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Conference Paper

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30th European Conference of the International Telecommunications Society (ITS): "Towards a Connected and Automated Society", Helsinki, Finland, 16th-19th June, 2019

Provided in Cooperation with:

International Telecommunications Society (ITS)

Suggested Citation: Logothetis, Vangelis et al. (2019) : Ex post regulation of NGA networks: A roadmap for calculating the cost of an efficient operator – The case of Greece, 30th European Conference of the International Telecommunications Society (ITS): "Towards a Connected and Automated Society", Helsinki, Finland, 16th-19th June, 2019, International Telecommunications Society (ITS), Calgary

This Version is available at:

<https://hdl.handle.net/10419/205195>

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Ex post regulation of NGA networks: A roadmap for calculating the cost of an efficient operator – The case of Greece[‡]

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Abstract

This paper provides a useful guide for telecom regulators on how to calculate the cost of an efficient operator investing in Next Generation Access (NGA) networks under regulatory uncertainty. When the regulator cannot make *ex ante* credible commitments, operators undertake their optimal investment decisions anticipating an *ex post* cost-oriented access regulation policy. A roadmap for estimating the cost of an efficient operator deploying an NGA network under regulatory uncertainty is provided for the purposes of setting copper and NGA wholesale prices where cost orientation is imposed as a remedy. Following a detailed analysis, the most impactful parameters are identified and presented so as to trigger a fruitful discussion among academics, economists and policy makers.

[‡] This paper is based on the public model for calculating the wholesale prices for copper and fiber access networks according to the 2013/466/EC Recommendation⁷ issued by Hellenic Telecommunications and Post Commission (EETT). The positions presented in this article do reflect the personal opinions of the authors and not the official positions of EETT.

1. Introduction

1.1. Introduction to NGA networks

According to the European Commission's (EC) Recommendation on promoting competition and enhancing the broadband investment environment¹, *Next Generation Access (NGA) networks means wired access networks which consist wholly or in part of optical elements and which are capable of delivering broadband access services with enhanced characteristics (such as higher throughput) as compared to those provided over already existing copper networks*. In most cases NGAs are the result of an upgrade of an already existing copper or coaxial access network.

Although this definition implies that fiber optics can replace any part of the copper local loop, technical restrictions considerably limit the available NGA architectures. Depending on the part of the copper wire being replaced, there are certain NGA architectures, the most common of which are: (i) Fiber-to-the-Curb (FTTC); and (ii) Fiber-to-the-Home (FTTH).

Regarding the FTTC architecture, the path from the service provider's central office to the intermediate node (street cabinet) that serves an entire neighborhood exclusively consists of optical fiber. The access of each end-user up to the switch of the street cabinet is realized using the standard copper cables used for the PSTN network and Very High Speed DSL (VDSL) technology over copper cables. Depending on both technology and distance, end-users experience symmetric or asymmetric data rates of up to 100Mbps according to the copper length.

The FTTC architecture provides the incumbent with the advantage of connecting its subscribers to existing copper cable infrastructure in the first mile. Additionally, it has lower capital requirements since the NGA investment is done only in part of the access network. However, it has a limited time frame since there is a need for capacity doubling every two years.

According to the FTTH architecture, the path from the service provider's central office to the end-user exclusively consists of optical fiber. The fiber is terminated inside the home or the workplace of the end-user. Therefore, each device at the subscriber premises is connected through a dedicated optical fiber to a switch port located at the central office or to the optical splitter which, in turn, is connected to the central office via a single feeder fiber.

Three FTTH technologies are mature enough to use in an NGA investment. The choice of each technology depends on the type of the transmitted service, the infrastructure cost, the existing infrastructure and future plans towards new technologies.

1.2. The economic impact of NGA investments

According to the European Commission Recommendation on regulated access to Next Generation Access Networks (NGA)², *the EU single market for electronic communications services, and in particular the development of very high-speed broadband services, is key to creating economic growth and achieving the goals of the Europe 2020 strategy. The*

¹ [European Commission Recommendation of 11 September 2013](#)

² [European Commission Recommendation of 20 September 2010](#)

fundamental role of telecommunications and broadband deployment in terms of EU investment, job creation and overall economic recovery was notably highlighted by the European Council.

