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Determinants of FTTH tariffs: an empirical EU study

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Abstract

This study examines the relevant factors that determine the FTTH tariffs within the European Union (EU) zone. FTTH networks, as a relevant new technology, have a significant impact on modern economies. This is reflected by their adoption and use across EU countries along with the increasing deployment. However, FTTH tariffs, play an important role in the technology's adoption, as they are driven both by the level of adoption and the market's competition. Looking at the EU countries between 2013 and 2018, we find a consistent effect of FTTH tariffs on national economic output with diminishing returns to scale. The study reveals that market player's competition is a moderator parameter on FTTH tariffs, in addition to the technology's adoption. Finally, FTTH tariffs tend to drop overall during the study's period across all the EU countries, motivating more residents to have access to high speed Internet and develop new applications. Hence, EU countries could achieve faster their goals, with subscribers' willingness to pay for high speed service with the right market competition and service offering in place, towards the 2020 national broadband plan regarding ultrafast connectivity.

Keywords

FTTH, FTTP, Tariffs, NGA Broadband. Forecasting

Highlights

- Comparison of different models for tariff prediction.
- Defining the FTTH effect to the national economy
- Tariff forecast results for FTTH
- Benefits from panel data regression

1. Introduction

In the past years, investments in fast broadband infrastructures continue to receive a considerable attention from regulators, public authorities, and market players. As the demand for bandwidth and Internet users' base continues to increase, telecom operators have been urged in most European countries to upgrade their legacy copper networks and start deploying the 'Next Generation Access' (NGA) broadband networks based on fiber-optic technology. This technology enables a massive increase in bandwidth capacity enabling 'fast broadband' of 100+Mbps fiber service but also the adoption of completely new services and applications forming a new high-tech ecosystem.

¹ The positions illustrated in this article do reflect the personal opinions of the authors and not the official positions of the organizations that the authors are employed to. These official positions of the organizations are presented via their public announcements and official documents such as decisions, etc.

Based on the recent Cisco's Annual Report (2018-2023), fixed broadband speeds will more than double by 2023. The global average broadband speed continues to grow and will be more than double from 2018 to 2023, from 45.9 Mbps to 110.4 Mbps with several factors to influence the fixed broadband-speed forecast, such as the deployment and adoption of Fiber-To-The-Home (FTTH), and fixed broadband adoption, as well as overall broadband penetration. By 2023, global fixed broadband speeds will reach 110.4 Mbps, up from 45.9 Mbps in 2018. During that time, Central and Eastern Europe will have 388 million Internet users (78 percent of regional population), with an average fixed broadband speed to reach 87.7 Mbps, where Western Europe will have 370 million Internet users (87 percent of regional population), with an average fixed broadband speed to reach 123 Mbps.

Cisco's projections' data justifies the urgent need for the adoption of fast broadband fiber-based networks that are considered fundamental as they contribute to long-term productivity and economic growth across the world and in particular in Europe. As it is stated, in the Digital Agenda for Europe (DAE), the European Commission not only pushes its plans for an European Gigabit Society but also strongly supports the strategic importance of broadband infrastructures and services for economic development and sets ambitious coverage and adoption goals. The DAE, seeks to ensure that, by 2020 and beyond, among the objectives that have been set in the field of 'provision of broadband, "50% or more of European households will subscribe to internet connections above 100 Mbps"

Achieving these goals entail substantial costs and investments, but also generating demand for service that derives also from the right tariffs to attract new users. That will will be the right tools to build and expand an entirely new infrastructure which is partly or entirely fiber-based. Therefore, as more that 50% of the European countries are still the early steps of their FTTH service, a technoeconomic analysis, using historical EU data, urges to understand the factors that influence the Fiber tariffs and potentially reveal the determinants of the faster service's adoption and the expansion of new (high-speed) broadband networks. Some forecasts are also generated for the next 3-years considering the Covid-19's effect and the potential upcoming recession.

2. Literature Review

The present study attempts to shed light into the determinants of the FTTH tariffs across EU and is among the few that studies the specific technology's features that set of countries in the period 2013 to 2017, when FTTH started to become a popular technology along with DSL. One early study Abrardia et al (2019) presented an updated ultra-fast deployment survey and a literature review, emphasizing that higher local growth in a certain country or region might drive the telecom operators' decision to invest in ultra-fast broadband infrastructure and that there is still a lot of work to be done in that space.

