Quantified Universal Broadband Investment by Country (Qubic)

Qubic Method for Bangladesh by Edward Oughton

Policy decisions require transparent and reproducible analytics. However, there are many policy reports that fail to explicitly report their method and assumptions for the whole policy community (both industry and government) to scrutinize and evaluate. The method presented in this document directly addresses the current reproducibility crises which exists with many pieces of policy evidence, particularly in the field of broadband assessment and telecommunication policy.

In the Quantified Universal Broadband Investment by Country (Qubic) project, the method provides an innovative analytical approach which combines the use of remote sensing and least-cost infrastructure network designs, with traditional telecommunications regulatory assessment techniques. This method builds off the previous open-source codebases developed, including the Policy Options for Digital Infrastructure Strategies (podis) and the Python Telecommunications Assessment Library repositories, both of which adhere to gold-standard software engineering methods (fully-tested, fully-documented) and are available openly from the repository for all to access.

A ‘what-if’ scenario approach is adopted enabling different questions pertaining to universal broadband to be tested. In scientific research areas where considerable uncertainties exist, and we lack comprehensive scientific information, a common approach is to use scenario analysis. Quantitative models are developed which can be explored in different ways, enabling comparative analytics to be developed against different potential futures. Decision makers in industry and government can then use these results as discussion tools to develop strategic insight on an important matter, such as universal broadband connectivity.

An important caveat is that the Qubic work does not explicitly model a single operator’s spectrum and asset portfolio, market share etc., instead focusing on modeling a ‘hypothetical operator’ with an average quantity of sunk costs and users. Explicitly modeling an operator’s supply and demand conditions can be challenging due to a lack of available data. Even if comprehensive information was available, explicit modeling often raises commercially sensitive issues which can hinder engagement with industry. Therefore, this approach is considered superior, but comes with the caveat that the model inputs will purposefully not identically match any of the operators currently active in the market (as is common in decision analytics for telecom regulation).

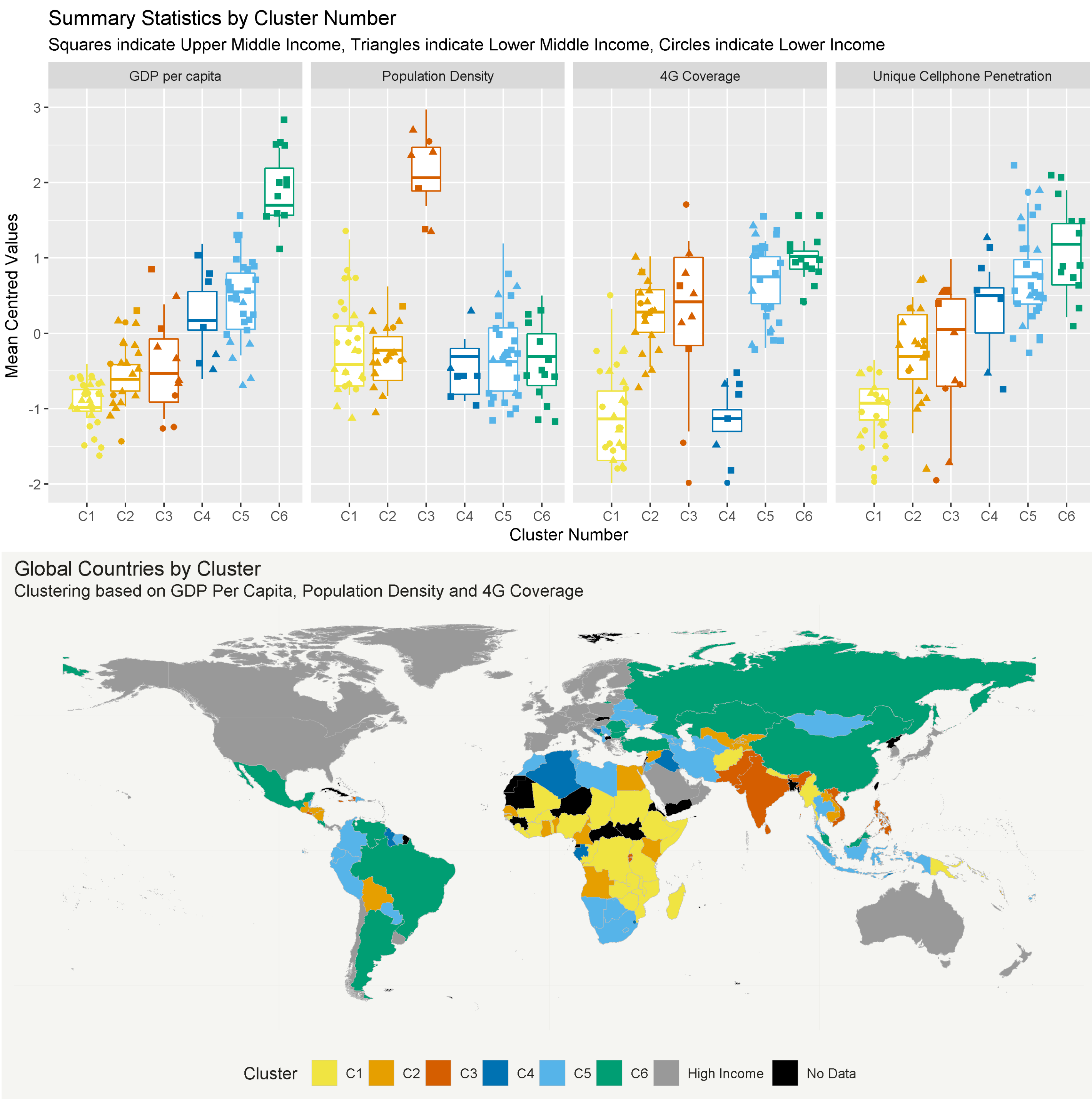
In the field of infrastructure modeling, a standard methodological approach consists of three distinct steps. Firstly, a demand module is developed which uses past data combined with forecasts to produce plausible scenarios of future change over a study period (e.g. the next decade, up to 2030). Secondly, a supply-side infrastructure module is developed which designs different network configurations, for different technologies, based on a least-cost algorithmic approach. Finally, an assessment model is used to apply different industry decisions or government policies, to quantitatively represent the implications of the strategic options available. Before a description of these three stages is presented, with regard to the open-source model developed, a method for clustering similar countries into groups will first be articulated.