Recent empirical studies have tried to quantify the positive impact of investing in broadband infrastructures on the main economic and social indices. Considering that broadband penetration may be endogenous to the growth process, Czernich, Falck, Kretschmer, & Woessmann (2011), estimate the effect of broadband infrastructure investments on economic growth in the panel of OECD countries in 1996–2007. They find that after a country had introduced broadband, GDP per capita was 2.7–3.9% higher on average than before its introduction. In terms of subsequent diffusion, an increase in the broadband penetration rate by 10 percentage points raised annual growth in per capita GDP by 0.9–1.5 percentage points.

Furthermore, Katz, Vaaterlaus, Zenhäusern, & Suter (2010) estimate the impact of broadband infrastructure investments on German employment and economic output, following the government's National Broadband Strategy that extends through 2014 and the subsequent ultra-broadband evolution from 2015 to 2020. They find that a total investment of close to 36 billion euros in broadband infrastructures would generate a total of approximately 1 million incremental jobs and an additional value added of 33.4 billion euros, while network externalities would result in an additional 137.5 billion euros. In total, this results in 170.9 billion euros of additional GDP (0.60% GDP growth) in Germany.

Given that this positive impact on economic outputs is increasing in the broadband speed (Rohman & Bohlin, 2012), it is expected that ultra-fast broadband services delivered via fiber-based, Next Generation Access (NGA), networks will have an even more profound effect on productivity, economic growth and job creation.

2. Regulatory framework

2.1. Access regulation

Technological advances in communications technologies allowed the transmission of high data rates over the twisted copper pair telephone lines, thus making available the provision of high-speed Internet access (or simply broadband access) using the legacy copper access networks. Since these networks were monopolized by the incumbents, the goal of regulators has been to reduce their monopoly power by enabling alternative firms (the so-called “new entrants”) to enter the market and compete effectively with the incumbents in the downstream (i.e., retail) market.

This goal has been fulfilled both in the United States (US) and in the European Union (EU) by enforcing a light retail price regulation combined with an *ex ante* cost-based regulation of the upstream copper facilities of the incumbents. Although uniform cost-based access prices promote service-based competition within one network, they are generally found to hinder (competitive) investments in broadband network upgrade (Cambini & Jiang, 2009).

Therefore, a regulatory policy stimulating static efficiency in the short-run also results in a substantial deviation from the socially desirable outcomes in terms of network deployment and timing of investment, thus implying significant losses in dynamic efficiency (Bouckaert, van Dijk, & Verboven, 2010). Perhaps the most challenging task for academics, governments

and policy makers is to design a regulatory policy that encourages investments in NGA networks without much distorting the competition level achieved through the regulation of the copper access networks.

2.2. The role of regulatory (un)certainty

Like many infrastructure investments, NGA networks may create positive spillover effects that are not captured in any individual user's willingness to pay. This implies a clear public policy case for governments to facilitate the roll out of NGA networks by reducing the risk for the investor.³ Indeed, the European Commission in its Recommendation on regulated access to Next Generation Access Networks, states that regulatory certainty is a key to promoting efficient investments by all operators.

Regulatory certainty is provided by fixing the principles of tariff regulation for the whole period of the economic lifecycle of an NGA investment. However, regulatory certainty bears the risk of erroneous intervention stemming from the argument that a regulator's initial assessment may be mistaken. In fact, it is socially not optimal for the regulator to make *ex ante* commitments for an unreasonably long regulatory period.⁴

Therefore, in providing greater regulatory certainty the regulator has to make another trade-off between the positive effects of greater certainty on investment incentives and possible negative effects of erroneous intervention on welfare.⁵ As a result, regulatory uncertainty is related to the regulator's limited ability to make *ex ante* credible commitments. In order to mitigate the regulatory uncertainty associated with periodical market reviews, National Regulatory Authorities (NRAs) should clarify to the greatest extent possible how foreseeable changes in market circumstances might affect remedies.

2.3. The EC recommendation

The EC recommendation of 11 September 2013 provides the main costing methodology guidelines for regulators around the EU. The first and foremost goal is to model a modern and efficient network replicating as best as possible a competitive market. Additionally, stable copper access prices "*servicing as an anchor*" for NGA investments are considered highly important especially when considering migrating consumers from legacy networks to NGA networks. Infrastructure competition is positively viewed as the EC sets another target, that of balancing out the dilemma between build-or-buy having always as underlying focus a healthy competitive environment. The bottom-up long run incremental costs plus (BU LRIC+) is considered the appropriate methodology to achieve these goals.

