillover is defined as an indirect impact that an economic event, activity, or policy in one area (like a region, country, or sector) has on another one. These effects are also known as economic externalities.

At a national level, spillovers generated by this expansion will reach 1.3 per cent of cumulative GDP during the analysed period (or USD 11 billion)[42]. Economic spillovers by sector are presented in Figure 4-3.

Figure 4-3: Ghana: Economic impact by sector

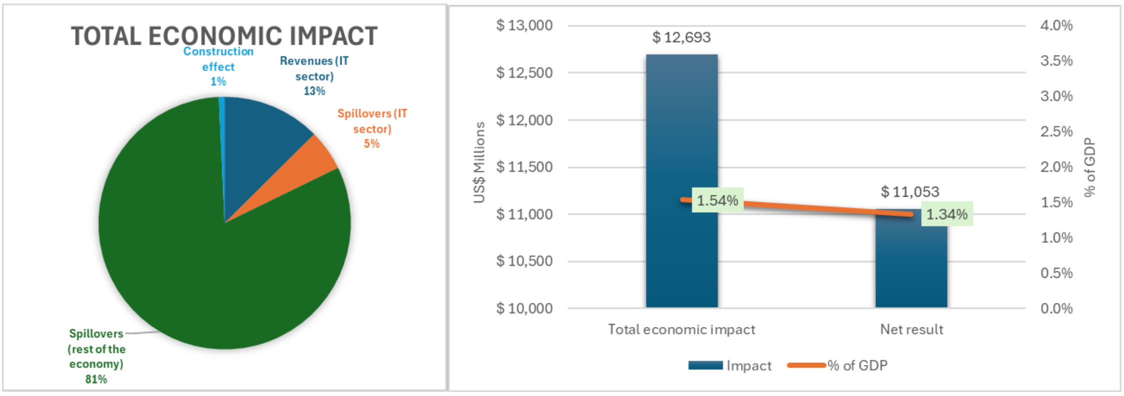


Note: the impact on the construction sector refers to direct activity (construction effect)
Source: Telecom Advisory Services analysis

The largest impact will be on wholesale and retail trade (USD 2.7 billion), followed by manufacturing (USD 916 million), IT (USD 661 million) and financial services (USD 434 million). The IT and the administrative and support sector, in turn, reach the maximum impact when measured as a share of their GDP (2.6% and 2.2%, respectively).

At the national level, the investment will yield an important economic impact. National impact includes all spillovers as well as the revenues of the telecommunication operators as direct impact. It also includes the direct effect generated for the construction sector due to civil work. This total amount represents USD 12.7 billion (or 1.5% of national GDP). Even after discounting the investment made, the returns seem to be largely profitable from a national perspective (USD 11.1 billion or 1.3% of GDP). The main source of impact is the spillovers generated over the different sectors of the economy, as represented in Figure 4-4.

Figure 4-4: Ghana: Country-level economic impact



Note: Net result refers to the total economic impact minus the investment made
Source: Telecom Advisory Services analysis

---

[42] Ghana's GDP is USD 88.33 billion (source: IMF)

4.4 Private returns

The local telecommunication operators are the parties that should conduct the deployment of these networks. Currently, Telecel Ghana supplies fixed broadband, while there are two mobile broadband operators (AT and MTN). However, this section analyses the impact of deployment on the telecommunication sector in the aggregate. This means that, for instance, if reference is made to investment being made by the mobile sector, it is referred to in the aggregate (not by operator).

That being said, for all these economic impacts to materialize, there must be a business case for the telecommunication operators, who decide to invest in the first place. This is not straightforward, as results for the operators (and then, their willingness to invest) will depend critically on the regulatory framework and on government policies conducted to facilitate these deployments.

Table 4-1 presents the mobile broadband deployment investment results for the operators. All figures are adjusted to present values, assuming a 1 per cent discount rate, although it is recognized that this rate should e adjusted based on the current local conditions. In absence of any policy action, the project is clearly unprofitable for the operators, as the investment requires USD 1.5 billion, however the revenues are much lower. This translates into a negative result, reflected through a return on investment (ROI) of −98.98 per cent. Under these conditions, no investment will be carried out, which means that the positive impacts for society calculated in the section above will not materialize.

Table 4-1: Ghana: Mobile broadband (MBB) investment results for telecommunication operators – by policy scenario

Segment	Baseline (USD)	With regulatory reforms (USD)	With regulatory reforms + government contributions (USD)	With regulatory reforms + government and other sector contributions (USD)
	None	• Spectrum trading • Infrastructure sharing	• Spectrum trading • Infrastructure sharing • USF financing 30% of investment • Demand subsidy (40% of price) for vulnerable population • Demand subsidy for LEO users (100% hardware kit + 50% monthly fee)	• Spectrum trading • Infrastructure sharing • USF financing 30% of investment • Demand subsidy (40% of price) for vulnerable pop. • Demand subsidy for LEO users (100% hardware kit + 50% monthly fee) • 0.05% revenue fee charged to other sectors
MBB investment needed	USD 1,476,426,905	USD 1,227,746,045	USD 1,227,746,045	USD 1,227,746,045
MBB investment induced by regulatory reform	USD 0	USD 29,155,964	USD 29,155,964	USD 29,155,964
MBB investment covered by government	USD 0	USD 0	USD 368,323,813	USD 368,323,813
MBB investment covered by other sectors	USD 0	USD 0	USD 0	USD 376,058,081
MBB revenues generated	USD 15,037,847	USD 14,249,132	USD 608,811,165	USD 608,811,165
Net result for operator	-USD 1,461,389,058	-USD 1,184,340,948	-USD 221,455,101	USD 154,602,980
ROI for operator (%)	-98.98%	-96.46%	-18.04%	12.59%

Source: Telecom Advisory Services analysis

The first action aimed at mitigating this situation would be for the regulatory agency to conduct some regulatory reforms. As the ITU ICT Regulatory Tracker indicates, Ghana's overall score is 81, disaggregated in 16 (regulatory authority), 19 (regulatory mandate), 18 (regulatory regime), and 28 (competition framework).

Two initiatives have been identified that could have a positive mitigating impact on the investment business case:

- Spectrum secondary markets, defined as the allowance of trading of spectrum rights or licences directly between original licensed holders and buyers or leasers. Ghana is not currently allowing this practice.
- Foster infrastructure sharing obligation, which addresses the mandate to share towers, base stations, posts, ducts or is granting of access and use to public telecommunication networks (e.g., optical fibre, wireless) required by monopoly or dominant operators. Currently, the country is not implementing this measure.

These two initiatives would require some regulatory actions:

- According to the research, allowing secondary spectrum trading yields a reduction in the cost of spectrum access relative to what mobile operators would pay if they acquired spectrum at auction. This would free up capital to be invested in network deployment.
- Similarly, an obligation of spectrum sharing would allow mobile networks to reduce investment in network deployment. This would be particularly impactful in suburban and rural areas.

As indicated in the second column of Table 4-1, allowing spectrum secondary markets and infrastructure sharing can generate efficiencies and cost reductions, reducing the investment needed to USD 1.2 billion. The effect would materialize at two levels:

- Spectrum secondary trading will allow an increase in investment of USD 29 million.
- Infrastructure sharing will allow fixed broadband operator(s) to reduce cost of access to ducts and electric distribution posts, while mobile operators will reduce the network deployment costs by sharing in towers in suburban areas. This can reduce the deploying costs in 17 per cent.

However, even after the regulatory changes, the return for the operator is still unprofitable, with a -96.46 per cent ROI (see second column in Table 4-1). This means that direct intervention from the government is required, which would entail providing funding for the network deployment (where it is assumed that the USF will cover 30 per cent of the required investment), and subsidizing the demand (it is assumed that the economically disadvantaged 50 per cent of the population will benefit from a reduced price by 40 per cent, while users of LEO broadband will see their monthly fee reduced in 50 per cent and the hardware kit subsidized by the government).[43] In this context, the financial return for the operator improves significantly, as investment financed by the operator is reduced and the revenues grow largely due to the stimulated demand. However, the ROI remains in negative zone, -18.04 per cent.

In the last column of Table 4-1, it is assumed that a fee of 0.05 per cent of the revenue is charged to the other sectors of the economy to finance this investment, that as seen before, are large beneficiaries of this broadband project. Now, there is a business case for the operators, as the ROI turns positive (12.59%). Therefore, now the financial incentives for the telecommunication operator to deploy these networks emerge.

---

[43] We include LEO broadband within the group of mobile broadband due to the nature of satellite connectivity as a wireless solution. However, we acknowledge that in most cases the technology objective is to connect households, as a fixed-wireless solution.

As for the fixed broadband case (Table 4-2), baseline results are also largely negative (ROI of -66.99%). With the implementation of infrastructure sharing, the investment costs are reduced, and the ROI improves to -36.50 per cent. Following this, if the USF provides support for 30 per cent of the investment, the ROI turns into -6.50 per cent, still in the negative zone. Finally, if a 0.05 per cent fee is charged to other sectors to contribute to this deployment, the ROI turns positive, reaching 22.24 per cent.[44]

Table 4-2: Ghana: Fixed broadband (FBB) investment results for telecommunication operators – by policy scenario

Segment	Baseline (USD)	With regulatory reforms (USD)	With regulatory reforms + government contributions (USD)	With regulatory reforms + government and other sector contributions (USD)
	None	• Infrastructure sharing	• Infrastructure sharing • USF financing 30% of investment	• Infrastructure sharing • USF financing 30% of investment • 0.05% revenue fee charged to other sectors
FBB investment needed	USD 2,460,098,360	USD 1,386,442,874	USD 1,386,442,874	USD 1,386,442,874
FBB investment induced by regulatory reform	USD 0	USD 30,250,140	USD 30,250,140	USD 30,250,140
FBB investment covered by government	USD 0	USD 0	USD 415,932,862	USD 415,932,862
FBB investment covered by other sectors	USD 0	USD 0	USD 0	USD 398,454,208
FBB revenues generated	USD 812,140,552	USD 850,187,491	USD 850,187,491	USD 850,187,491
Net result for operator	-USD 1,647,957,808	-USD 506,005,243	-USD 90,072,381	USD 308,381,827
ROI for operator (%)	-66.99%	-36.50%	-6.50%	22.24%

Source: Telecom Advisory Services analysis

---

[44] From the economic perspective of the operator, loses can be reduced if the target covers only urban and a third of suburban areas. In such a case, the ROI in absence of any regulatory or policy intervention decreases from 66.99 per cent to 45.29 per cent. However, once regulatory and policy measures are implemented, the results from this alternative target scenario are very much aligned to the one presented in Table 4-2, thus being socially desirable to pursue the target of all urban and suburban areas.

4.5 Conclusion

If both projects in 5G and FTTH are implemented, the overall result for the operators will improve as there are combined synergies, for example, the impact on the rest of the economy will be larger if two technologies are deployed (instead of a single one), and therefore the contribution of other sectors to finance networks (as the spillovers they enjoy will increase). Overall, this will make the overall ROI for the operator can reach 23.87 per cent (Table 4-3). If spillovers from economic impact are added as another source of gain, now the IT sector as a whole (which includes telecommunications but also OTT services, software companies, etc.) will reach a net result of the investment close to 49.1 per cent (or 5% of its GDP).

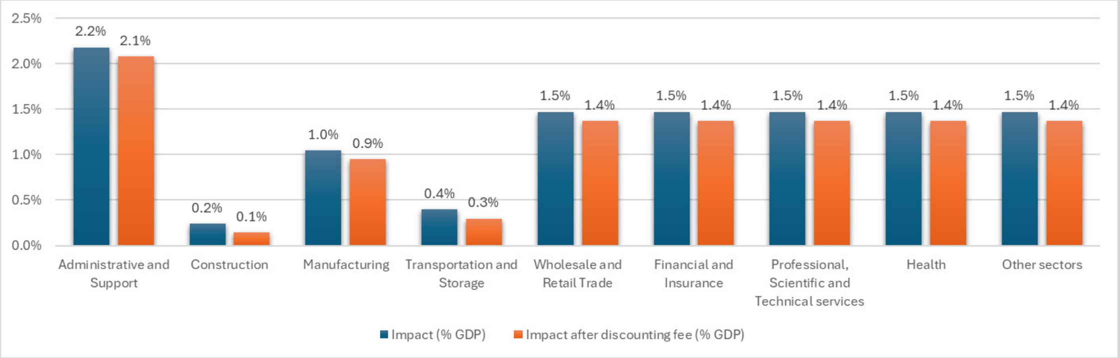
Table 4-3: Ghana: Overall results for IT sector

Segment	With regulatory reforms + government and other sector contributions
IT sector investment needed	USD 2,614,188,918
Cost savings due to regulatory reform	USD 59,406,104
Investment covered by government	USD 784,256,676
Investment covered by other sectors fee	USD 798,816,682
IT sector revenues	USD 1,595,777,007
Net result for operator	USD 624,067,551
ROI for operator (%)	23.87%
IT sector spillovers	USD 660,596,995
Net result IT sector (inc. spillovers)	USD 1,284,664,546
Net result IT sector (% of investment)	49.14%
Net result IT sector (% of cumulated sector GDP)	5.02%

Source: Telecom Advisory Services analysis

It is worth mentioning that, despite both 0.05 per cent fees applied to the other sectors of the economy, the net result for them is still largely positive, as represented in Figure 4-5.

Figure 4-5: Ghana: Impact for remaining economic sectors (as % of their GDP)



Source: Telecom Advisory Services analysis

In sum, Ghana has the potential to implement regulatory and policy reforms that will stimulate network deployments and will be largely beneficial to the society. The actions that need to be taken for these deployments to be feasible are the following:

- Implement regulatory measures to promote infrastructure sharing for operators participating in both wired and wireless networks, and between them and other sectors of the economy (such as electric utilities and transportation) that deploy infrastructure.
- Provide a more flexible approach for managing spectrum, allowing secondary trading of this resource between operators.
- Universal service must contribute to financing an important percentage of these investments.
- Create subsidies to stimulate demand. This is critical as affordability problems are limiting the access of important segments of the population to digital services. More demand will mean more revenue for the operator (then contributing to making the deployments profitable) and also larger economic impact through spillovers across the economy.
- Make other sectors contribute to network deployments. In this simulation, an overall 0.1 per cent fee was charged on their revenues, that is more than enough to make these investments profitable and thus, for the operator to have incentives to deploy them.

5 Case study pilot: Guatemala[45]

5.1 Starting point

Current telecommunication network coverage for Guatemala is presented in Figure 5-1 for 4G, 5G and FTTH networks. According to the ITU DataHub and the GSMA, Guatemala has a good coverage of 4G, reaching 93.1 per cent of total population. Based on these estimations, all urban and suburban areas are completely served by this technology, while 4G coverage reaches 85.2 per cent of rural areas. On the other hand, the country has reached 53.5 per cent coverage of 5G. Our estimates indicate that, while all the population of urban and suburban areas are covered by 5G, there is a lack of availability of this technology in rural areas.