Another fixed broadband EU study, Haucap et al. (2016) showed that an increase in tariff diversity provides a significant impetus to broadband adoption. Sudtasan (2015) showed that the share of optical fiber behaves well according to the demand theory on the own-price and cross-price effects.

Moreover, Grzybowski (2015) concluded that consumer valuation of FTTH broadband in 2013 increased over time, while Beckert (2017) presented a success factors FTTH

deployment analysis across European countries targeting on market structure, competition, regulation and demand. Saheballi (2019) revealed among others and regarding coverage, that regions might learn from one another and that projects expand in geographical clusters and how different areas of coverage are characterized in terms of different types of costs.

Finally, Koutroumpis (2019) concluded that broadband adoption and speed, shape the key priorities in terms of their coverage and quality trade-offs.

3. The model and methodology

The methodology is based on a panel data regression analysis, examining with fixed and random effects methods the important factors that affect the countries' tariff and its future value. The panel data analysis is expressed by the following regression equation (1):

$$Y_i = a_i + \beta * X_{it,k} + \varepsilon_{it} \quad (1)$$

Where,

Y_i the dependent variable and X_i the independent variable

β , is the coefficient that reflects the different countries' variation that remains stable along time.

In this study, the fixed effects method is preferred over the random since it is related to a specific set of countries and their results. Any unobserved effect could be related to the regressors and in general as the number of countries is not that large along with the number of parameters to be estimated, then we could avoid any multicollinearity issues. Whereas, random effects method introduces a random collection of a large population, where any relation between regressors and unobserved effect cannot be accomplished, Baltagi (2013).

The times effects are also included to investigate the dependent variable 's diminishing trend

$$Y_i = a_i + T_t + \beta * X_{it,k} + \varepsilon_{it} \quad (2)$$

And finally, we transform time with a logarithmic value as follows:

$$Y_i = a_i + \beta * X_{it,k} + \gamma * \ln(T) + \varepsilon_{it} \quad (3)$$

Following these steps and the panel data analysis method, and in order to study the specific problem of the EU tariffs, the following equation derives with specific independent parameters:

$$\ln(FTT \text{ Tariff}_{it}) = a_1 \ln(HHI_{it}) + a_2 \ln(\text{Time}) + \alpha_3 \ln(GDP_{it}) + \alpha_4 FTTP_{it} + \alpha_5 \ln(\text{Penetration}_{it}) + \alpha_6 \ln(\text{Urbanization}_{it}) \quad (4)$$

Where,

$FTTH \text{ Tariff}_{it}$, it is the monthly subscriber's cost for standalone fiber Internet service.

GDP_{it} , *GDP per capita*, (Index (EU27_2020 = 100)), it is defined as the value of all goods and services produced less the value of any goods or services used in their creation. The

volume index of GDP per capita in Purchasing Power Standards (PPS) is expressed in relation to the European Union average set to equal 100.

HHI_{it} , is the Hirschman-Herfindahl market and technology concentration index for each country i is calculated as the sum of of subscribers ‘shares of all operators in the fixed broadband technology at time t . HHI presents the degree of competition in the market. The more carriers entering the market, offering FTTH service, the more subscribers grow due to intense market competition.

$FTTP_{it}$ (Fiber To The Premises), it is the percentage of households covered with fiber service.

$Penetration_{it}$, the number of fixed broadband subscribers per 100 inhabitants.

$Urbanization_{it}$, refers to the total number of people that live in urban areas

$Time$, it refers to the period of the study in years.

4. Data

Building on the work of the previous studies, the dataset used in this study consists of annual observations, where available, from 25 EU countries for the six-year period between 2013 and 2018. The countries included in the analysis used are listed in Appendix A (Table A1). The data used have been collected by the past and latest European Commission studies, Trading Economics as well as operators’ public data of market shares. The Hirschman-Herfindahl (HHI_{it}) market and technology concentration index for each country i is calculated as the sum of the squares of market shares of fixed broadband technology in the market at time t .

Table 1: Source of Data

Variables	Source
FTTH tariff	European Commission (2013-2018)
HHI	Operators’ public data (2013-2018)
GDP per capita	Trading Economics (2020)
FTTP	European Commission (2013-2018)
Penetration	European Commission (2013-2018)

5. Results

Random vs fixed effect, this is usually tested by a (Durbin-Wu-) Hausman test. However, the Hausman test is only valid under homoscedasticity and cannot include time fixed effect

Fixed effects models control, or partial out, the effects of time-invariant variables related with time-invariant effects.