As NGA networks are competing in a favorable way against copper networks, SMP operators look to upgrade their legacy networks to keep up with the competition. The deployment of a copper network is no longer considered a viable business option, explaining beyond doubt

³ [DotEcon \(2012\). Regulatory policy and the roll-out of fibre-to-the-home networks](#)

⁴ [WIK \(2009\). The Economics of Next Generation Access - Addendum](#)

⁵ [OPTA \(2010\). Regulation, risk and investment incentives Regulatory Policy Note 06](#)

that the efficient hypothetical operator builds an NGA network consisting at least partially of optical elements.

A most important obstacle for regulating authorities comes up when dealing with reusable assets. Assets to be considered as such and their subsequent valuation is a decision bound to be put under the microscope as conflicting interests between incumbents and alternative operators arise. Copper networks are not expected to be replicated in their entirety by the EC suggesting that civil engineering assets would be reused whenever possible. Though there seems to exist some level of ambiguity when interpreting the recommendation on the reusability of cables.⁶ Not to be overlooked is also the discussion regarding the valuation of the reusable assets, but on this issue the EC provides a safe pathway going forward, meaning the application of the indexation method to calculate current costs for the Regulatory Asset Base corresponding to the reusable legacy assets.

It becomes apparent that even though the recommendation discusses NGA networks, a lot of its focus is put on copper costing. For member states, copper prices continue to be of relevance as countrywide fiber deployment is a difficult goal to achieve. Legacy networks will not be decommissioned in the foreseeable future and the ECs call for general market stability could not exclude copper pricing from the regulatory mix. Till 2017, years after the recommendation's publication, 30 Mbps coverage across the European Union had not reached a level that would prove otherwise reaching an average of 80%, with some members being seriously behind said average. The percentages in rural areas are expectedly lower as 30 Mbps coverage reached lower than 50% on average while 14 members were below that threshold.⁷

The EC even anticipates the level of wholesale copper access prices given the guidelines provided within the recommendation manuscript. To determine those prices entirely based on copper two possible methodologies are described, the first one being a cost estimation based on the NGA network modelled *by replacing the optical elements with efficiently priced copper elements, where appropriate, in the NGA engineering model*. Costs could be otherwise determined by modelling an *NGA overlay network* sharing to some extent the same infrastructure with the copper network. The two perspectives are not differentiated in any way, suggesting that they should be equivalent, if applied correctly. The one to be followed though, could be entirely dependent on other methodological aspects of the network. For example, if the NGA network is set to be as efficient as possible with a brand-new topological design, then an overlaying network could better reflect an efficient operator for a specific nation. In the case that a network reliant on legacy topology is being deployed, then replacement method could be the appropriate approach. On a purely theoretical basis, the most-efficient trenching calculations should not change regardless of transmission medium buried, *ceteris paribus*.

3. The characteristics of an efficient operator

In order to model an efficient operator, we have to undertake some critical decisions which form the profile of such an operator. This task requires a deep analysis because it crucially

⁶ [BEREC Report Regulatory Accounting in Practice 2018](#)

⁷ [Broadband in the EU Member States](#)

affects the final results. Below, we discuss the most significant aspects that determine the efficiency level of the operator in question.

3.1. Scorched earth vs scorched node approach

A very important aspect of the network design deals with the placement of its nodes and the degree of alignment with actual locations that providers have already deployed. The scorched earth approach allows for a completely new design without inheriting any of the preexisting inefficiencies. This approach is good on paper but is seldom used in bottom-up models as it departs heavily from real life applications, especially when regulation comes well after network deployment. The scorched node method is commonly used, taking existing node locations granted, a much more down to earth perspective that keeps close ties with provider's actual networks. In order to achieve a higher level of efficiency, a model can move towards the *modified* scorched node approach that allows adjustments of node characteristics such as its role in the switching hierarchy.

3.2. Network technology/topology

Considering the technology adopted, the recommendation defines in a straightforward manner the hypothetical efficient network as one *capable of delivering the Digital Agenda for Europe targets set out in terms of bandwidth, coverage and take-up, which consists wholly or partly of optical elements*. Thus, the possible solutions strictly include FTTx solutions as the deployment of fiber optics is seen as mandatory. Fiber proximity to consumer premises may vary and all possible solutions, Curb, Building or Home, are considered viable leading to different types of networks depending on each country's circumstances.

3.3. Network Footprint

When examining the network's size, one can sense a clash of perspectives coming to the surface. Following the recommendation's guidelines would lead towards a countrywide network designed to provide universal service, but on the other hand, the modelled provider should be hypothetically efficient. It seems entirely possible that deployment in certain regions would not be a viable option for a profit maximizing firm. Reasons behind this could be population scarcity, difficult terrain or even both, as is true in parts of the Balkans or the Iberian Peninsula, for example.