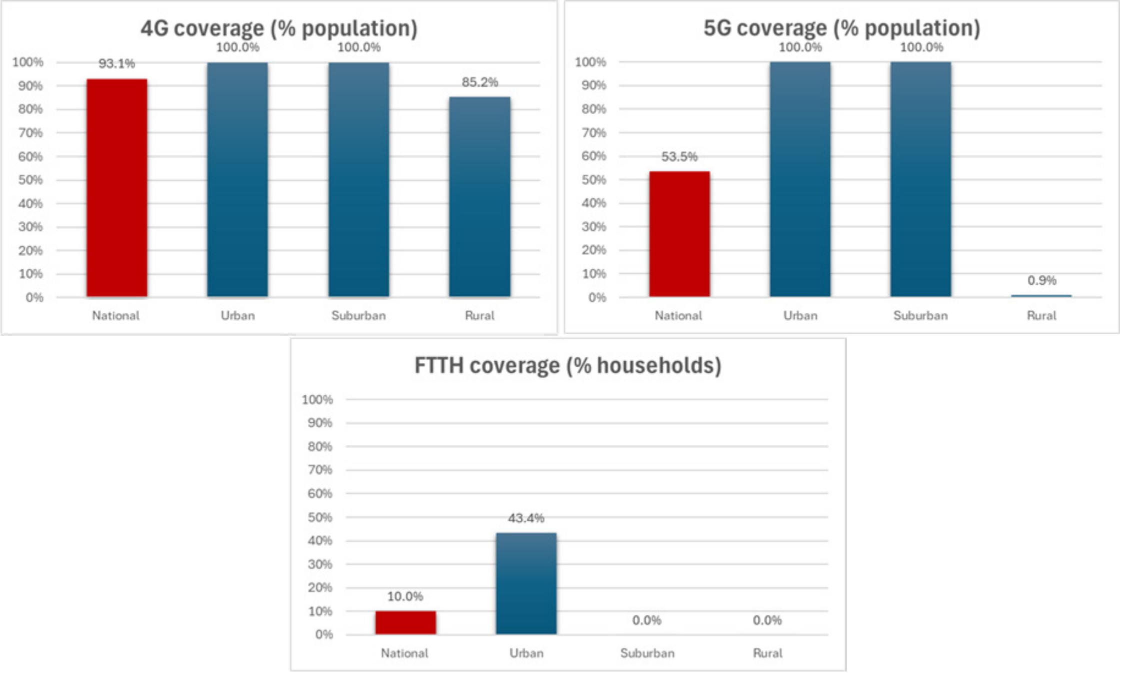
Regarding fixed broadband, this technology has limited coverage (64.43% of households are passed), as most of the connectivity is fulfilled through wireless networks. Consequently, FTTH coverage is very limited (an estimated 10% of households are covered by this technology). This means that only 43.4 per cent of households located in urban areas are covered by FTTH, while there is no coverage in suburban and rural regions.

As a result of the constrained supply situation, fixed broadband adoption level is low: only 21.45 per cent of households have adopted fixed broadband, mostly through copper lines; on the other hand, mobile broadband adoption is much higher: unique subscribers of mobile Internet account for 47.78 per cent of the population.

---

[45] This case study was conducted by relying on the following data sources: ITU DataHub, ITU Regulatory Tracker, ITU ICT Price Baskets, World Development Indicators from the World Bank, International Monetary Fund World Economic Outlook, IDATE Market Panorama, Ookla Speedtest, GSMA publicly available data, and additional local demographic sources.

Figure 5-1: Guatemala: Current coverage levels by technology and area



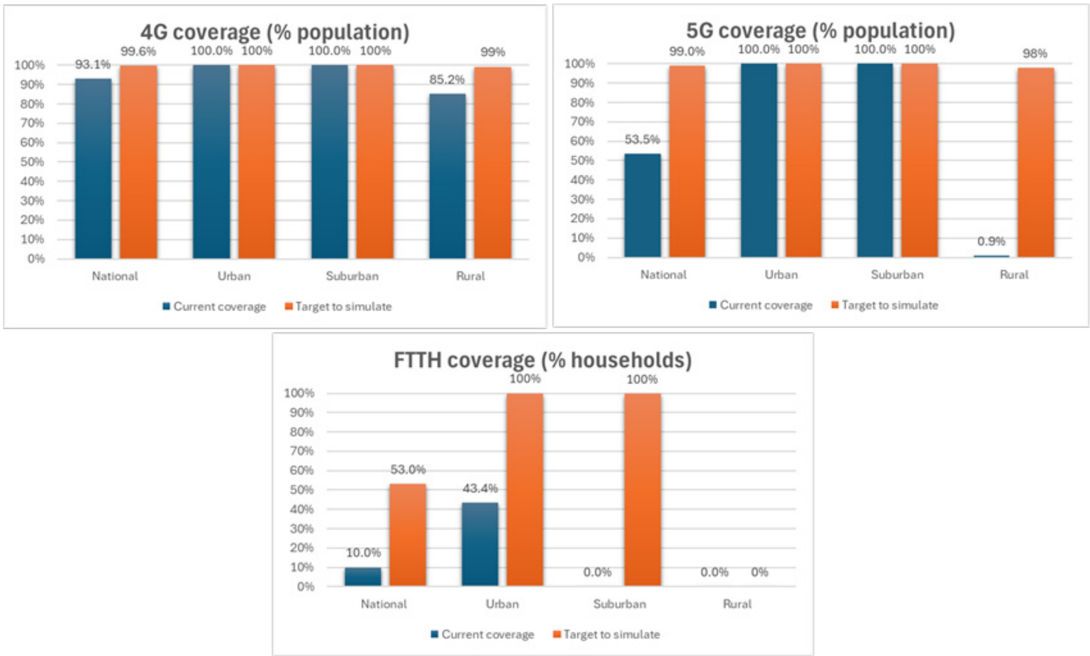
Source: Telecom Advisory Services analysis

Based on this situation as the starting point, an estimation of future deployment of the pilot was carried out focusing on accelerating roll-up of 4G, 5G and FTTH.

5.2 Pilot targets

The pilot purpose is to simulate an expansion of the coverage footprint for 4G, 5G and FTTH. The first objective is that wireless technologies (4G and 5G) should cover almost the entire population. In the case of FTTH, it is assumed that the expansion into rural areas is not economically feasible; therefore, the objective in this case is to cover only urban and suburban areas (see Figure 5-2).

Figure 5-2: Guatemala: Coverage targets by technology and area



Source: Telecom Advisory Services analysis

Serving the entire urban and suburban population through FTTH means expanding coverage to 53 per cent of households in the country in eight years. On the other hand, covering rural areas with 5G should require 5 years.

5.3 Social impact

If this project is completed in the allotted time, both fixed and mobile broadband adoption and their respective broadband speeds will improve considerably. Fixed broadband adoption is expected to reach 28 per cent of households in the eighth year, while mobile Internet unique subscribers will account for nearly 55 per cent of the population by the fifth year (these estimations are largely conservative as they do not consider the natural growth trends in adoption for both technologies). Under this scenario, the average fixed broadband speed will reach 759 Mbit/s (from 74.61 according to Ookla), while the average for mobile broadband will grow to 350 Mbit/s (from 104.52 according to Ookla). All of these effects will yield important economic spillovers[46], both in the aggregate and for the different sectors.[47]

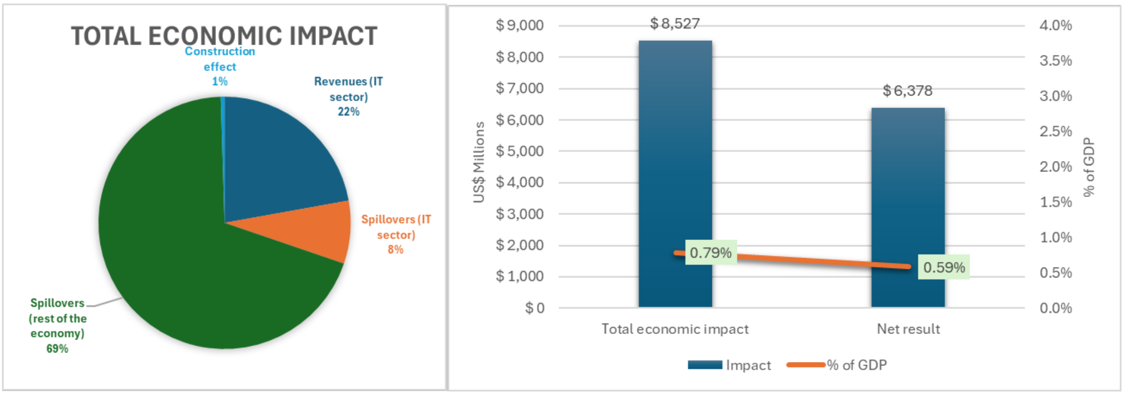
The investment in network deployment will yield an important economic impact. National impact includes all economic spillovers as well as the revenues of the telecommunication operators, which are considered as direct impact. It also includes the direct effect generated for the construction sector due to networks deployment works. The total of all these three effects represents USD 8.5 billion (or 0.79% of the national GDP). Even after discounting the investment in network construction, the returns are positive from a national economic perspective (USD 6.4 billion or 0.59% of GDP). The main source of impact is the spillovers generated over the different sectors of the economy, as represented in Figure 5-3.

---

[46] Economic spillover is defined as an indirect impact that an economic event, activity, or policy in one area (like a region, country, or sector) has on another one. These effects are also known as economic externalities.

[47] See Katz (2025). The impact of digital transformation of the economy. Econometric modelling. Geneva: International Telecommunication Union.

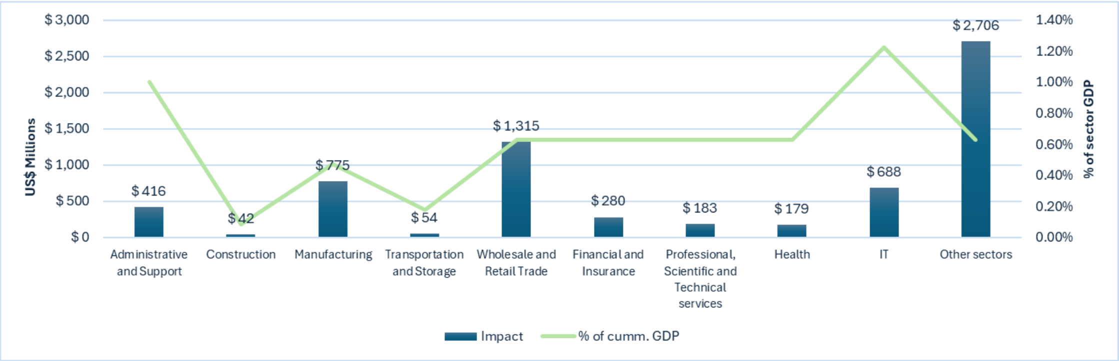
Figure 5-3: Guatemala: Country-level economic impact



Note: Net result refers to the total economic impact minus the investment made
Source: Telecom Advisory Services analysis

At a national level, GDP spillovers generated by this expansion will reach USD 6.6 billion (or 0.61% of cumulative economy during the analysed period)[48]. Economic spillovers flow to each economic sector, as presented in Figure 5-4.

Figure 5-4: Guatemala: Economic impact by sector



Note: the impact on the construction sector refers to direct activity (construction effect).
Source: Telecom Advisory Services analysis

The largest benefit will flow to the wholesale and retail trade sector (USD 1.3 billion), as triggered by broadband contributions to e-commerce on the retail side and logistics on the wholesale side. It is followed by manufacturing (USD 775 million), IT (USD 688 million) and administrative and support (USD 416 million), as general impact on digital transformation of the economy. The IT and the administrative and support sector, in turn, reach the maximum impact when measured as a share of their GDP (1.2% and 1.0%, respectively). Even the health sector benefits from the broadband input in areas such as general facilities operations at hospitals and clinics, but also the ability to deliver telemedicine services.

5.4 Private returns

The local telecommunication operators are the service providers that are responsible for deploying the broadband networks. Currently, the two large operators being present in the Guatemalan market are America Movil (Claro) and Millicom (Tigo). This section measures the financial impact of network deployment on the telecommunication sector in the aggregate.

---

[48] Guatemala's GDP is USD 121.18 billion (source: IMF)

This means that, for instance, if a reference is made to investment being made by the mobile sector, it is referred to in the aggregate, not by operator.

For all the economic impacts estimated in the prior section to materialize, there must be a business case for the telecommunication operators. This is not straightforward, as results for the operators (and consequently, their willingness to invest) will depend critically on the regulatory framework and on government policies implemented to facilitate these deployments.

Table 5-1 presents the mobile broadband deployment investment required for the operators under four scenarios, and the consequent return on investment (ROI) for the sector after factoring in the revenues to be generated by the enhanced infrastructure. All ROI values are adjusted to represent net present values, assuming a 1 per cent discount rate, although it is recognized that this should shift based on the current local conditions. The tool allows for adjustment of such rate.

Each scenario presents the ROI calculated by the tool according to the impact specific changes on the framework conditioning the business case. The tool calculates the ROI of the deployment for mobile and fixed broadband separately.

In absence of any policy intervention (scenario displayed in the first column), the mobile broadband project is clearly unprofitable for the operators, as the investment requires USD 3.3 billion. Furthermore, in the absence of any government initiative to stimulate demand under current service pricing, the revenues to be generated do not compensate for the investment to be made in deploying networks to the targets mentioned above. This translates into a negative result, reflected in a negative return on investment (ROI) of -88.25 per cent. Under these conditions, no investment will be carried out, which means that the positive impacts for society calculated in the section above will not be generated.