Country clustering

We do not always have complete evidence for all countries in the world which makes it challenging to undertake systematic cross-country analysis. Often survey data from one country, could be used to inform other countries, providing a suitable comparison can be made. Country-to-country variation needs to be controlled for in this process. Therefore, in this assessment a representative set of country clusters is developed for all 135 emerging economies by using a k-means clustering approach based on four key metrics which affect the supply and demand of broadband infrastructure.

Firstly, Gross Domestic Product (GDP) per capita represents the economic purchasing power of consumers, and secondly, population density represents the general spatial distribution of humans living in a particular country (World Bank, 2020). Thirdly, 4G coverage provides insight into the level of existing availability of telecom infrastructure and wireless broadband availability, and finally, the penetration rate for unique cellphone subscribers is used (recognizing that as many people multiple SIM cards, therefore the unique number of users is required) (GSMA, 2020). While these metrics are by no means a fully comprehensive set of country indicators, it is preferable to use a small number of metrics when clustering. This keeps the analysis as explainable as possible (e.g. for why certain countries are in each cluster), as well as keeping any illustrations visually succinct (e.g. making it possible to visualize the inputs and results in a single set of plots). Figure 1 reports the mean centered results of the clustering process, along with the six different country segments selected.

Figure 1 K-means clustering results for each country grouping

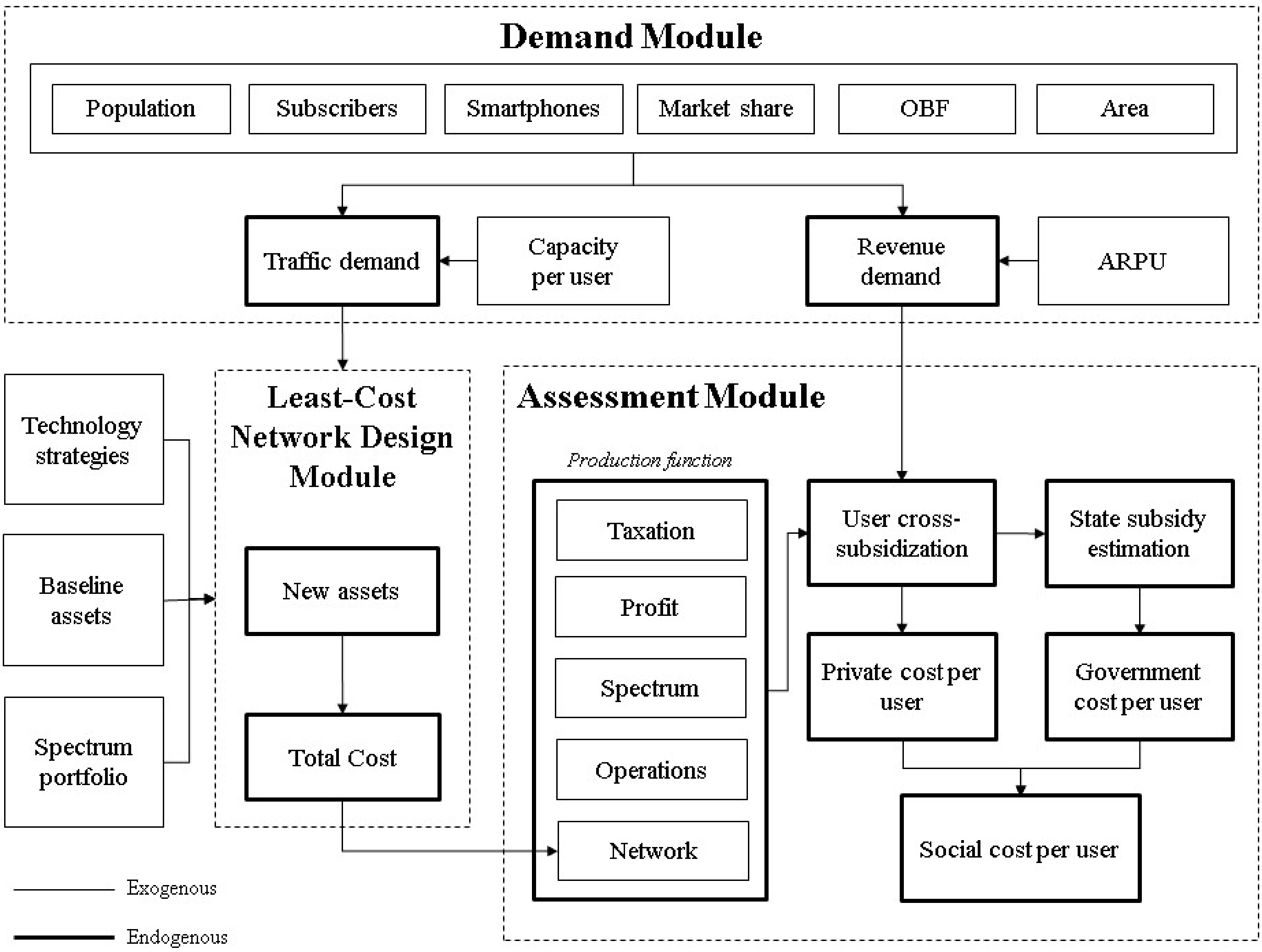


To avoid overcomplicating this assessment, high-income countries are excluded as the focus of this analysis is Low- and Middle-Income Countries (LMICs). Due to the unique geographic characteristics of very small countries, we drop those under 5,000 square kilometers, so the focus can be on providing wide-area access in challenging deployment conditions. This generally excludes very small islands, such as Grenada, Saint Lucia, or The Maldives. Countries with very high population density (over 5,000 inhabitants per square kilometer) are also excluded as these nations have favorable economic conditions that may not warrant the type of universal broadband analysis carried out in this assessment (such as Lebanon). The exact R code uses the inbuilt kmeans function from the R stats package and is available for inspection in the Qubic code repository (Oughton, 2021).

Open-source engineering-economic model

The modeling techniques have been applied to many countries around the world, with the foundations of the method developed for national 5G assessments in OECD markets, such as the UK (Oughton et al., 2018; Oughton and Frias, 2018, 2016; Oughton and Russell, 2020) and the Netherlands (Oughton et al., 2019). More recently, the methods have been deployed in the Pytal and Podis repositories. Figure 2 visualizes the assessment method, divided into the three software modules, which will now be presented.

Figure 2 Universal broadband assessment method applied in Qubic



Demand module

The demand module uses a variety of data inputs. For a detailed description of the mathematical model, see the affiliated document.