No reference is made by the Commission to subsidized areas and expectedly most NRAs choose to exclude them from the costing process. Problems arise with the emergence of unappealing - from a firm perspective - areas where no fiber is being deployed at all. The impact on prices by including said areas cannot be safely predicted, resulting to ambiguity in their appeal for an efficient provider. Lack of determination in defining the hypothetical network can add friction to the modelling process and the subsequent consultation.

Some NRAs choose to imitate the incumbent's footprint, a safe choice that does not necessarily solve issues described in the previous paragraph. Another interesting decision that relates to the hypothetical operator's network is the possible existence of more wholesalers in

the market designed. Deploying multiple smaller operators would eventually intensify conversations regarding indirect costs incurred by the efficient operator and the extent to which economies of scale can be achieved. Nonetheless, this approach would not be outside of the recommendation's scope.

According to European Commission's report⁸, 4G LTE coverage has reached more than 90% even in rural areas of Europe. LTE technology can provide broadband speeds up to 300Mbps or more depending on network load and LTE version deployed. Fixed Wireless Access (FWA) networks based on LTE technology or the upcoming 5G technology could be used as a "last mile" solution for providing high speed broadband services to underserved areas. In this case, considerable cost savings can be expected by reusing the existing infrastructure or sharing of infrastructure between operators.

Although, various studies have been conducted (Feijóo, Ramos, Armuña, Arenal, & Gómez-Barroso, 2018; Ovando, Pérez, & Moral, 2015) and FWA networks have been deployed on some European rural and suburban areas, these networks neither have been widely adopted as an NGA solution nor the regulators have considered these technologies in their NGA models. As stated in the European Commission's reports, FTTC VDSL is still the go-to solution in rural areas and has the highest coverage growth and availability compared to other technologies.

4. The case of Greece

4.1. A brief description of the fixed broadband market

This text intends to take a closer look into the case of Greece where the landline broadband landscape is heavily affected by its late liberalization with a clear market front-runner in the incumbent, which holds a healthy 46% of the broadband market while being the sole wholesale access provider in the country.

This single wholesaler status quo is set to change with the introduction of VDSL vectoring technology to the access network through the allocation process designed by the national regulator (EETT) in 2017. Unvectoring VDSL was already being deployed by the incumbent with the necessary equipment placed mostly inside the Central Offices (CO), leading to an increase in 30-50 Mbps penetration, that reached a 15% of broadband connections at the second quarter of 2018.⁹

This technological approach could not adhere to the recommendation's guidelines since the ability to provide the minimum 30 Mbps was heavily hampered by the limitations of copper as a transmission medium, particularly in distances greater than 550 meters from the DSLAM¹⁰. Not being able to reach the Digital Agenda's goals brought to the surface a need to move the DSLAM closer to customer premises, i.e. the cabinet. Already lagging, NGA investments were far more feasible through continued usage of the legacy copper network, rendering Fiber to the Curb (FTTC) the most appealing solution.

⁸ [Study on Broadband Coverage in Europe](#)

⁹ [Broadband report Q2-2018](#)

¹⁰ [Techniques to Mitigate Uncancelled Crosstalk on Vectored VDSL2 Lines](#)

4.2. The allocation process

The distance closing between customer and DSLAM was regulated and incentivized through a unique multi-phased bidding process by the national regulator.¹¹ Operators were able to assume VDSL vectoring deployment responsibilities via regional bidding, selecting COs and underlying cabinets from the incumbent's legacy network.

The first phase allows bidding only to the incumbent granting first mover advantage alongside an obligation to cover 80% of existing cabinets. The COs not selected by the incumbent become available to the other operators in the second phase with 50% coverage obligation. In the third phase, every operator can select from the remaining COs committing to a 30% coverage.

Throughout these three stages, it is made clear that only one operator can deploy VDSL vectoring on selected region. This means that during the second and third stage, an operator cannot select to invest in regions already selected. This guideline removes infrastructure competition on the early stages of the NGA deployment looking for investment spreading and faster network expansion. After the completion of the three phases, there follows a yearly bidding process that relieves the aforementioned competitive restrictions. Noteworthy fact is that cabinets within 550 meters from the CO (cable distance), are excluded from every phase, and the incumbent keeps providing unvectorized services inside this "circle".