Table 5-1: Guatemala: Mobile broadband (MBB) investment results for telecommunication operators – by policy scenario

Segment	Baseline (USD)	With regulatory reforms (USD)	With regulatory reforms + government contributions (USD)	With regulatory reforms + government and other sector contributions (USD)
	None	• Infrastructure sharing • Colocation/ site-sharing	• Infrastructure sharing • Colocation/ site-sharing • USF financing 35% of investment • Demand subsidy (25% of price) for vulnerable population	• Infrastructure sharing • Colocation/ site-sharing • USF financing 35% of investment • Demand subsidy (25% of price) for vulnerable population • 0.05% revenue fee charged to other sectors
MBB investment needed	USD 3,286,428,983	USD 1,749,390,820	USD 1,749,390,820	USD 1,749,390,820

Table 5-1: Guatemala: Mobile broadband (MBB) investment results for telecommunication operators – by policy scenario (continued)

Segment	Baseline (USD)	With regulatory reforms (USD)	With regulatory reforms + government contributions (USD)	With regulatory reforms + government and other sector contributions (USD)
MBB investment induced by regulatory reform	USD 0	USD 0	USD 0	USD 0
MBB investment covered by government	USD 0	USD 0	USD 612,286,787	USD 612,286,787
MBB investment covered by other sectors	USD 0	USD 0	USD 0	USD 507,013,203
MBB revenues generated	USD 386,299,732	USD 379,679,820	USD 1,289,038,391	USD 1,256,529,898
Net result for operator	-USD 2,900,129,251	-USD 1,369,711,001	USD 151,934,357	USD 626,439,067
ROI for operator (%)	-88.25%	-78.30%	8.68%	35.81%

Source: International Telecommunication Union

What can Guatemala do to alleviate this situation? The first mitigating initiative would be for the regulatory agency to conduct some regulatory reforms (second column in Table 5-1). As the ITU ICT Regulatory Tracker indicates, Guatemala's overall score is 66, disaggregated as follows: 16 (for regulatory authority), 12 (for regulatory mandate), 11 (for regulatory regime), and 27 (for competition framework). Two initiatives have been identified that could have a positive mitigating impact on the investment business case:

- Foster infrastructure sharing obligation, which addresses the mandate to share towers, base stations, posts, ducts or is granting of access and use to public telecommunication networks (e.g., optical fibre, wireless) required by monopoly or dominant operators. Currently, the country is not implementing this measure.
- Mandate or strongly incentivize co-location/site sharing practices for mobile operators. Currently, the country is not implementing this measure.

These two initiatives will have an impact on reducing network deployment investment, since it will force operators to share infrastructure. However, it would require actions in the regulatory front. Similarly, an obligation of infrastructure sharing and co-location/site sharing mandates would allow mobile networks to reduce investment in network deployment. This would be particularly impactful in the case of deployments in suburban and rural areas.

As indicated in the second column of Table 5-1, allowing infrastructure sharing and co-location/site sharing can generate efficiencies and cost reductions, reducing the investment needed to USD 1.7 billion. However, even after the regulatory changes are implemented, the return for the operator is still unprofitable, with a -78.30 per cent ROI. The negative ROI in the second column implies that direct government intervention is required.

A third policy intervention could entail providing funds to subsidize network deployment (where it is assumed that the universal service fund will cover 35 per cent of the required investment) and support demand (it is assumed that the economically disadvantaged 50 per cent of the population will benefit from a reduced price by 20 per cent, due to a government voucher subsidization programme). In this context, the financial return for the operator improves significantly, with the ROI reaching 8.68 per cent.

The last column of Table 5-1 tackles yet another policy intervention. It is assumed, in this case, that a fee of 0.05 per cent of the revenue is charged to the other sectors of the economy to finance this investment, since as indicated above, they are large beneficiaries of this broadband project (see Figure 5-3). At this point, a positive business case for the telecommunication operators is confirmed, as the ROI reaches 35.81%.

As for the fixed broadband case (Table 5-2), baseline results (in the first column) are also largely negative (ROI of -79.19%). With the implementation of infrastructure sharing, the investment costs are reduced, and the ROI improves to -66.31 per cent (second column). Following this, if the USF provides support for 35 per cent of the investment and a subsidy for the demand is incorporated for the vulnerable population (third column), the ROI turns to -28.54 per cent, still in the negative zone. Finally, if a 0.05 per cent fee is charged to other sectors of the economy to contribute to this deployment (fourth scenario), the ROI turns positive, reaching 0.13 per cent.

Table 5-2: Guatemala: Fixed broadband (FBB) investment results for telecommunication operators – by policy scenario

Segment	Baseline (USD)	With regulatory reforms (USD)	With regulatory reforms + government contributions (USD)	With regulatory reforms + government and other sector contributions (USD)
	None	• Infrastructure sharing	• Infrastructure sharing • USF financing 35% of investment • Demand subsidy (40% of price) for vulnerable population	• Infrastructure sharing • USF financing 35% of investment • Demand subsidy (40% of price) for vulnerable population • 0.05% revenue fee charged to other sectors
FBB investment needed	USD 2,919,992,229	USD 1,768,948,746	USD 1,768,948,746	USD 1,768,948,746
FBB investment induced by regulatory reform	USD 0	USD 60,859,507	USD 60,859,507	USD 60,859,507
FBB investment covered by government	USD 0	USD 0	USD 619,132,061	USD 619,132,061
FBB investment covered by other sectors	USD 0	USD 0	USD 0	USD 507,185,415

Table 5-2: Guatemala: Fixed broadband (FBB) investment results for telecommunication operators – by policy scenario (continued)

Segment	Baseline (USD)	With regulatory reforms (USD)	With regulatory reforms + government contributions (USD)	With regulatory reforms + government and other sector contributions (USD)
FBB revenues generated	USD 607,657,853	USD 535,097,186	USD 584,101,796	USD 584,101,796
Net result for operator	-USD 2,312,334,375	-USD 1,172,992,054	-USD 504,855,382	USD 2,330,033
ROI for operator (%)	-79.19%	-66.31%	-28.54%	0.13%

Source: Telecom Advisory Services analysis

5.5 Conclusion

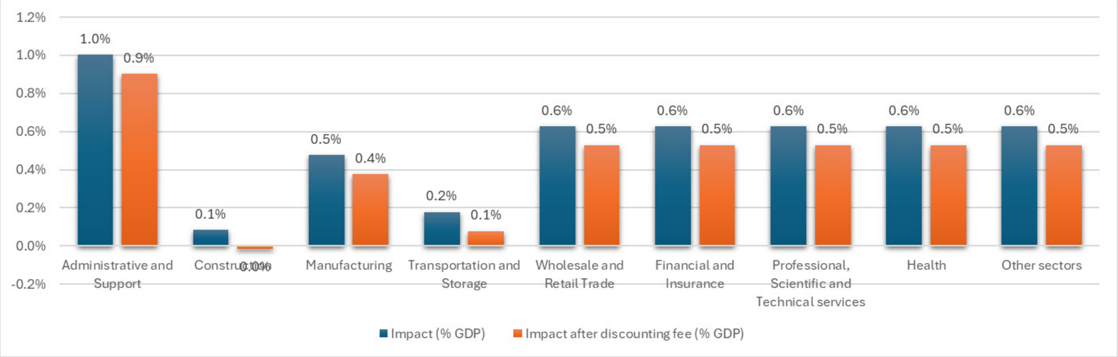
If the intended projects in 4G, 5G and FTTH in Guatemala are implemented jointly, the overall ROI for the operators will improve as there are combined synergies. For example, the impact on the rest of the economy will be larger if two or more technologies (instead of one) are deployed simultaneously, and therefore the contribution of other sectors to finance networks (as the spillovers they enjoy will increase). In this case, the overall ROI for the operator can reach 19.64 per cent If spillovers from economic impact are added as another source of gain, now the IT sector as a whole (this includes telecommunications but also OTT services, software companies, etc.) will reach a net result of the investment close to 39.2 per cent (or 2.5% of its GDP). (Table 5-3).

Table 5-3: Guatemala: Overall results for IT sector

Segment	With regulatory reforms + government and other sector contributions
IT sector investment needed	USD 3,518,339,566
Cost savings due to regulatory reform	USD 60,859,507
Investment covered by government	USD 1,231,418,848
Investment covered by other sectors fee	USD 1,026,444,452
IT sector revenues	USD 1,890,650,728
Net result for operator	USD 691,033,969
ROI for operator (%)	19.64%
IT sector spillovers	USD 687,619,651
Net result IT sector (inc. spillovers)	USD 1,378,653,620
Net result IT sector (% of investment)	39.18%
Net result IT sector (% of cumulated sector GDP)	2.45%

Source: International Telecommunication Union It is worth mentioning that, despite the 0.05 per cent fees applied to the other sectors of the economy, the net result for them is still positive, except for the construction sector, as represented in Figure 5-5. This raises the possibility of establishing a differentiated fee by economic sector, depending on their expected economic benefit derived from digitization.

Figure 5-5: Guatemala: Impact for remaining economic sectors (as % of their GDP)



Source: Telecom Advisory Services analysis

In sum, Guatemala has the potential to implement regulatory and policy reforms that will stimulate network deployments and will be largely beneficial to society. The actions that need to be taken for these deployments to be feasible are:

- Implement regulatory measures to promote infrastructure sharing for operators participating in both wired and wireless networks, and also between them and other sectors of the economy (such as electric utilities and transportation) that deploy infrastructure.
- Mandate or strongly incentivize co-location/site sharing practices for mobile operators.
- Universal service must contribute to financing an important percentage of these investments.
- Create subsidies to fund service consumption from the vulnerable population. This is critical as affordability problems are limiting digital services access to important segments of the population. More demand will mean more revenue for the operator (then contributing to making the deployments profitable) and will generate a larger economic impact through spillovers across the economy.
- Make other sectors contribute to network deployments. In this simulation, an overall 0.1 per cent fee was charged on their revenues, that is more than enough to make these investments profitable and thus, for the operator to have incentives to deploy them.

6 Case study pilot: Saudi Arabia

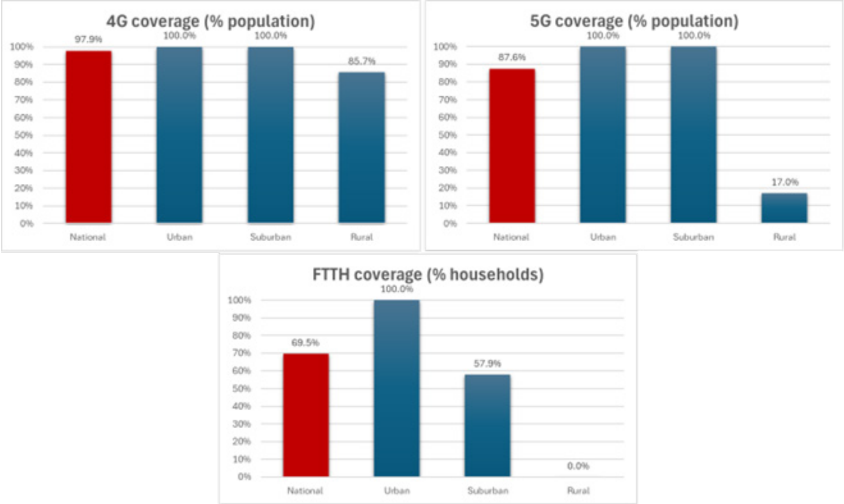
The Vision 2030 programme of Saudi Arabia aims to build across the country sophisticated digital networks as key infrastructures to today's advanced industrial activities, identifying these as critical to attract investors and enhance the competitiveness of the economy in Saudi Arabia. More specifically, among the goals established, the programme aims to develop the telecommunications and information technology infrastructure, especially high-speed broadband, expanding its coverage and capacity within and around cities and improving its quality.

Consistent with Vision 2030, in recent years the country has been experiencing important advances in digital infrastructure deployments, although more effort is needed to bridge the digital divide and to fulfil the programme targets. While certain regulatory obligations in terms of broadband coverage currently exist in Saudi Arabia, Vision 2030 consists of a much more ambitious target. Therefore, this chapter simulates the associated costs and the economic effects derived from the process of bridging the coverage gap across Saudi Arabia, distinguishing those regulatory obligations with those requirements to fulfil a more ambitious national goal aligned with the Vision 2030 programme.

6.1 Starting point

Current telecommunication network coverage levels for Saudi Arabia are presented in Figure 6–1 for 4G, 5G and FTTH networks. According to GSMA, Saudi Arabia has 97.9 per cent of the population covered with 4G networks meaning that all urban and suburban areas are served by this technology, while in rural areas 4G coverage reaches 85.7 per cent.[49] This means that nearly 15 per cent of rural population does not have coverage for mobile broadband. On the other hand, the country has been expanding its coverage of 5G, as the network is available to 87.6 per cent of the population. Estimates indicate that while all of the population of urban and suburban areas are covered by 5G, there is a lack of availability of this technology in rural areas (17% coverage).

Figure 6-1: Saudi Arabia: Current coverage levels by technology and area



Source: Telecom Advisory Services analysis

Regarding fixed broadband, this technology is extensively deployed in the country, with penetration levels reaching more than 100 per cent of households, while FTTH coverage is almost 70 per cent at the national level. Critically, there is a lack of FTTH coverage across suburban areas, as current levels lie below 60 per cent of households. As a result of the supply situation, fixed broadband adoption is largely available, although several households must rely on copper or older technologies, while the unique subscribers of mobile Internet account for

---

[49] This estimation is done by assuming that the first areas to be covered are the urban ones (where 48% of the population lives), and once urban areas are completely covered the expansion continues through suburban areas (37% of the population). Only when suburban areas are completed the rural regions start to be covered (15% of the population). Assumptions and definitions of urban, suburban and rural areas is described in section 6.3.

73.56 per cent of the. Based on this situation as the starting point, the next section develops the targets to be simulated for the case of Saudi Arabia.

6.2 Targets

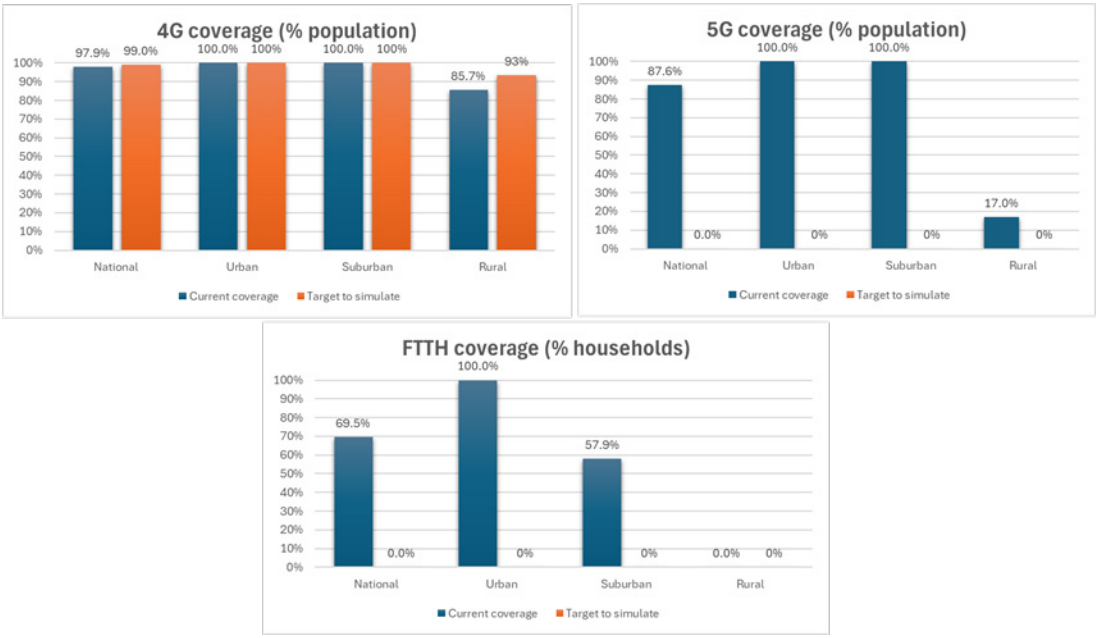
As explained above, targets will be distinguished between those that reflect a regulatory obligation, and those that have a more ambitious national goal aligned with the Vision 2030 programme.[50]

6.2.1 Regulatory obligation

Regulatory obligations establish the need to cover almost the entire country with 4G technology. More specifically, 99 per cent of the population in Saudi Arabia should have 4G coverage according to this requirement.