Figure 3 Demand forecasts for Bangladesh

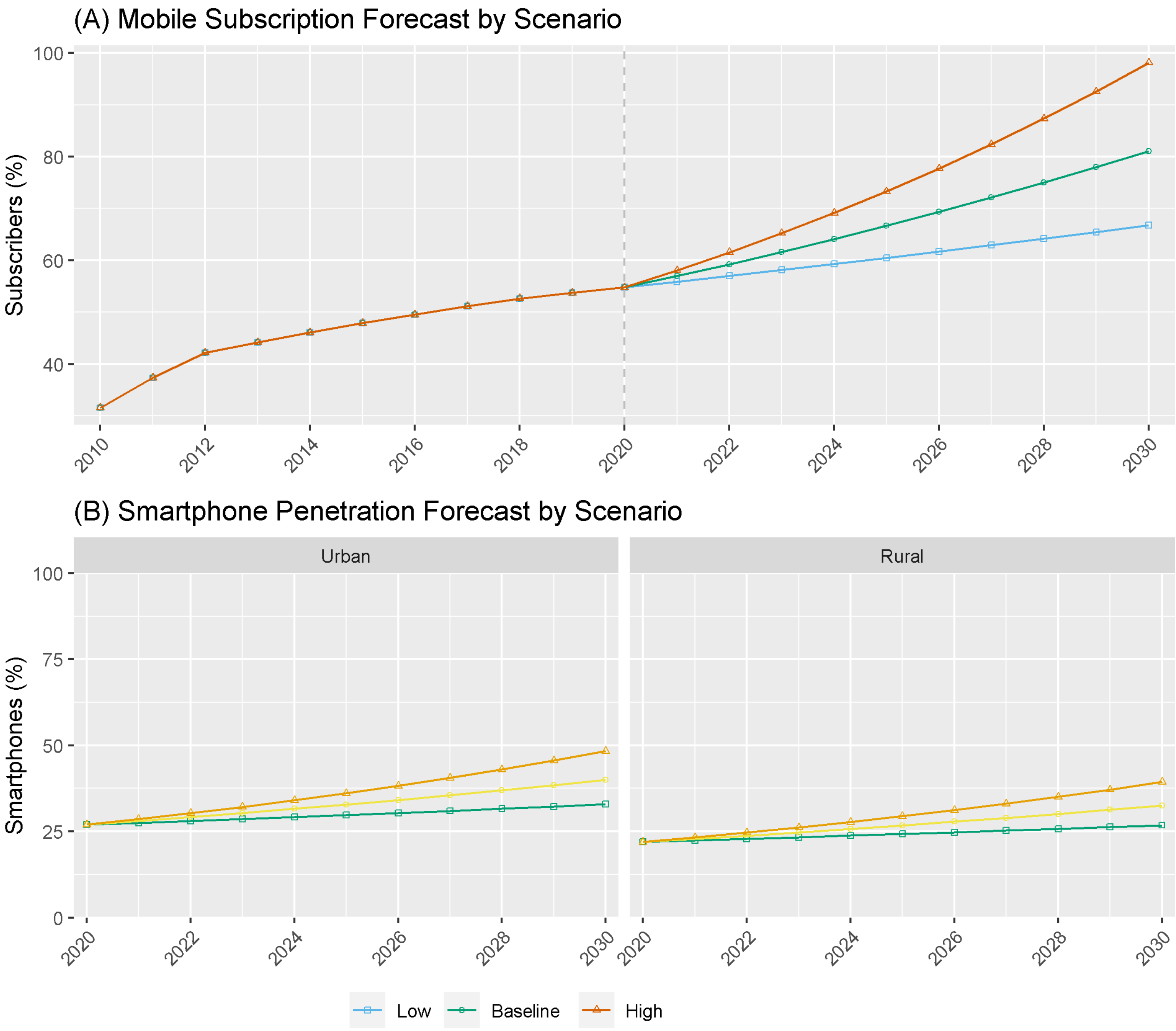


Table 1 General country information for Bangladesh

Country Parameter	**Value**
Global Region	S&SE Asia
ISO3	BGD
ISO2	BD
GADM GID level for core nodes	1
GADM GID level for regional nodes	2
Settlement population density (km^2)	500
Aggregate settlement size	500
Core node settlement size	2000
Country cluster	C3

Table 2 Model parameters for Bangladesh

Model Parameter	Value
Weighted average cost of capital (%)	10
Allowed return on capital employed (%)	20
Baseline coverage spectrum cost (USD/MHz/pop)	0.04
Baseline capacity spectrum cost (USD/MHz/pop)	0.03
Low spectrum price cost decrease (%)	25
High spectrum price cost increase (%)	200
High tax rate (%)	40
Baseline tax rate (%)	32
Low tax rate (%)	10
Admin cost based on network investment (%)	20
Overbooking factor	20
Investment return period (years)	10
Discount rate (%)	5
Opex cost based on network capex (%)	10
Confidence interval (%)	[50]
TDD DL to UL ratio	80:20

Table 4 Cost parameters for Bangladesh

Cost Parameter	Value
Site equipment cost ($)	40000
Site civil engineering cost ($)	30000
Equipment installation cost ($)	30000
Operation and maintenance cost ($)	7400
Power cost ($)	3000
Annual site rental cost (urban) ($)	10000
Annual site rental cost (suburban) ($)	5000
Annual site rental cost (suburban) ($)	3000
Fiber optic cost (urban) ($ per meter)	25
Fiber optic cost (suburban) ($ per meter)	15
Fiber optic cost (rural) ($ per meter)	10
Wireless backhaul (small) ($)	15000
Wireless backhaul (medium) ($)	20000
Wireless backhaul (large) ($)	45000
Core node ($)	1000000
Core edge fiber optic cost ($ per meter)	25
Regional node ($)	100000
Regional edge fiber optic cost ($ per meter)	25

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