4.3. Cost modeling

4.3.1 Defining the efficient operator

The efficient operator in the case discussed was defined by answering all the possible dilemmas that have been previously mentioned inside this document. In more detail, the modified scorched node was adopted as in most other countries. Not only does it compare better to what a hypothetical efficient and FTTC deploying operator would do, but it also is an approach incredibly in sync with the allocation process that took place in Greece, as providers made business decisions based on legacy topology.

The Network technology also follows the operators' business plans as they were unveiled through the allocation process. The main technology deployed was FTTC vectoring for reasons previously explained though some pilot FTTH were announced by the operators. As far as the hypothetical efficient goes, FTTC and some pilot FTTH is deployed outside of the 550 meter range. Inside the CO 550 meter perimeter the efficient is expected to use exclusively FTTH technology. The restraints posed from the application of vectoring technology coupled with the expected increase demand for highspeed broadband and the ongoing fiber deployment farther away from the CO explains the decision behind this FTTH heavy development close to the CO. The described business plan, followed by the modelled operator, is not foreign to what actual operators elected to do in specific areas of the country

Establishment of the technology modelled is followed by the definition of the network's footprint. In this specific case discussed, a wide network capable of reaching the digital agenda's goals is being designed leaving every subsidized MDF area out of the costing procedure as one would expect. If fiber deployment is subsidized the preexistent copper is not

¹¹ [ΑΠ ΕΕΤΤ 792/07/22.12.16](#)

excluded from the copper cost modelling since the legacy copper network was not the actual result of the subsidization.

A single efficient wholesale operator is considered, resulting from the fact that no signals of regional competition were given from actual market data. Various localized single efficient wholesalers if properly costed should be the equivalent of a single countrywide efficient wholesaler with possible added benefits of achieving economies of scale especially regarding common costs incurred necessary for the business side of things to run.

4.3.2 Describing the cost model

The cost model follows the general rules of a Bottom-Up technoeconomic model. Based on the methodological principles upon which the network is build, follows the creation of a list of needed components that an operator must deploy in the field in order to create a fully functioning network. Single unit prices, both CAPEX and OPEX, are then set combined with the calculation of possible price changes in case where component repurchase is needed, something that depends on asset lifetime. The foundational part of a cost model is the dimensioning, that is the calculation of the number of the network assets required for a smoothly operational network.

Having completed the dimensioning, one can then proceed to define the yearly costs of the hypothetical operator by depreciating the initial investment summed up with the yearly operational costs. Worthy of note is the fact that revenues are not a part of the bottom-up implementation as its purpose is to calculate cost recovery and not a general business plan investment evaluation.

In the general scope of an NGA operator, a variety of services are being offered to consumers while not all services consume network resources equally. Thus, cost allocation calculations are due in order to accurately cost each separate service. For example, in Greece's case the existence of two parallel networks (FTTC/FTTH) demand a cost splitting between them, when network assets are used by both. A straightforward way to automate the allocation is through the usage of routing factors for each separate service that serve as multiplication tables for the yearly costs resulting to a yearly cost per service. Obviously, there needs to be a high level of sophistication when deciding factors and cost allocation but a detailed description of said process is outside the scope of this text.

4.4. Main results of the technoeconomic analysis

The results stemming from an exhaustive technoeconomic analysis are always subject to discussion. Assumptions and methodological perspective can influence the outcome but if the modelling architecture is appropriately reflected and sufficiently flexible it should be able to facilitate rather than hamper discussion. In fact, a successfully built model is not defining prices but instead provides the necessary tools to do so, becoming a loyal servant to the regulator. Following this rationale, it becomes unnecessary to talk about sheer numbers resulting in a discussion regarding the main cost drivers and its impact on wholesale prices.

4.5 Sensitivity analysis

Conducting a rigorous sensitivity analysis on the two simultaneously active networks, some expected results are derived but also some interesting insights can be extracted. Obviously, trenching is among the most powerful cost drivers something that no analysis is needed to understand. Installing thousands of kilometers of duct and fiber underground, while striving to futureproof the investment is a cumbersome task for any provider across the globe. Especially when modelling a hypothetical operator with a wide network footprint, possibly reaching areas with lower population density for example, could further impact the trenching effect.

In the FTTC case, apart from the fresh trenching a big part of the existent copper network can be reused. The undepreciated value of the reusable trench is confirmed to be a driving cost factor revealing the correct evaluation of the regulatory asset base to be highly important.