Therefore, an initial exercise to simulate will consist in estimating the investment required and the economic impact if this obligation is met. As presented in Figure 6-2, this will represent an improvement only in 4G, leaving 5G and FTTH coverage levels unchanged.

Figure 6-2: Saudi Arabia: Coverage targets under the regulatory obligations scenario



Source: Telecom Advisory Services analysis

The improvement in 4G coverage will be concentrated in the rural areas of the country, that following these deployments will experience an increase in coverage from 85.7 per cent to 93 per cent of its population.

6.2.2 National goals

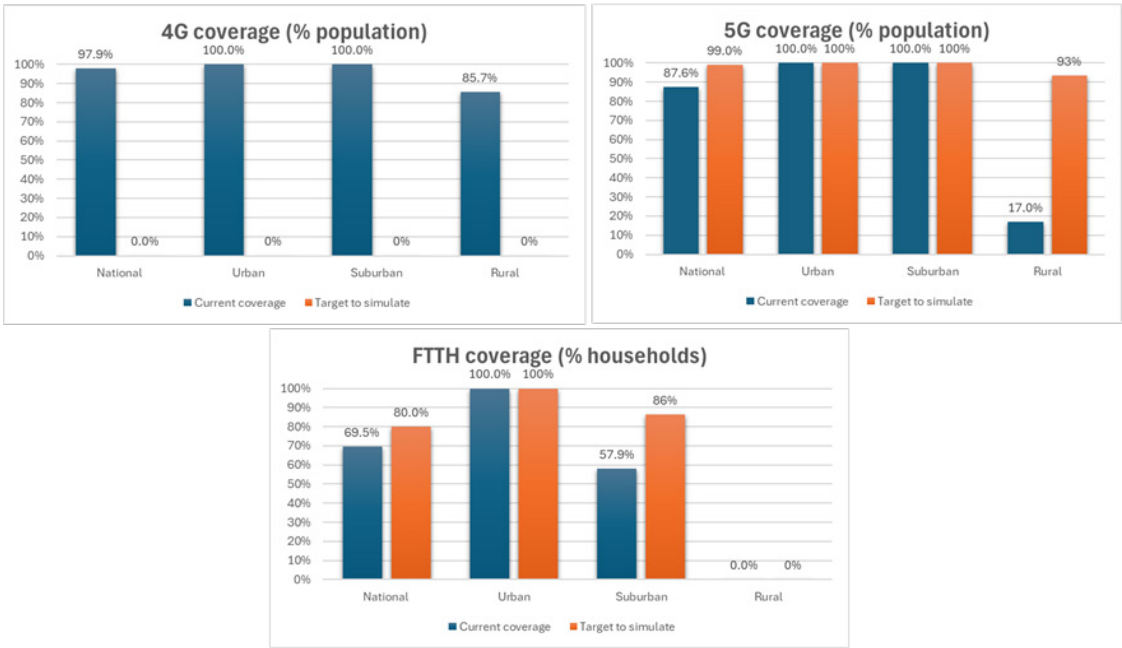
Aligned with the Vision 2030, there are more ambitious goals that Saudi Arabia may reach in terms of broadband coverage. This includes reaching 80 per cent of households covered

---

[50] The assumptions of the previous footnote also apply for the case of the coverage targets across the different areas of the countries.

by FTTH, that will consist in expanding these deployments across 86 per cent of households in suburban areas and making 5G widely available, reaching 99 per cent of coverage (from current 86.7% levels). These are necessary conditions for reaching other goals aligned with the Vision 2030 programme, such as increasing the maturity of digital services; developing smart cities/ports/airports; implementing the national strategies regarding Fintech, National Gaming and E-sports; the development of Cloud Computing and Informatics Special Economic Zone; and to situate three Saudi Arabian cities among top-100 liveable cities in the world.

Figure 6-3: Saudi Arabia: Coverage targets under the national goals scenario



Source: International Telecommunication Union

Beyond the expansion of FTTH across suburban areas, these ambitious goals also mean focusing on 5G (and not 4G as the regulatory obligation establishes) as the main technology to be deployed in rural areas.

For both scenarios, a period of three years was established starting in 2026/2027 for the development of these deployments, with 2030 as the ending point of the simulation.

6.3 Data collection and assumptions

To calibrate the model to be used for simulation of the targets, some important secondary data was collected, and assumptions were made regarding the case of Saudi Arabia telecommunication market, as described below.

- Capex per capita. Total annual investment according to the latest ITU figures is USD 4.09 billion, of which USD 3.08 billion corresponds to mobile networks according to GSMA (the difference between both figures is the amount attributed to fixed broadband). Weighting by population, the starting investment values (per capita) are calculated as follows:
    - USD 26.81 dollars per capita for fixed broadband
    - USD 81.56 dollars per capita for mobile broadband

- Coverage starting points
    - 69.50 per cent of households passed by FTTH
    - 95 per cent of households passed by fixed broadband (assumption)
    - 97.85 per cent of population covered by 4G (source: GSMA)
    - 87.55 per cent of population covered by 5G (source: GSMA)
- Initial speed levels (source: Ookla speedtest)
    - Fixed broadband: 132.66 Mbit/s
    - Mobile broadband: 194.37 Mbit/s
- Prices
    - Fixed broadband: USD 8/month (FBB basket 5GB)
    - Mobile broadband: USD 18.40/month (data only MBB basket 2GB)
- Penetration levels
    - Fixed broadband penetration: 95 per cent of households (assumed)
    - Mobile broadband unique subscribers' penetration: 73.56 per cent of population (source: GSMA)
- Revenues. Total revenue according to the latest ITU figures is USD 20.9 billion, of which USD 11.86 billion is reported as associated with mobile networks (the difference between both figures is the amount attributed to fixed broadband). Therefore:
    - Fixed broadband USD 9 082.30 million
    - Mobile broadband USD 11 861.30 million

Based on desk research conducted through secondary sources regarding the main cities and towns in the country, their population and area covered, for simulation purposes Saudi Arabia's territories are separated according to the following characteristics:

- **Urban areas**: it considers the main cities of the country: Riyadh, Jeddah, Mecca, Medina and Dammam. Taken together, they present a population density of 2 953 people per square km. The share of population living in these areas is 48 per cent.
- **Suburban areas**: it considers intermediate cities and towns. In total, they present a population density of 380 people per square km. The share of population living in these areas is 37 per cent.
- **Rural areas**: it considers the remaining territory of the country (98% of the land), that taken together presents a population density of 3 people per square km. The share of population living in these areas is 15 per cent.

The sectoral composition of Saudi Arabia's economy is structured (in terms of their share of the national GDP), according to the latest sector GDP figures reported in the national accounts:

- Administrative and support services: 1.4 per cent
- Construction: 7.8 per cent
- IT: 2.7 per cent
- Manufacturing: 16.8 per cent
- Transportation and storage: 3.2 per cent
- Wholesale and retail trade: 9.3 per cent

- Financial and insurance: 3.9 per cent
- Professional, scientific and technical services: 1.1 per cent
- Health: 3.6 per cent
- Other sectors: 50.2 per cent

Finally, other important assumptions made include a 1 per cent discount rate, to be applied for financial flows corresponding to future periods. Total population figure is 37.7 million inhabitants, while the number of households is reported at 5.6 million.

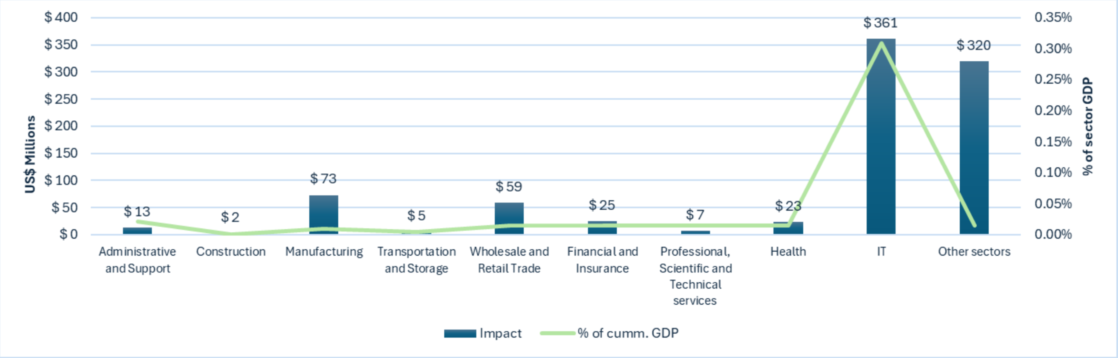
6.4 Social impact

6.4.1 Impact under the regulatory obligation scenario

If the regulatory obligations are met, broadband coverage will increase considerably, although only through 4G developments. Mobile Internet unique subscribers will account for 83 per cent of the population by the third year (this estimation is largely conservative as it does not consider the natural growth trends in adoption for this technology). This broadband adoption growth will yield some economic spillovers[51], both in the aggregate and for the different sectors.

At a national level, GDP spillovers generated by this expansion will reach 0.02 per cent of cumulated economy size during the analysed period (or USD 888 million)[52]. Economic spillovers by sector are presented in Figure 6-4.

Figure 6-4: Saudi Arabia: Economic impact by sector under the regulatory obligations scenario



Note: The impact on the construction sector refers to direct activity (construction effect). Results correspond to scenarios that include government and other sector contribution.
Source: Telecom Advisory Services analysis

As can be seen in Figure 6-4, the spillovers are modest. This is because the extra population and firms to be covered is small (the simulation only consists in expanding rural population coverage from 86% to 93%) and also because the development of 4G (rather than 5G) will limit the economic effects regarding speed increases. The most favoured sector is IT (USD 361 million), followed by manufacturing (USD 73 million). At the national level, the investment will yield a modest economic impact. National impact includes all spillovers as well as the revenues of the telecommunication operators as direct impact. It also includes the direct effect generated for

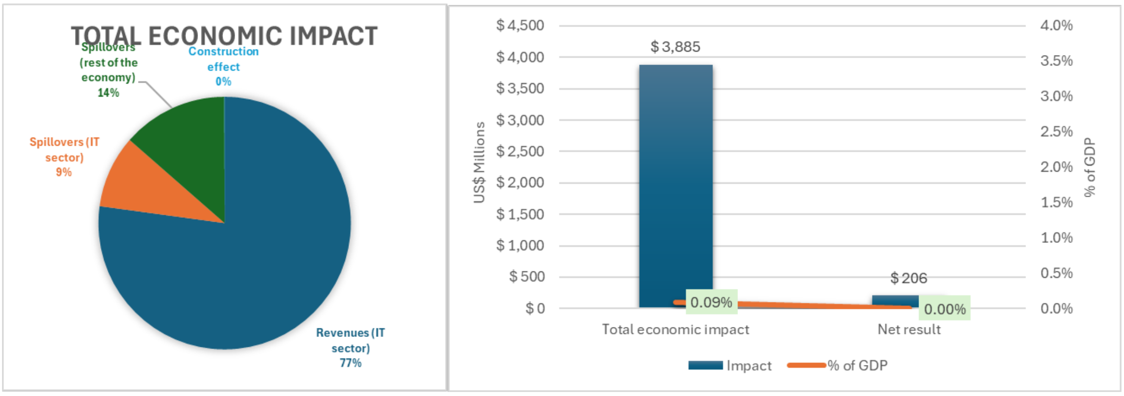
---

[51] Economic spillover is defined as an indirect impact that an economic event, activity, or policy in one area (like a region, country, or sector) has on another one. These effects are also known as economic externalities.

[52] Saudi Arabia's GDP is USD 1 083.75 billion (source: IMF)

the construction sector due to civil work. This total amount represents USD 3.9 billion (or 0.09% of the national GDP). After discounting the investment made, the returns seem to be barely profitable from a national perspective (USD 206 million or less than 0.01% of GDP). The main source of impact is the IT revenues (Figure 6-5).

Figure 6-5: Saudi Arabia: Country-level economic impact under the regulatory obligations scenario



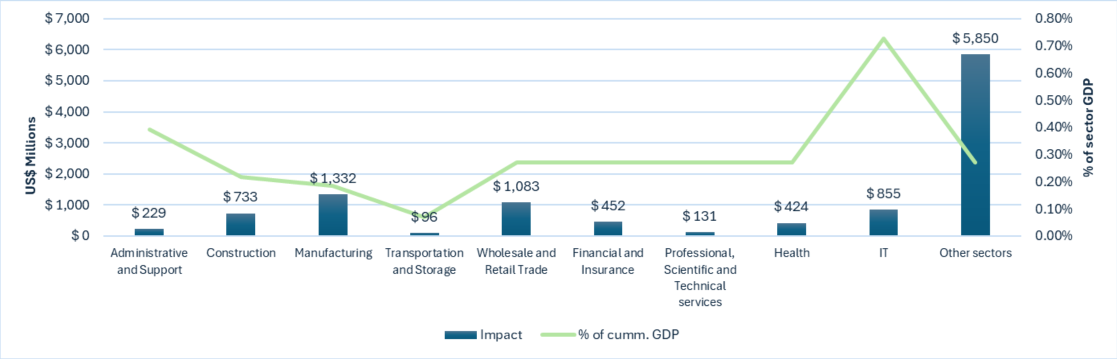
Note: Net results refer to the total economic impact minus the investment made. Results correspond to scenarios that include government and other sector contributions.
Source: Telecom Advisory Services analysis

6.4.2 Impact under the national goals scenario

If the national goals are met, broadband expansion across the country will be much deeper, through both FTTH and 5G deployments. Mobile Internet unique subscribers will account for 84 per cent of the population, again this being largely conservative as it does not consider the natural growth trends in adoption. Fixed broadband in turn will continue serving almost all households, although now at much faster speeds that arise from optical fibre. These developments will yield much larger economic spillovers in comparison with the regulatory obligation scenario, both in the aggregate and for the different sectors.