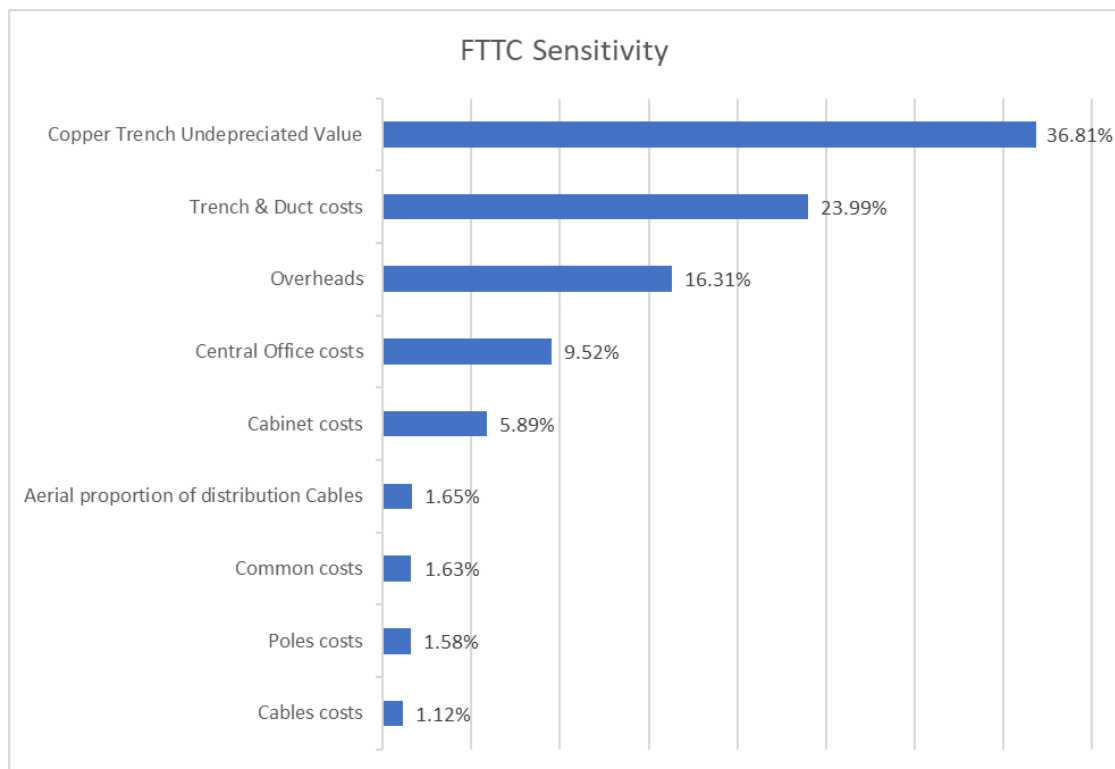


Fig 1. Sensitivity analysis results for FTTC wholesale service costs.

When building FTTH solutions, the issue of reusable asset valuation becomes less important as optical equipment replaces the old copper, followed by the need to renew equipment in every building where active subscribers reside. As seen in the FTTH sensitivity analysis, this is a substantial cost that includes Building Entry Points for every building, Floor Boxes and vertical cabling for the connection of each subsequent floor. A strict FTTH deployment would incur heavy costs for the operator trying to supply high speed services to the entirety of the population per DAE 2020.

The intermediate step of FTTC deployment, may delay the ultra-fast broadband adoption but is a much more prudent step to take, especially when economic instability is a part of the equation. The important goal for operators that elect to follow this staggered process of NGA

deployment is to devise a FTTH ready plan reusing their former fiber investments in the future even at their entirety if possible. Otherwise, the benefits of following a two-step path into the FTTH connectivity would come with come along with added burden that a next generation of regulators will need to face.

The present hypothetical efficient operator should be entirely compatible with the hypothetical efficient operator of the future and vice versa. Additionally, when looking into the cost impact of COs, the standard application of scorched node deployments across EU could be disputed especially regarding exclusively fiber based networks. Of course, a detailed analysis could eventually lose some relevance due to the impact of parameters such as the weighted-cost average and operator overheads that affect horizontally the technoeconomic analysis' outcome.