At a national level, GDP spillovers generated by this expansion will reach 0.26 per cent of cumulated economy size during the analysed period (or USD 11.2 billion). Economic spillovers by sector are presented in Figure 6-6.

Figure 6-6: Saudi Arabia: Economic impact by sector under the national goals scenario



Note: the impact on the construction sector refers to direct activity (construction effect). Results correspond to scenarios that include government and other sectors' contribution
Source: International Telecommunication Union

The largest impact will be on the manufacturing sector (USD 1.3 billion). Fast broadband is a critical enabler for the manufacturing sector, driving productivity, innovation, and competitiveness through diverse mechanisms:

- High-speed connectivity supports the Industrial Internet of Things (IIoT), allowing for predictive maintenance, remote monitoring, and automation, which lowers downtime and maintenance costs.
- Fast broadband facilitates cloud-based collaboration, supply chain integration, and real-time decision-making, helping manufacturers respond quickly to market changes and disruptions.
- Digital transformation attracts skilled workers and supports innovation, such as the use of machine learning, 3D modelling, and advanced analytics, which are essential for firm competitiveness.
- Reduced latency and increased reliability in broadband networks can facilitate the use of advanced manufacturing applications like robotics, augmented reality training, and remote control of production lines.
- Enhanced connectivity allows manufacturers to expand e-commerce activities, access global markets, and participate in digital supply chains.

Beyond manufacturing, the next sector by economic gains are the wholesale and retail services (USD 1,083 million). The key economic relevance of fast broadband networks for these services can be described as:

- Internet enables e-commerce growth by allowing retailers and wholesalers to process transactions online, reaching wider consumer markets and reducing dependency on physical sales channels.
- High-speed connectivity improves supply chain management and inventory control by enabling real-time data sharing with suppliers and logistics.
- The use of advanced data analytics can help retailers to better understand consumer patterns, personalize offerings, and conduct targeted marketing.
- Retailers can provide more interactive and multichannel customer experiences, such as click-and-collect, digital catalogues, and social media engagement, enhancing customer satisfaction and retention.
- The competitive pressure from online marketplaces can push traditional brick-and-mortar stores to innovate their business models.

Beyond the IT sector itself (USD 855 million in economic gains) and the construction sector impact (USD 733 million) that depends on the construction expenditure for deploying broadband, there are also important gains for financial services (USD 452 million). This can be described as:

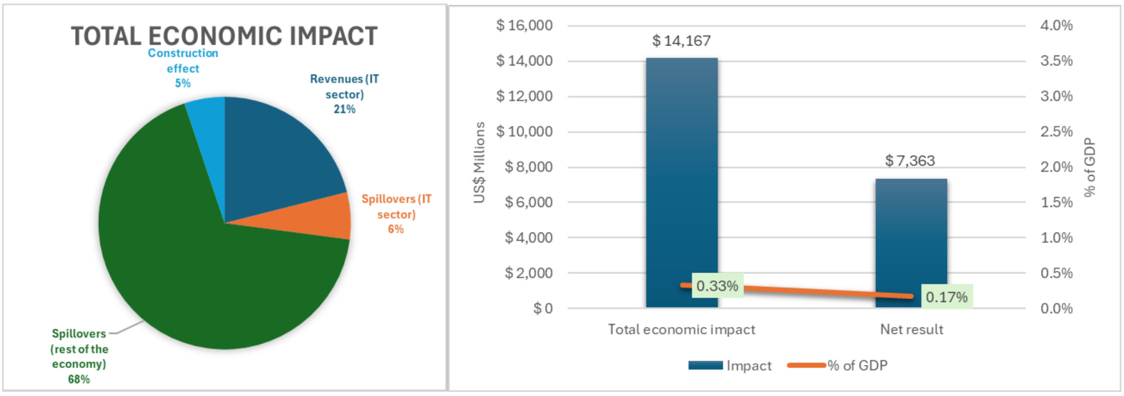
- Connectivity lowers operational costs and enables greater productivity in banks, fostering competition and expansion of financial services beyond traditional geographic limits.
- Internet enhances the ability of banks to supply credit by improving information acquisition, processing, and monitoring, leading to increased loan supplies.
- Internet reduces information asymmetry, enabling better risk assessment and more efficient screening and monitoring of borrowers.
- Financial firms can automate back-office tasks, streamline payment processing, facilitate real-time trading, and increase efficiency.
- Internet supports innovation in digital banking, mobile finance, and fintech products, enabling new business models.

Finally, the Health sector also achieves important benefits (USD 424 million), as the relevance of fast broadband for this sector can contribute through several paths:

- Health sector providers can use high-speed Internet for rapid transmission of critical medical information and multimedia applications, enhancing the quality and speed of care.
- Broadband supports electronic health records and remote monitoring, reducing administrative errors, lowering annual healthcare costs, and facilitating earlier disease detection.
- Increased reach of telemedicine services, making healthcare more accessible for rural, elderly, and disabled populations while reducing associated costs.

At the national level, the investment will yield an economic impact. National impact includes all spillovers as well as the revenues of the telecommunication operators as direct impact. It also includes the direct effect generated for the construction sector due to civil work. This total amount represents USD 14.2 billion (or 0.33 per cent of the national GDP). Even after discounting the investment made, the returns seem to be profitable from a national perspective (USD 7.4 billion or 0.17% of GDP). The main source of impact is the economic spillovers (Figure 6–7).

Figure 6-7: Saudi Arabia: Country-level economic impact under the national goals scenario



Note: Net results refer to the total economic impact minus the investment made. Results correspond to scenarios that include government and other sector contributions.
Source: Telecom Advisory Services analysis

6.5 Private returns

The local telecommunication operators are the parties that should conduct the deployment of these networks. Currently, there is a competitive sector in Saudi Arabia, served by operators STC, Mobily, and Zain Saudi Arabia. However, this section analyses the impact of deployment on the telecommunication sector in the aggregate. This means that, for instance, if refence is made to investment being made by the mobile sector, it is referred to in the aggregate (not by operator).

That being said, for all these economic impacts to materialize, there must be a business case for the telecommunication operators, who decide to invest in the first place. This is not straightforward, as results for the operators (and then, the willingness to invest) will depend critically on the regulatory framework and on government policies conducted to facilitate these deployments.

Next, analysis shows how the results for the telecommunication operators evolve under the different scenarios proposed.

6.5.1 Private returns under the regulatory obligation scenario

Table 6-1 presents the mobile broadband deployment investment results for the operators in the regulatory obligation scenario. All figures are adjusted to present values, assuming a 1 per cent discount rate, although it is recognized that this should shift based on the current local conditions. In absence of any policy action, the project is clearly unprofitable for the operators, as the investment requires USD 6.1 billion, however the revenues are much lower. This translates into a negative result, reflected through a return on investment of -97.6 per cent. Under these conditions, no investment will be carried out, which means that the positive impacts for society calculated in the section above will not be generated.

Table 6-1: Saudi Arabia: Mobile broadband investment results for telecommunication operators under the regulatory obligations scenario

Segment	Baseline (USD)	With government contributions (USD)	With government and other sector contributions (USD)
	None	• Government financing 33% of investment • Demand subsidy (40% of price) for vulnerable pop.	• Government financing 33% of investment • Demand subsidy (40% of price) for vulnerable pop. • 0.08% revenue fee charged to other sectors
4G+5G investment needed	USD 6,149,937,570	USD 6,149,937,570	USD 6,149,937,570
Satellite investment needed	USD 0	USD 0	USD 0
Total wireless investment needed	USD 6,149,937,570	USD 6,149,937,570	USD 6,149,937,570
Wireless investment induced by regulatory reform	USD 0	USD 0	USD 0
Wireless investment covered by government	USD 0	USD 2,029,479,398	USD 2,029,479,398
Wireless investment covered by other sectors fee	USD 0	USD 0	USD 3,339,650,814
Wireless revenues generated	USD 149,132,643	USD 2,997,670,408	USD 2,997,670,408
Net result for operator	- USD 6,000,804,927	- USD 1,122,787,764	USD 2,216,863,049
ROI for operator (%)	-97.58%	-18.26%	36.05%

Source: Telecom Advisory Services analysis

The first action aimed at mitigating this situation should be for the regulatory agency to conduct some regulatory reforms, however, Saudi Arabia is already adopting advanced regulatory practices. As the ITU ICT Regulatory Tracker indicates, Saudi Arabia's overall score is 96, disaggregated in 18 (regulatory authority), 22 (regulatory mandate), 30 (regulatory regime), and 26 (competition framework).

This means that direct intervention from the government is required, which would entail providing funding for the network deployment (although the Saudi Arabia does not currently has a USF, this intervention will consist that the government will cover a third of the required investment), and subsidizing the demand (it is assumed that the economically disadvantaged 50 per cent of the population will benefit from a reduced price by 40 per cent, due to government voucher subsidization). The magnitude of the proposed subsidy is inspired in the case of Colombia, were the poorer 50 per cent of households[53] are applicable to receive certain financial helps for accessing Internet, that in some cases can represent more than 50 per cent of the price.[54] In this context, the financial return for the operator improves significantly, as investment financed by the operator is reduced and the revenues grow largely due to the stimulated demand. However, the ROI remains in negative zone, -18.3 per cent.

In the last column of Table 6-1, it is assumed that a fee of 0.08 per cent of the revenue is charged to the other sectors of the economy to finance this investment, that as seen before are beneficiaries of this broadband project. This fee was selected as an example to illustrate how can the telecommunication industry can achieve a positive ROI if other sectors contribute. To determine the magnitude of the imposition, the following criteria was considered:

- The imposition level was designed to represent a share of firm revenues rather than a lump sum, to take into account the economic size of the different businesses.
- The applicable fee percentages were selected to be large enough to ensure that ROI levels turned into a positive zone.
- However, the overall imposition (considering fees applicable to both fixed and mobile deployments) must not be larger than the benefit that these sectors obtain from the spillovers generated by these investments, otherwise it will make no economic sense to justify the contribution.
- The previous conditions will mean that the fees will be simulated to be applied to all other economic sectors except transportation and storage, as their estimated benefits from these deployments were lower than the proposed fee.

Now, there is a business case for the operators, as the ROI turns positive (36.1%). Therefore, now there are incentives for the telecommunication operator to deploy these networks.

6.5.2 Private returns under the national goals scenario

Table 6-2 presents the mobile broadband deployment investment results for the operators in the ambitious national goals scenario, that focus on 5G expansions as explained above. In absence of any policy action, the project is again unprofitable for the operators, as the investment requires USD 8 billion, however the revenues are much lower. This translates into a negative result, reflected through a return on investment (ROI) of -98.5 per cent. Under these

---

[53] La República (2022): "*Cifras de Kantar indicaron que la población estrato 1 en Colombia corresponde al 21%*" (March 15th). https://www.larepublica.co/empresas/kantar-da-a-conocer-cifras-relevantes-en-el-marco-del-dia-mundial-del-consumidor-3322740

[54] Diario del Otún (2025): "*MinTIC propone que estratos altos y empresas subsidien internet para familias de bajos ingresos*" (August 24th). https://www.eldiario.com.co/noticias/economia/mintic-propone-que-estratos-altos-y-empresas-subsidien-internet-para-familias-de-bajos-ingresos/. Gobierno de Bogotá (2026): "Más de 12.000 hogares de Bogotá ya cuentan con internet gratuito" (January 7th). https://bogota.gov.co/mi-ciudad/integracion-social/mas-de-12000-hogares-de-bogota-ya-cuentan-con-internet-gratuito

conditions, no investment will be carried out, which means that the positive impacts for society calculated in the section above will not be generated.

If the government intervenes to cover a third of the required investment, and if demand is subsidized in the same conditions as described before, the financial return for the operator improves significantly, although the ROI remains at negative levels, reaching -29.9 per cent. The last column of Table 6-2 assumes that a fee of 0.08 per cent of the revenue is charged to the other sectors of the economy to finance this investment,[55] with the ROI now turning into the positive zone (11.94%).

Table 6-2: Saudi Arabia: Mobile broadband investment results for telecommunication operators under the national goals scenario

Segment	Baseline (USD)	With government contributions (USD)	With government and other sector contributions (USD)
	None	• Government financing 33% of investment • Demand subsidy (40% of price) for vulnerable pop.	• Government financing 33% of investment • Demand subsidy (40% of price) for vulnerable pop. • 0.08% revenue fee charged to other sectors
4G+5G investment needed	USD7 998 343 940	USD 7,998,343,940	USD 7,998,343,940
Satellite investment needed	USD0	USD 0	USD 0
Total wireless investment needed	USD7 998 343 940	USD 7,998,343,940	USD 7,998,343,940
Wireless investment induced by regulatory reform	USD0	USD 0	USD 0
Wireless investment covered by government	USD0	USD 2,639,453,500	USD 2,639,453,500
Wireless investment covered by other sectors fee	USD0	$ 0	USD 3,348,164,125
Wireless revenues generated	USD116 932 796	USD 2,965,353,228	USD 2,965,353,228
Net result for operator	-USD 7 881 411 144	- USD 2,393,537,212	USD 954,626,913
ROI for operator (%)	-98.54%	-29.93%	11.94%

Source: Telecom Advisory Services analysis

As for the fixed broadband case (Table 6-3), baseline results are also largely negative (ROI of -100%). If the government finances a third of the investment, the ROI improves to -67 per cent. Finally, if a 0.08 per cent fee is charged to other sectors to contribute to this deployment, the ROI turns positive, reaching 51.3 per cent.

---

[55] As in the case of the regulatory obligation scenario, the fee is simulated to be applied to all other economic sectors except transportation and storage, for the same reasons.

Table 6-3: Saudi Arabia: Fixed broadband (FBB) investment results for telecommunication operators under the national goals scenario

Segment	Baseline (USD)	With government contributions (USD)	With government and other sector contributions (USD)
	None	- Government financing 33% of investment	- Government financing 33% of investment - 0.08% revenue fee charged to other sectors
FBB investment needed	USD 2 815 911 064	USD2 815 911 064	USD 2,815,911,064
FBB investment induced by regulatory reform	USD0	USD0	USD 0
FBB investment covered by government	USD0	USD929 250 651	USD 929,250,651
FBB investment covered by other sectors	USD0	USD0	USD 3,331,106,490
FBB revenues generated	USD0	USD 0	USD 0
Net result for operator	-USD 2 815 911 064	-USD 1 886 660 413	USD 1,444,446,077
ROI for operator (%)	-100.00%	-67.00%	51.30%

Source: Telecom Advisory Services analysis

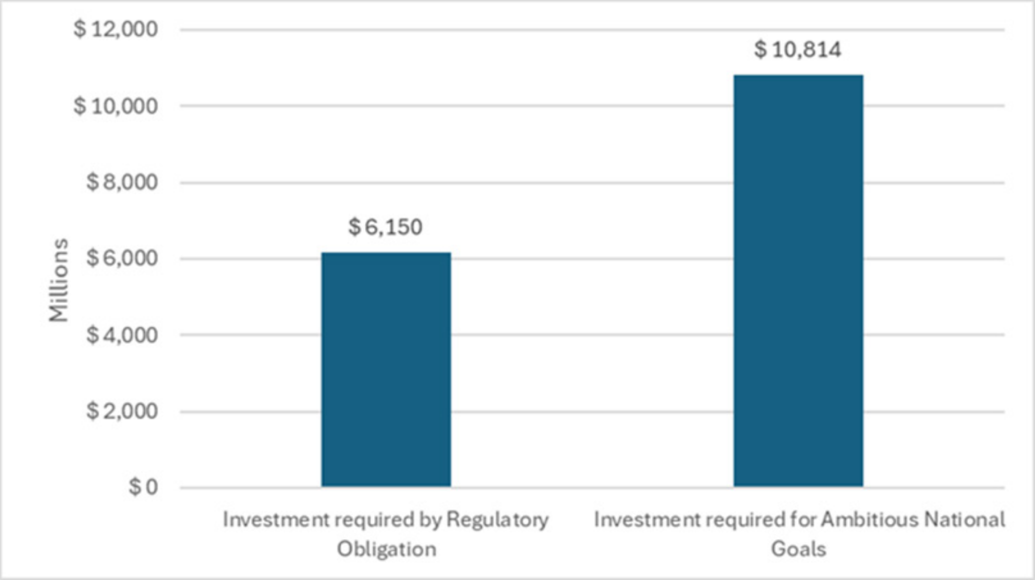
These results mean that the government and other sectors' contribution can be the key to materializing the required deployments to fulfil with the ambitious targets established in Saudi Arabia for 2030.

6.6 Identifying investment gaps between regulatory obligations and national goals scenarios

As established above, the national goal explicitly targets to reach 80 per cent of households covered with fast broadband networks, as well as reaching 99 per cent of 5G coverage. In contrast, the regulatory obligations only stipulate 99 per cent of 4G coverage.

Therefore, the "mandated" investment required to fulfil with this target can be accounted in USD 6.2 billion only, largely below the overall investment figure of USD 10.8 billion resulting from the simulation presented in Tables 6-2 and 6-3 for the more ambitious scenario. Therefore, the investment gap for completely bridging the coverage divide with fast broadband across all the country amounts to USD 4.7 billion (Figure 6-8).

Figure 6-8: Saudi Arabia: Investment gap between different scenarios



Source: International Telecommunication Union

6.7 Sectoral fee design

As can be assumed from the simulation results, the contribution of other sectors of the economy appears to be key to making these investments profitable. The mechanisms or framework for the collection of these sector-level fees can be diverse. Examples of schemes that can be applied for the collection of these resources follow.

6.7.1 Sector levies earmarked to a broadband fund

Public authorities can propose a cross-sector levy on gross revenues to finance a national broadband fund. This can be justified in the dependence of current business operations on low-latency connectivity and real-time interactions. In turn, these sectors may translate a portion of these fees into those products or services that are more reliant on fast connectivity. As an example:

- Health providers and insurers could introduce a micro-levy on teleconsultations, electronic medical record services, and digital diagnostic platforms.
- Large manufacturers could pay a levy on certain turnover categories (e.g. sales from “connected products” or from plants certified as Industry 4.0 sites), which are particularly reliant on high-capacity networks for robotics, predictive maintenance, and supply-chain integration.

The contributions should flow into an independent broadband investment fund with a clear mandate (coverage targets, quality thresholds, periodic evaluation). The rate can be designed to be progressive, where higher contribution rates for sectors and firms whose business models depend more strongly on high-capacity networks and who realize larger productivity gains.

Another important aspect to define is the temporality. These levies can be designed to automatically decline as deployment targets are met, framing this as a temporary cost-sharing effort rather than a permanent tax.

6.7.2 Mandatory or incentivized co-investment schemes

An alternative to pure transfers could be to create incentives for other sectors to act as co-investors in broadband projects, especially in underserved areas. This can take the form of:

- Anchor-tenant co-investment, though which hospitals, banks, or large factories may commit to long-term connectivity contracts (e.g. dark fibre or fixed-term capacity contracts) in exchange for equity or revenue-sharing stakes in local broadband networks. Their long-term demand reduces revenue risk for the telecommunication operator and helps make the business case viable.
- Sectoral infrastructure funds: financial institutions may create dedicated funds that coinvest with telecommunication operators in optical fibre/5G, backed by regulatory incentives. This frames broadband as a core infrastructure asset.

These schemes transform some of the positive externalities into internalized cash flows: sectors that gain productivity also receive a financial claim on the infrastructure, aligning incentives. Long-term contracts and anchor-tenant commitments reduce demand uncertainty and make marginal projects profitable.

6.7.3 Results-based contributions tied to sector outcomes

Instruments can be introduced to make sure that funds from other sectors are disbursed only when specific connectivity and performance goals are met. For example, the fee may take the form of:

- Pay-for-success contracts: manufacturing associations or chambers of commerce may fund "innovation bonuses" that are paid to broadband providers when firms in the area reach certain digitalization or productivity targets (e.g. adoption of cloud-based ERP, share of firms engaged in e-commerce).
- Results-based payments, through which companies (for example health insurers) pay bonuses to broadband projects once clinics and hospitals in specific regions achieve defined connectivity standards (bandwidth, latency, reliability) and start using telehealth services.

This mechanism explicitly links contributions to measurable spillovers, reinforcing the externality argument.

6.8 Conclusion

If the 5G and FTTH deployment project is implemented, this will make the overall ROI for the operator can reach 22.62 per cent (Table 6-4). If spillovers from economic impact are added as another source of gain, now the IT sector as a whole (this includes telecommunications but also OTT services, software companies, etc.) will reach a net result of the investment close to 30.52 per cent (or 2.81% of its GDP).

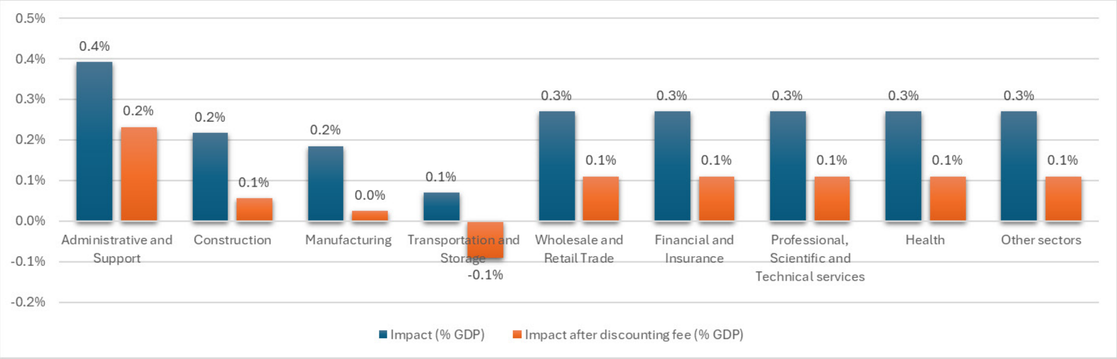
Table 6-4: Saudi Arabia: Overall results for IT sector under the national goals scenario

Segment	With government and other sector contributions
IT sector investment needed	USD 10,814,255,004
Cost savings due to regulatory reform	USD 0
Investment covered by government	USD 3,568,704,151
Investment covered by other sectors fee	USD 6,708,935,361
IT sector revenues	USD 2,982,440,893
Net result for operator	USD 2,445,825,400
ROI for operator (%)	22.62%
IT sector spillovers	USD 854,595,283
Net result IT sector (inc. spillovers)	USD 3,300,420,684
Net result IT sector (% of investment)	30.52%
Net result IT sector (% of cumulated sector GDP)	2.81%

Note: results correspond to scenarios that include government and other sectors' contribution
Source: Telecom Advisory Services analysis

It is worth mentioning that, despite the overall 0.16 per cent of fees applied to the other sectors of the economy, the net result for them is still positive, as represented in Figure 6-9, except for Transportation and Storage. As argued above for other pilot cases, it may be necessary to establish a differentiated fee by economic sector, depending on their expected economic benefit derived from digitization.

Figure 6-9: Saudi Arabia: Impact for remaining economic sectors (as % of their GDP) under the national goals scenario



Note: Results correspond to scenarios that include government and other sector contributions.
Source: Telecom Advisory Services analysis

In sum, Saudi Arabia has the potential to implement policy reforms that will stimulate network deployments and will be largely beneficial to the society. The actions that need to be taken for these deployments to be feasible are the following:

- The public authorities must contribute to financing an important percentage of these investments.

- Create subsidies to stimulate demand. This is critical as affordability problems are limiting the access of important segments of the population to digital services. More demand will mean more revenue for the operator (then contributing to making the deployments profitable) and also larger economic impact through spillovers across the economy.
- Make other sectors contribute to network deployments. In this simulation, an overall 0.16 per cent fee was charged on their revenues, that is more than enough to make these investments profitable and thus, for the operator to have incentives to deploy them.

Table 6-5: Country pilots

	High income	Upper middle income	Lower middle income
Arab States	Kingdom of Saudi Arabia		
Americas		Guatemala	
Africa			Ghana

The country pilot results were useful to validate the tool applicability at several levels:

- **Applicability**: the tool can be used in countries with different development levels. Even advanced economies can face network development requirements which require additional investment (particularly in rural and isolated areas). Along these lines, it is useful to quantify the capital required and assess the impact of various regulatory initiatives to stimulate such investment.
- **Versatility:** the tool is flexible enough to be used for a single technology. Also, the tool presents wide temporal horizons for analysing the deployments, ranging from 2 to 10 years.
- **Macroeconomic conditions**: by selecting different discount rates, the tool can be adapted to different macroeconomic scenarios regarding the evolution of the interest rates established by the main central banks.
- **Policy scope:** the policy and regulatory scope of the simulation tool is also wide, covering from regulations applicable to telecommunication operators, policy interventions at the supply side and demand sides, as well as contributions from other actors.
- **Scope of involved actors**: this is probably the first tool that involves all the sectors in the economy not only as beneficiaries, but also as potential contributors of network deployments.

The results obtained should open some important regulatory and policy debates, as well as enhance cooperation among different economic actors and stakeholders. In particular, some regulations were identified that can contribute to stimulating investments and to facilitating the expansion of coverage levels:

- Spectrum secondary trading
- Band migration allowed
- Infrastructure sharing for mobile operators permitted
- Infrastructure sharing mandated
- Co-location/site sharing mandated

In addition, national governments may also contribute to these deployments' projects, as long as they are socially desirable. As documented in the pilot cases study, government contribution can take the form of:

- Universal service to financing a part of these investments
- Create subsidies to stimulate demand

Finally, it is proposed another policy that consists in making other economic sectors contribute to network deployments. For example, through a fee based on their revenues, that can facilitate the investments and at the same time ensure that these industries benefit from their economic spillovers.

Based on the robust econometric analysis and the practical application in the case studies, it is proposed the "GEMS Framework for Unlocking Digital Investment"—a three-pillar approach for policy-makers seeking to break the investment impasse.

Pillar 1: Create an attractive investment environment

The foundation of any successful deployment is a regulatory framework that minimizes costs and encourages efficiency. Key policies include:

- Spectrum secondary trading
- Band migration allowed
- Infrastructure sharing for mobile operators permitted
- Infrastructure sharing mandated
- Co-location/site sharing mandated

Pillar 2: Share the financial burden through smart subsidies

Where the market alone cannot justify investment, targeted public funding is essential. Government contributions should be twofold:

- Supply-side support: Use mechanisms like the universal service fund (USF) to co-finance a portion of the capital expenditure in commercially unviable areas.
- Demand-side stimulation: Implement programmes, such as vouchers for vulnerable populations, to ensure affordability, which boosts adoption and operator revenues, creating a sustainable market.

Pillar 3: Build cross-sector coalitions for co-investment

The most innovative and powerful lever is to formalize a contribution mechanism from the economic sectors that are the primary beneficiaries of enhanced connectivity. As the GEMS tool quantifies the specific GDP spillovers for sectors like finance, manufacturing, and retail, it provides the evidence to justify a modest fee or co-investment model. This transforms the beneficiaries of digital infrastructure into active partners in its creation, ensuring a sustainable financial model for the digital economy of the future.

Bibliography

Alesina, A., Ardagna, S., Nicoletti, G., & Schiantarelli, F. (2005). Regulation and investment. *Journal of the European Economic Association*, 3(4), 791-825.

Arezki, R., Dequiedt, V., Fan, R. Y., & Rossotto, C. M. (2021). Liberalization, Technology Adoption, and Stock Returns: Evidence from Telecom.

Bahia, K., & Castells, P. (2021). The impact of spectrum assignment policies on consumer welfare. *Telecommunications Policy*, 102228.

Calzada, J., & Martínez-Santos, F. (2014). Broadband prices in the European Union: Competition and commercial strategies. *Information Economics and Policy*, 27, 24-38.

Cartesian. (2019). All fiber deployment cost study. FTTH Council Europe (2012). Creating a brighter future. The Cost of Meeting Europe's Network Needs.

Czernich, N., Falck, O., Kretschmer, T., & Woessmann, L. (2011). Broadband infrastructure and economic growth. *The Economic Journal*, 121(552), 505-532.

Do, M. T., Falch, M., y Williams, I. (2018). Universal service in Vietnam: the role of government. *Digital Policy, Regulation and Governance*, 20(2), 178–190.

Genakos, C., Valletti, T., & Verboven, F. (2018). Evaluating market consolidation in mobile communications. *Economic Policy*, 33(93), 45-100.

Grechyn, V., & McShane, I. (2016). What influences international differences in broadband prices.

Katz, R. and Berry, T. (2015). *Driving demand of broadband networks and services*. London: Springer.

Jung, J., & Katz, R. (2023). Exploring the heterogeneous link between broadband investment and coverage expansion using unconditional quantile regressions. *Telecommunications Policy*, 47(9), 102623.

International Telecommunication Union (ITU). Katz, R. and Callorda, F. (2019a). The economic contribution of broadband, digitization and ICT regulation Econometric modelling for the Americas. Telecom Advisory Services.

International Telecommunication Union (ITU). Katz, R. and Callorda, F. (2019b). *Economic contribution of broadband, digitization and ICT regulation Econometric modelling for Africa*. Telecom Advisory Services.