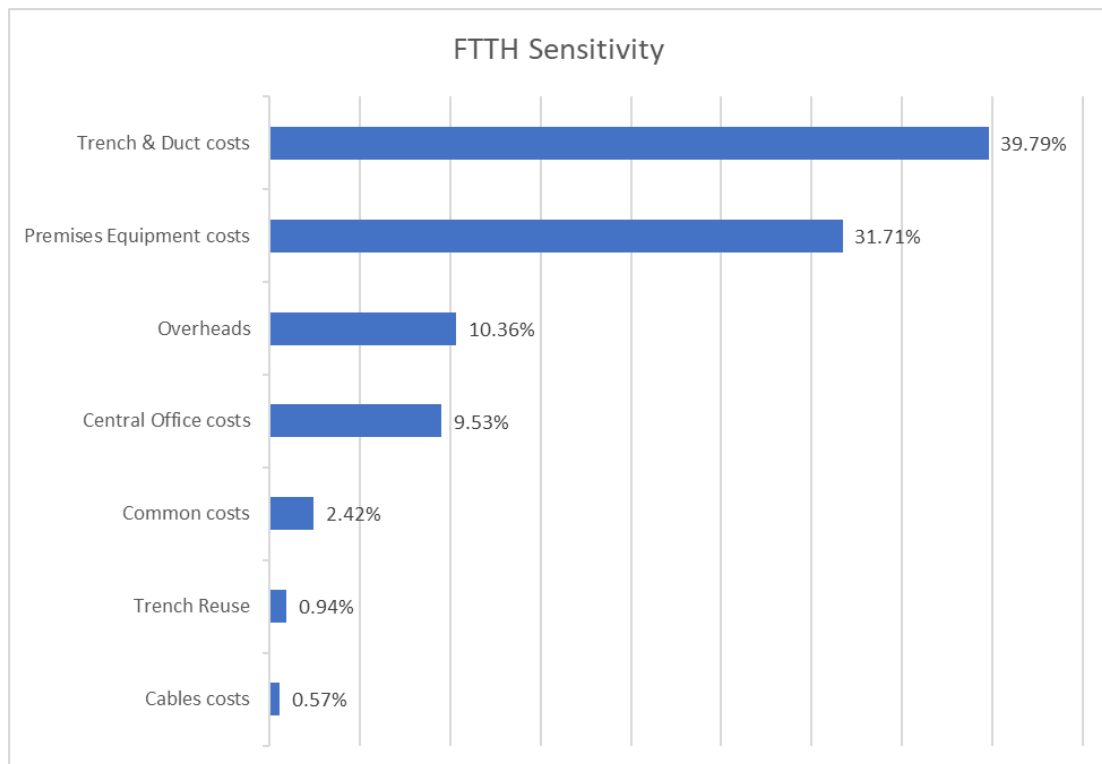


Fig 2. Sensitivity analysis results for FTTH wholesale service costs.

Adding the Weighted Average Costs of Capital (WACC) to the sensitivity analysis has shown that FTTH is more sensitive to WACC than FTTC. Capital expenditure (CAPEX) is a much bigger part of total FTTH costs than operational expenses (OPEX). In contrast, FTTC has lower proportion of CAPEX to OPEX costs which makes WACC a less important factor for the costs of FTTC services.