International Telecommunication Union (ITU). Katz, R. (2020). *How broadband, digitization and ICT regulation impact the global economy*. Telecom Advisory Services.

International Telecommunication Union (ITU). Katz, R. and Callorda, F. (2020a). *The economic contribution of broadband, digitization and ICT regulation: Econometric modelling for the ITU Europe region*. Telecom Advisory Services.

International Telecommunication Union (ITU). Katz, R. and Callorda, F. (2020b). *Economic contribution of broadband, digitization and ICT regulation Econometric modelling for the ITU Commonwealth of Independent States region*. Telecom Advisory Services.

International Telecommunication Union (ITU). Katz, R. and Callorda, F. (2020c). *The economic contribution of broadband, digitization and ICT regulation Econometric modelling for the Arab States region*. Telecom Advisory Services.

Katz, R. and Callorda, F. (2020d). *Assessing the economic potential of 10 G networks*. International Telecommunication Union. Telecom Advisory services.

Katz, R., & Jung, J. (2023). *The impact of taxation in the telecommunications industry*. Information Economics and Policy, 101016.

Kim, J., Kim, Y., Gaston, N., Lestage, R., Kim, Y., Flacher, D. (2011). Access regulation and infrastructure investment in the mobile telecommunications industry. *Telecommunications Policy* 35 (11), 907–919.

Kravis, I., & Lipsey, R. E. (1988). *National price levels and the prices of tradables and nontradables*.

Lamont, O. A., & Thaler, R. H. (2002). Anomalies: The law of one price in financial markets. *Journal of Economic Perspectives*, 17(4), 191-202.

Lipsey, R. E., & Swedenborg, B. (2010). Product price differences across countries: determinants and effects. *Review of World Economics*, *146*(3), 415-435.

Mack, E., & Faggian, A. (2013). Productivity and broadband: The human factor. *International Regional Science Review*, 36(3), 392-423.

Mas, M., & Quesada, J. (2009). The Role of ICT on the Spanish Productivity Slowdown.

Okuda, A., Lee, D., Vakataki 'Ofa, S., Roeder, E., Jantarasaengaram, A., y Marand, J. (2017). *The Impact of Universal Service Funds on Fixed-Broadband Deployment and Internet Adoption in Asia and the Pacific*. United Nations ESCAP.

Oughton, E. J., & Frias, Z. (2018). The cost, coverage and rollout implications of 5G infrastructure in Britain. *Telecommunications Policy*, 42(8), 636-652.

Reddick, C. G., Enriquez, R., Harris, R. J., & Sharma, B. (2020). Determinants of broadband access and affordability: An analysis of a community survey on the digital divide. *Cities*, 106, 102904.

Röller, L. H., & Waverman, L. (2001). Telecommunications infrastructure and economic development: A simultaneous approach. *American economic review*, 91(4), 909-923.

Selian, A. N. (2001). From 2G to 3G-the evolution of international cellular standards. *arXiv preprint cs/0110046*.

Shaalan, A. S. (1990). "2 The Impact of Macroeconomic Policies on Investment". In *Investment Policies in the Arab Countries*. USA: International Monetary Fund.

Tech4i2, Real Wireles, Trinity College, & Interdigital (2016). Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe. Brussels: European Union.

Weiss, J. W., Gulati, G. J., Yates, D. J., & Yates, L. E. (2015, January). Mobile broadband affordability and the global digital divide--an information ethics perspective. In *2015 48th Hawaii International Conference on System Sciences* (pp. 2177-2186). IEEE.

Appendix

A.1 Variables used in empirical analysis

Table A-1: Variable description – national analysis

Group	Variable	Description	Source
MBB outcomes	MCapex pc	Investment per capita on mobile networks	GSMA
	4G coverage	Population covered by 4G network (%)	GSMA
	5G coverage	Population covered by 5G network (%)	GSMA
	5G share	5G share over mobile broadband connections (%)	GSMA
	MBB speed	Average speed from mobile networks (kbit/s)	Ookla/TAS
	MBB price	Data-only mobile broadband basket (2GB)	ITU
	MBB adoption	Mobile Internet unique subscribers' penetration (%)	GSMA
FBB outcomes	FCapex pc	Investment per capita on fixed networks	ITU
	FBB coverage	Households passed by fixed broadband (%)	ITU/TAS
	FTTH coverage	Households passed by fibre-optic broadband (%)	IDATE/OECD/TAS
	FTTH share	FTTH share over fixed broadband coverage (%)	ITU/IDATE/OECD/TAS
	FBB speed	Average speed from fixed networks (kbit/s)	Ookla/TAS
	FBB price	Fixed broadband basket (5GB)	ITU
	FBB adoption	Fixed broadband adoption (% households)	ITU

Table A-1: Variable description – national analysis (continued)

Group	Variable	Description	Source
Controls	Revenue pc	Revenue per capita from all telecom services	ITU
	MBB HHI	Mobile broadband Herfindahl-Hirschman Index	GSMA
	FBB HHI	Fixed broadband Herfindahl-Hirschman Index	OVUM/TAS
	Electricity coverage	Population covered by electricity networks (%)	World Bank
	Intl. Bandwidth	International Internet bandwidth per Internet user	ITU/TAS
	Population density	Population per squared kilometre	World Bank
	Urban	Share of population living in urban areas	World Bank
	Education	Average years of school (population over 25)	UNESCO/TAS
Instruments	Energy Regulation	RISE score of country's policies and regulations in the energy sector	World Bank / ESMAP
	Cellular HHI	Cellular Herfindahl-Hirschman Index	GSMA
	Mobile share over voice	Cellular share over voice connections	ITU
	Fixed telephony adoption	Fixed telephony adoption (% population)	ITU
	Fixed share over voice	Fixed share over voice connections	ITU

Table A-1: Variable description – national analysis (continued)

Group	Variable	Description	Source
Regulatory	Regulatory Regime	Regulatory regime pillar of ICT Regulatory Tracker	ITU
	Neutral licences	Scale from 0 to 2 depending on licences being: service-specific; multi-service or class; unified or global, general authorizations or simple notification.	ITU
	SMP	Scale from 0 to 4 depending on law defining SMP or dominance and the criteria used to define it.	ITU
	Spectrum policy	Scale from 0 to 6 depending on allowance of: i) mobile infra. sharing (e.g.: MVNO); ii) secondary spectrum trading; iii) spectrum refarming or in-band migration	ITU
	Inf. sharing mobile	Scale from 0 to 6 depending on: i) mobile infrastructure sharing permitted; ii) infrastructure sharing mandated or access granted; iii) co-location / site sharing regulated/mandated or incentivized.	ITU
	Inf. sharing fixed	Variable that takes value of 2 if infrastructure sharing is mandated or access granted, and use of public telecommunication networks is required by monopoly or dominant operators (0 in other case).	ITU
	QoS regulation	Variable that takes value of 2 if QoS monitoring regulation (0 in other case)	ITU
	Band migration	Variable that takes value of 2 if spectrum refarming or in-band migration allowed (0 in other case)	ITU
Macro variables	GDP	Gross Domestic Product (in billion dollars)	IMF
	Capital	Capital stock (in billion dollars)	PWT/IMF
	Labour	Number of employees (in thousands)	TCB

Source: International Telecommunication Union

Table A-2: Descriptive statistics – national analysis

Group	Variable	Mean	Std. Dev.
MBB outcomes	MCapex pc	58.518	51.022
	4G coverage	0.438	0.443
	5G coverage	0.087	0.246
	5G share	0.154	0.310
	MBB speed	24,574.650	42,846.420
	MBB price	27.539	66.498
	MBB adoption	0.362	0.260
FBB outcomes	FCapex pc	73.711	83.010
	FBB coverage	0.637	0.365
	FTTH coverage	0.221	0.315
	FTTH share	0.247	0.331
	FBB speed	40,043.910	65,808.110
	FBB price	58.048	70.110
	FBB adoption	0.465	0.440
Controls	Revenue pc	692.499	757.210
	MBB HHI	5,114.533	2,550.635
	FBB HHI	4,377.843	2,853.505
	Electricity coverage	89.195	22.304
	Intl. Bandwidth	153,320.000	808,324.800
	Population density	233.252	738.529
	Urban	66.205	20.092
	Education	9.404	2.961
Instruments	Energy Regulation	41.049	25.258
	Cellular HHI	3,956.964	1,287.833
	Mobile share over voice	0.835	0.123
	Fixed telephony adoption	21.440	17.241
	Fixed share over voice	0.165	0.123

Table A-2: Descriptive statistics – national analysis (continued)

Group	Variable	Mean	Std. Dev.
Regulatory	Regulatory Regime	19.721	7.892
	Neutral licences	1.335	0.907
	SMP	3.198	1.346
	Spectrum policy	4.055	1.768
	Inf. sharing mobile	4.305	1.935
	Inf. sharing fixed	1.200	0.980
	QoS regulation	1.805	0.593
	Band migration	1.468	0.884
Macro variables	GDP	1,148.965	3,044.519
	Capital	4,755.662	12,053.620
	Labour	26,116.770	86,428.400

Source: International Telecommunication Union

Table A-3: Variable description – sectoral analysis

Group	Variable	Description	Source
BB outcomes	MBB adoption	Business with a mobile broadband connection	OECD
	FBB adoption	Business with a fixed broadband connection	OECD
	Average speed	Average broadband speed (Mbit/s)	OECD
	Capex pc	Investment per capita on fixed and mobile networks	ITU / GSMA
	BB	Construct built form PCA applied to MBB adoption, FBB adoption and Average speed	OECD
Instruments	MBB HHI	Mobile broadband Herfindahl-Hirschman Index (national)	GSMA
	FBB HHI	Fixed broadband Herfindahl-Hirschman Index (national)	
	Regulatory Regime	Regulatory regime pillar of the ICT Regulatory Tracker (national)	ITU
	BB network effects	Average BB value for other economic sectors by country-year	OECD
Sectoral activity	GDP	Output	OECD
	Capital	Capital stock	OECD
	Labour	Number of employees	OECD

Source: International Telecommunication Union

Table A-4: Descriptive statistics – variables of sectoral analysis

Group	Variable	Mean	Std. dev.
	MBB adoption	72.417	17.241
BB outcomes	FBB adoption	92.584	6.718
	Average speed	188.389	131.312
	Capex pc	116.228	59.352
	BB	-0.034	1.338
Instruments	MBB HHI	3,012.772	402.514
	FBB HHI	2,880.896	1,185.388
	Regulatory Regime	27.049	3.877
	BB network effects	-0.046	1.133
Sectoral activity	GDP	1,296,187	7,321,258
	Capital	1,632,826	9,032,715
	Labour	582.084	967.764

Source: International Telecommunication Union

A.2 Models for investment drivers

Table A-5: Drivers of broadband investment

Dep. variable:	Log (MCapex pc)	Log (MCapex pc)	Log (MCapex pc)	Log (FCapex pc)
Log (MCapex pc)t-1	0.8509***	0.8700***	0.8603***	
	[0.0336]	[0.0309]	[0.0335]	
Log (FCapex pc)t-1				0.5855***
				[0.0787]
Log (Revenue pc)t-1	0.0401*	0.0441	0.0460**	0.0575
	[0.0213]	[0.0492]	[0.0182]	[0.0747]
Log (GDPpc)t-1	0.0506**	0.0379	0.0502**	0.2154**
	[0.0242]	[0.0506]	[0.0216]	[0.1009]
MBB HHI	0.0000	0.0000	0.0000	
	[0.0000]	[0.0000]	[0.0000]	
MBB HHI squared	0.0000	0.0000	0.0000	
	[0.0000]	[0.0000]	[0.0000]	
FBB HHI				0.0000

Table A-5: Drivers of broadband investment (continued)

Dep. variable:	Log (MCapex pc)	Log (MCapex pc)	Log (MCapex pc)	Log (FCapex pc)
				[0.0000]
FBB HHI squared				0.0000
				[0.0000]
Urban	0.0002	0.0000	0.0001	0.0004
	[0.0007]	[0.0007]	[0.0007]	[0.0023]
Regulatory Regime	0.0055**			0.0195*
	[0.0024]			[0.0107]
Neutral licences		0.0060		
		[0.0314]		
SMP		0.0330		
		[0.0245]		
Spectrum policy		0.0009	0.0161*	
		[0.0126]	[0.0090]	
AB test AR(1) first diff.	-5.77***	-5.72***	-5.67***	-5.21***
AB test AR(2) first diff.	-1.35	-1.58	-1.26	0.08
Hansen test	135.65	81.52	81.24	143.09
Year Fixed Effects	YES	YES	YES	YES
Observations	1,296	1,239	1,283	1,070
Number of id	95	95	95	90
Method	GMM	GMM	GMM	GMM

Note: Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.
Source: International Telecommunication Union

A.3 Models for coverage drivers

Table A-6: Drivers of broadband coverage

Dep. variable:	4G coverage	5G coverage	FTTH coverage
Log (MCapex pc)$_{t-1}$ * Pop. density	-0.0021		
	[0.0013]		
Log (MCapex pc)$_{t-1}$ * Pop. density squared	0.0000*	0.0000**	
	[0.0000]	[0.0000]	
Log (MCapex pc)$_{t-1}$ * Inf. sharing mobile	0.0678*	0.0301***	
	[0.0360]	[0.0025]	
Log (FCapex pc)$_{t-1}$ * Pop. density			0.0001*
			[0.0000]
Log (FCapex pc)$_{t-1}$ * Inf. sharing fixed			0.0010*
			[0.0249]
3G coverage $_{t-5}$	0.7428***		
	[0.0634]		
4G coverage $_{t-5}$		-0.1766*	
		[0.1017]	
Population density	-0.0013	-0.0133**	-0.0009
	[0.0030]	[0.0056]	[0.0007]
MBB HHI	0.0001***	-0.0000***	
	[0.0000]	[0.0000]	
MBB share	-1.4912*	7.4416	
	[0.8906]	[5.8520]	
MBB share squared	1.0470*	-4.4934	
	[0.6346]	[3.5606]	
Level of competition IMT	-0.0186	-0.0350	
	[0.0134]	[0.0306]	
Fixed monopoly			-0.0113
			[0.0090]
F-test instruments first stage #1	8.80**	7.26**	18.25***
F-test instruments first stage #2	103.26***	265.95***	69.61***
Hansen test	0.099	2.114	1.899

Table A-6: Drivers of broadband coverage (continued)

Dep. variable:	4G coverage	5G coverage	FTTH coverage
Country Fixed Effects	YES	YES	YES
Year Fixed Effects	YES	YES	YES
Observations	670	668	542
Number of id	97	97	89
Method	IV-LIML	IV-LIML	IV-LIML

Note: Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.
Source: International Telecommunication Union

A.4 Models for speed drivers

Table A-7: Drivers of broadband speed

	Log (MBB speed)	Log (MBB speed)	Log (MBB speed)	Log (FBB speed)	Log (FBB speed)	Log (FBB speed)	Log(FBB speed)
≥4G coverage	0.1011	2.9106***	3.0667***				
	[0.0920]	[1.0406]	[0.9890]				
5G share	0.6745***	3.0696***	2.9305***				
	[0.0391]	[0.7869]	[0.7687]				
FBB coverage				0.0673	4.7745***	2.8648***	5.7856***
				[0.1961]	[0.9774]	[0.9244]	[1.9712]
FTTH share				-0.0246	3.5880	-0.5002	4.1230**
				[0.1766]	[3.4450]	[0.6097]	[1.6056]
Log(Intl. Bandwidth)	0.1262***	0.2063***	0.2065***	0.0167	0.0612	-0.0275	0.1431***
	[0.0335]	[0.0702]	[0.0707]	[0.0274]	[0.1427]	[0.0447]	[0.0310]
Population density	0.0004***	0.0011***	0.0018***	-0.0002	-0.0007	0.0019***	-0.0008
	[0.0001]	[0.0004]	[0.0003]	[0.0002]	[0.0028]	[0.0004]	[0.0015]
MBB HHI	0.0000	0.0001	0.0000				
	[0.0000]	[0.0000]	[0.0001]				
FBB HHI				0.0000	0.0000	0.0000	0.0001**
				[0.0000]	[0.0000]	[0.0000]	[0.0000]
Electricity coverage	0.0224***	0.0166	0.0138	0.0467**	0.0213	-0.0110	0.0099
	[0.0048]	[0.0122]	[0.0136]	[0.0167]	[0.0286]	[0.0102]	[0.0159]

	Log (MBB speed)	Log (MBB speed)	Log (MBB speed)	Log (FBB speed)	Log (FBB speed)	Log (FBB speed)	Log(FBB speed)
QoS regulation		0.2731			3.1333		
		[0.1968]			[2.2743]		
Band migration			0.3821*				
			[0.2084]				
F-test instruments first stage #1		38.27***	46.17***		958.45***	491.52***	473.22***
F-test instruments first stage #2		12.30***	14.12***		28.29***	31.03***	31.44***
F-test instruments first stage #3		9.73***	96.52***		9.73***		
Hansen test		0.180	0.031		Exactly id	2.098	1.987
Country Fixed Effects	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES
Observations	1,294	1,033	1,014	2,268	1,314	1,342	862
Number of id	108	95	95	108	96	96	96
Method	OLS-FE	IV-LIML	IV-LIML	OLS-FE	IV-LIML	IV-LIML	IV-LIML

Note: Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.
Source: International Telecommunication Union

A.5 Models for price drivers

Table A-8: Drivers of broadband prices

	Log(MBB price)	Log(MBB price)	Log(MBB price)	Log(FBB price)	Log(FBB price)	Log(FBB price)
Log(≥4G coverage)	-0.2766***	-0.3870***	-0.4536***			
	[0.0385]	[0.0906]	[0.0780]			
Log(FTTH coverage)				-0.0393***	-0.1771***	-0.1121**
				[0.0053]	[0.0624]	[0.0530]
MBB HHI	0.0000**	0.0000***	0.0000***			
	[0.0000]	[0.0000]	[0.0000]			
FBB HHI				0.0000**	0.0001***	0.0001***
				[0.0000]	[0.0000]	[0.0000]
Education	0.1988***	0.1425***	0.1774***	0.0530	0.2741***	0.1917***
	[0.0453]	[0.0485]	[0.0382]	[0.0398]	[0.0299]	[0.0500]
SMP		-0.1237			0.1460	
		[0.0844]			[0.0928]	
F-test instruments first stage #1		9.40***	10.46***		23.99***	191.31***
F-test instruments first stage #2		25.77***			34.79***	
Hansen test		0.730	1.053		1.680	2.601
Country Fixed Effects	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES
Observations	1,210	975	992	1,240	841	856

(continued)

	Log(MBB price)	Log(MBB price)	Log(MBB price)	Log(FBB price)	Log(FBB price)	Log(FBB price)
Number of id	108	97	97	83	72	72
Method	OLS-FE	IV-LIML	IV-LIML	OLS-FE	IV-LIML	IV-LIML

Note: Robust standard errors in brackets. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.
Source: International Telecommunication Union

A.6 Models for adoption drivers

Table A-9: Drivers of broadband adoption

	Log (MBB adoption)	Log (FBB adoption)
Log (MBB price)	-0.6140*	
	[0.3666]	
Log (FBB price)		-0.0725**
		[0.0314]
Log (≥4G coverage)	0.4445*	
	[0.2416]	
5G share	1.2186	
	[0.8530]	
Log (FBB coverage)		0.7378***
		[0.2037]
Log (FTTH coverage)		0.1140***
		[0.0290]
Education	0.2317***	0.0902***
	[0.0834]	[0.0140]
Log (GDPpc)$_{t-1}$	0.5774*	0.1420**
	[0.3248]	[0.0596]
F-test instruments first stage #1	1263.77***	84.72***
F-test instruments first stage #2	247.56***	99.60***
F-test instruments first stage #3	490.98***	
Hansen test	2.359	0.577
Country Fixed Effects	YES	YES
Year Fixed Effects	YES	YES
Observations	927	855
Number of id	97	
Method	IV-LIML	IV-LIML

Note: Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.
Source: International Telecommunication Union

A.7 Models for GDP drivers

Table A-10: GDP impact of broadband

Dep. variable: Log (GDP)	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
Log (Capital)	0.3816***	0.4235***	0.4196***	0.4213***	0.2986***	0.3354***	0.3531***	0.3369***
	[0.0357]	[0.0426]	[0.0394]	[0.0429]	[0.0270]	[0.0515]	[0.0408]	[0.0469]
Log (Labour)	0.2763***	0.2431***	0.2639***	0.2576***	0.3164***	0.1311***	0.2926***	0.1883***
	[0.0345]	[0.0418]	[0.0387]	[0.0410]	[0.0281]	[0.0507]	[0.0273]	[0.0466]
Log (FBB adoption)	0.0267***				0.0758***			
	[0.0026]				[0.0150]			
Log (FBB speed)		0.0093***				0.1039***		
		[0.0022]				[0.0201]		
Log (MBB adoption)			0.0171***				0.0878***	
			[0.0043]				[0.0204]	
Log (MBB speed)				0.0102***				0.0952***
				[0.0022]				[0.0096]
F-test instruments first stage					7.58***	12.18***	10.77***	10.68***
Hansen test					1.757	1.368	1.776	1.325
Country Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Observations	2,210	2,255	2,255	2,214	1,879	1,891	1,891	1,855
Number of id	108	108	108	107	108	108	108	106

(continued)

Dep. variable: Log (GDP)	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
Method	OLS-FE	OLS-FE	OLS-FE	OLS-FE	IV-LIML	IV-LIML	IV-LIML	IV-LIML

Note: Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1
Source: International Telecommunication Union

Table A-11: GDP impact of Broadband – by sector

Dep. variable: Log (GDP)	Overall	Overall	Overall	Overall	Overall	Admin. and Support	Construction	Construction	IT	Manufacturing	Transportation and Storage
Log (Capital)	0.3953***	0.3314***	0.2855***	0.5204***	0.5210***	0.3661***	0.6741***	0.6657***	0.6881***	0.3626***	0.7173***
	[0.0406]	[0.0355]	[0.0465]	[0.0395]	[0.0252]	[0.0555]	[0.0825]	[0.0853]	[0.0735]	[0.1183]	[0.0385]
Log (Labour)	0.2515***	0.2741***	0.2391***	0.4161***	0.4364***	0.1204***	0.5198***	0.5437***	0.1228	-0.2079**	0.2982***
	[0.0394]	[0.0315]	[0.0538]	[0.0807]	[0.0504]	[0.0467]	[0.1755]	[0.1739]	[0.1024]	[0.0844]	[0.0357]
BB	0.0397***	0.0870***	0.1449**	0.0710*	0.1004***	0.1675*	-0.0461	-0.0392	0.1903***	0.0791***	0.0296**
	[0.0045]	[0.0113]	[0.0607]	[0.0394]	[0.0187]	[0.0859]	[0.0465]	[0.0502]	[0.0491]	[0.0259]	[0.0129]
Log (Capex pc)								0.0560***			
								[0.0127]			
F-test instruments first stage		49.56***	10.78***	184.98***	22.33***	4.93*	9.61**	9.40**	18.58***	28.98***	43.18***
Hansen test		2.269	3.136	2.337	-	-	-	-	-	-	-
Country Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	2,210	1,879	1,734	883	774	169	162	162	138	148	157
Number of id	108	108	108	94	92	20	19	19	17	17	19
Sample	National	National	National	Sectoral	Sectoral	Sectoral	Sectoral	Sectoral	Sectoral	Sectoral	Sectoral
Method	OLS-FE	IV-LIML	IV-LIML	IV-LIML	IV-LIML	IV-LIML	IV-LIML	IV-LIML	IV-LIML	IV-LIML	IV-LIML

Note: Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.
Source: International Telecommunication Union

Office of the Director
International Telecommunication Union (ITU)
Telecommunication Development Bureau (BDT)
Place des Nations
CH-1211 Geneva 20
Switzerland

Email: bdtdirector@itu.int
Tel.: +41 22 730 5035/5435

Office of the Deputy Director
Operations Coordination Department (DDR)
Place des Nations
CH-1211 Geneva 20
Switzerland

Email: bdtdeputydir@itu.int
Tel.: +41 22 730 5131

Digital Networks and Environment Department (DNE)
Email: bdt-dne@itu.int
Tel.: +41 22 730 5421

Digital Knowledge Society Department (DKS)
Email: bdt-dks@itu.int
Tel.: +41 22 730 5900

Projects, Partnerships and Digital Skills Department (PPS)
Email: bdt-pps@itu.int
Tel.: +41 22 730 5447

Africa

Ethiopia

International Telecommunication Union (ITU) Regional Office
Gambia Road
Leghar Ethio Telecom Bldg. 3rd floor
P.O. Box 60 005
Addis Ababa
Ethiopia

Email: itu-ro-africa@itu.int
Tel.: +251 11 551 4977
Tel.: +251 11 551 4855
Tel.: +251 11 551 8328
Fax: +251 11 551 7299

Cameroon

Union internationale des télécommunications (UIT)
Bureau de zone
Immeuble CAMPOST, 3e étage
Boulevard du 20 mai
Boîte postale 11017
Yaoundé
Cameroon

Email: itu-yaounde@itu.int
Tel.: + 237 22 22 9292
Tel.: + 237 22 22 9291
Fax: + 237 22 22 9297

Senegal

Union internationale des télécommunications (UIT)
Bureau de zone
8, Route du Méridien Président
Immeuble Rokhaya, 3e étage
Boîte postale 29471
Dakar - Yoff
Senegal

Email: itu-dakar@itu.int
Tel.: +221 33 859 7010
Tel.: +221 33 859 7021
Fax: +221 33 868 6386

Zimbabwe

International Telecommunication Union (ITU) Area Office
USAF POTRAZ Building
877 Endeavour Crescent
Mount Pleasant Business Park
Harare
Zimbabwe

Email: itu-harare@itu.int
Tel.: +263 242 369015
Tel.: +263 242 369016

Americas

Brazil

União Internacional de Telecomunicações (UIT)
Escritório Regional
SAUS Quadra 6 Ed. Luis Eduardo Magalhães,
Bloco “E”, 10º andar, Ala Sul
(Anatel)
CEP 70070-940 Brasilia - DF
Brazil

Email: itubrasilia@itu.int
Tel.: +55 61 2312 2730-1
Tel.: +55 61 2312 2733-5
Fax: +55 61 2312 2738

Barbados

International Telecommunication Union (ITU) Area Office
United Nations House
Marine Gardens
Hastings, Christ Church
P.O. Box 1047
Bridgetown
Barbados

Email: itubridgetown@itu.int
Tel.: +1 246 431 0343
Fax: +1 246 437 7403

Chile

Unión Internacional de Telecomunicaciones (UIT)
Oficina de Representación de Área
Merced 753, Piso 4
Santiago de Chile
Chile

Email: itusantiago@itu.int
Tel.: +56 2 632 6134/6147
Fax: +56 2 632 6154

Honduras

Unión Internacional de Telecomunicaciones (UIT)
Oficina de Representación de Área
Colonia Altos de Miramontes
Calle principal, Edificio No. 1583
Frente a Santos y Cía
Apartado Postal 976
Tegucigalpa
Honduras

Email: itutegucigalpa@itu.int
Tel.: +504 2235 5470
Fax: +504 2235 5471

Arab States

Egypt

International Telecommunication Union (ITU) Regional Office
Smart Village, Building B 147,
3rd floor
Km 28 Cairo
Alexandria Desert Road
Giza Governorate
Cairo
Egypt

Email: itu-ro-arabstates@itu.int
Tel.: +202 3537 1777
Fax: +202 3537 1888

Asia-Pacific

Thailand

International Telecommunication Union (ITU) Regional Office
4th floor NBTC Region 1 Building
101 Chaengwattana Road
Laksi,
Bangkok 10210,
Thailand

Email: itu-ro-asiapacific@itu.int
Tel.: +66 2 575 0055

Indonesia

International Telecommunication Union (ITU) Area Office
Gedung Sapta Pesona
13th floor
Jalan Medan Merdeka Barat No. 17
Jakarta 10110
Indonesia

Email: bdt-ao-jakarta@itu.int
Tel.: +62 21 380 2322

India

International Telecommunication Union (ITU) Area Office and Innovation Centre
C-DOT Campus
Mandi Road
Chhatarpur, Mehrauli
New Delhi 110030
India

Email:
Area Office: itu-ao-southasia@itu.int
Innovation Centre: itu-ic-southasia@itu.int
Website: ITU Innovation Centre in New Delhi, India

CIS

Russian Federation

International Telecommunication Union (ITU) Regional Office
4, Building 1
Sergiy Radonezhsky Str.
Moscow 105120
Russian Federation
Email: itu-ro-cis@itu.int
Tel.: +7 495 926 6070

Europe

Switzerland

International Telecommunication Union (ITU) Office for Europe
Place des Nations
CH-1211 Geneva 20
Switzerland
Email: eurregion@itu.int
Tel.: +41 22 730 5467

International Telecommunication Union
Telecommunication Development Bureau
Place des Nations
CH-1211 Geneva 20
Switzerland

ISBN 978-92-61-42251-6

9 789261 422516

Published in Switzerland
Geneva, 2026