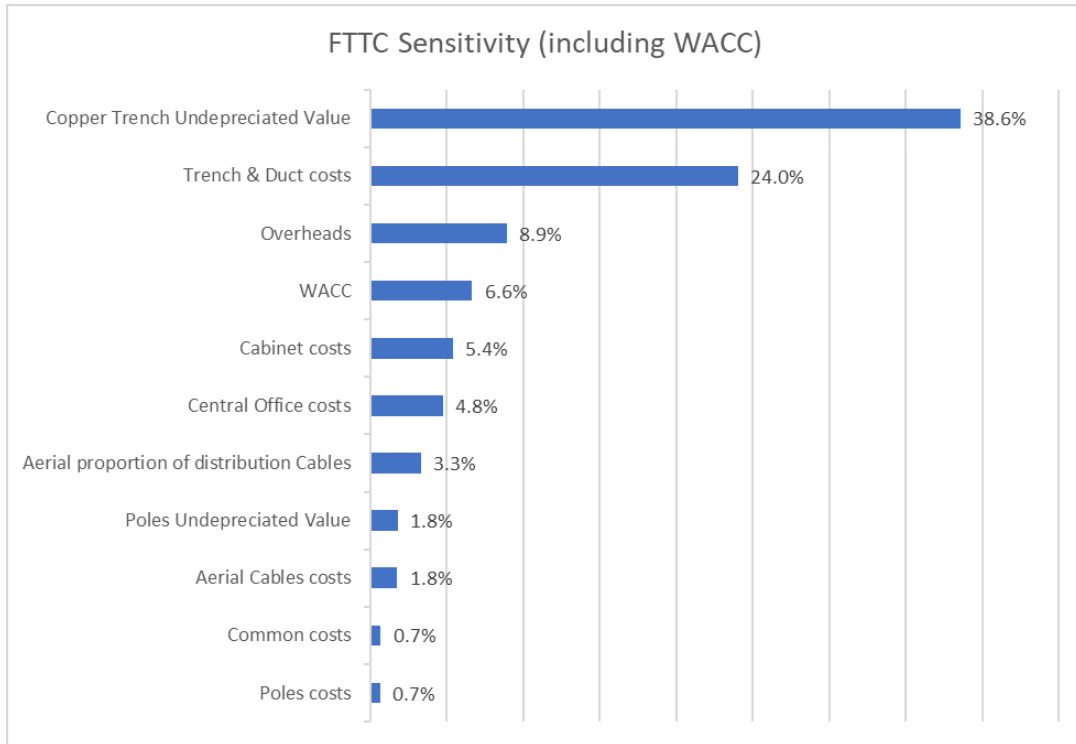


Fig 3. Sensitivity analysis results for FTTC wholesale service costs including the WACC.

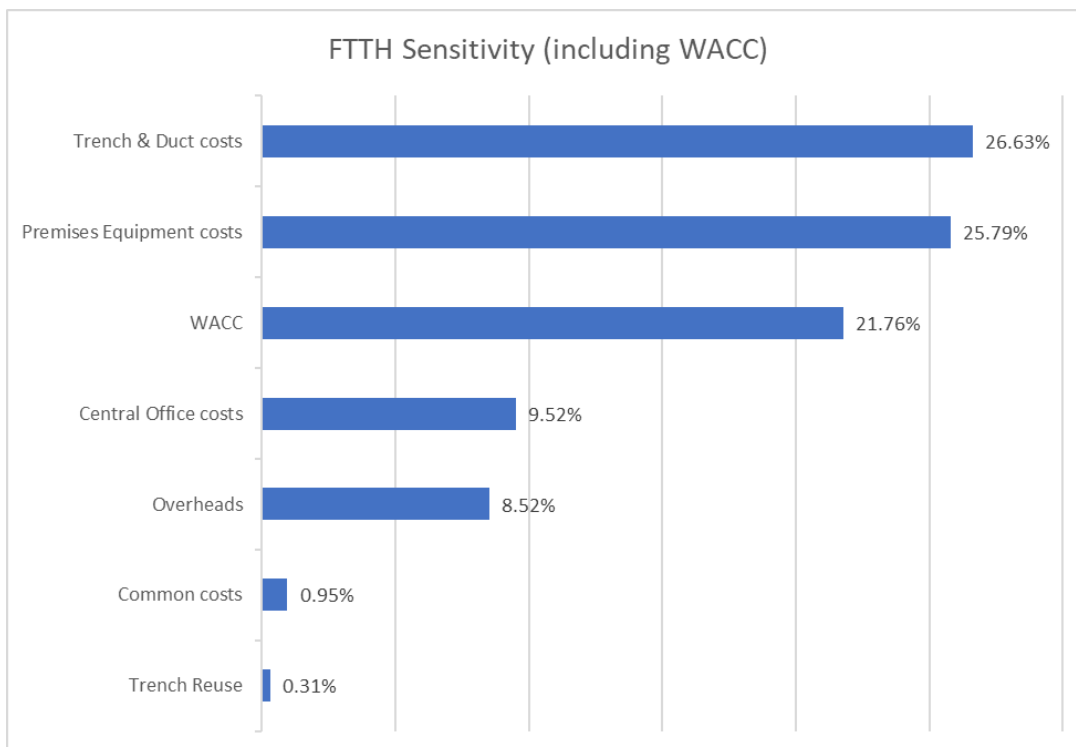


Fig 4. Sensitivity analysis results for FTTH wholesale service costs including the WACC.

5. Conclusions

This manuscript provides a roadmap for the purposes of setting copper and NGA wholesale access prices where cost orientation is imposed as a remedy. By conducting an extensive cost analysis on the proposed telecom networks, some expected quantitative results are derived, but also some interesting insights can be extracted. Trenching, cost of capital and premises equipment are among the most powerful cost drivers, especially when possibly reaching areas with lower population density in FTTH footprint. As a result, telecom regulators should be fully aware of such costs when dealing with access price regulation.

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ACKNOWLEDGMENTS

The work described in this article has been funded by the Special Account for Research Grants of the National and Kapodistrian University of Athens (N.K.U.A.).