Table 2: Scenario 1: Estimation Analysis without Time Effects

Methodology	Intercept	Ln (Penetration)	FTTP	Ln (GDP)	Ln(HHI)	Ln (Urban)	SSE	R Sq.
OLS Pooling	3.775 (0.615)***	-0.143 (0.031)***	-0.316 (0.164).	0.18 (0.05)***	0.042 (0.167)	-0.093 (0.001)**	17.889	0.36101
Within Fixed Estimation (FE)	-	-0.131 (0.03)***	-0.418 (0.223).	-1.756 (0.386)** *	0.184 (0.191)	0.504 (0.635)	3.2323	0.63946
Between Fixed	3.47 (1.451)*	-0.133 (0.084)	-0.165 (0.386)	0.208 (0.112).	0.156 (0.419)	-0.087 (0.07)	2.4106	0.40089
Random GLS Swamy-Arora	5.673 (1.332)***	-0.188 (0.026)***	-0.629 (0.199)**	0.03 (0.112)	0.056 (0.184)	-0.098 (0.055).	4.6774	0.59006
Random GLS Wallace Hussain	5.364 (1.213)***	-0.19 (0.026)***	-0.601 (0.197)**	0.061 (0.102)	0.048 (0.184)	-0.1 (0.05)*	4.8955	0.59354
Random GLS Amemiya	11.794 (3.118)***	-0.162 (0.026)***	-0.63 (0.206)**	-0.664 (0.244)**	0.128 (0.181)	-0.032 (0.137)	3,7559	0,59363

Note: All variables are expressed in natural algorithm (LN) except the “FTTP” variable.

Hausman test: Chisq:
196.99 on 5 DF,
p-value: < 2.22e-16

***, **, * denote statistical significance at the 0.1%, 1% and 5% respectively

In Table 2, Ordinary Least Square Pooling (OLS) shows that there is dependence within individual countries, in that case the panel data cannot be treated as one large, pooled dataset and is not acceptable. Fixed Effect Estimation methodology indicates the significance of two variables, GDP and Penetration to explain FTTH tariffs among countries. In addition, the Between model of Table 2, does not offer any significant estimations.

The results from the within Fixed model (Table 2) in first scenario (Sc1 without Time Effects) revealed two strong significant coefficients, Penetration (-0.131) and GDP (-1.756), where HHI and Urbanisation variables failed to provide some useful insights. Baltagi and Griffin (1983) analyze the gasoline demand of a sample of eighteen OECD countries, with the pooled technique to offer an impressive improvement to the efficiency of the parameter estimates in comparison with the individual regressions. These provide irrelevant and biased coefficients, which do not add any value to the model as random values are assigned in each case.

The relevant signs of the estimators confirm some reasonable expectations. The within estimator analysis revealed a negative relation of the GDP compared to the other models. The within estimators’ analysis relies entirely on the intra-country variation effect over the between estimators that explains the inter-country effects.

The other models contain both inter and intra country effects. The positive relation of GDP indicates that wealthier countries can afford to pay more for the same service, increasing the willingness to pay. On the other hand, the negative relation within estimator suggests that as economies improve within a country, lower service's prices could be expected.

The Penetration estimator of all models (Table 2) converges to the same level from a value of -0.131 (within model) to -0.188 (random effects) adding to the strong significant estimates, gained from pooling. The adoption of the premium service (100 Mbps or higher) increases, following a S-like shape due to the viral marketing and similar network effects, lowering the prices, associated with the price elasticity. FTTP, which includes the Fiber to the premises coverage, has a variation among the models, with a possible multicollinearity with the penetration variable. Pearson correlation confirms that indication that should be carefully considered if it should be included in the model for further predictions. As for the other regressors there is no evidence that should be included due to high uncertainty.

In the second scenario (Sc2 with Time Effects), Time Effects are included in the model to capture any time variation. From the analysis it derives that there are no significant time effects, during the period, 2015 to 2018) Also there is no significant reduction in price as expected. One possible explanation is the fact that any reduction in price is captured from the other regressors and possibly exhausted, hence there is no variation left for time to possibly contribute. The only exception is for the year 2014 when tariffs increased, and more research could investigate the reasons of that. From Wallace-Hussain method, variation due to time effects is very low and only a 5.4 percentage is explained. The benefits from this scenario are the ability to assign a separate effect value for each year although very low, since a monotonic sequence of effects is not required. Analysis can be yield between years, but no further projections and forecasts could be accomplished.

Table 3: Scenario 2: Analysis with Time Effects

Methodology	Intercept	Ln (Penetration)	FTTP	Ln (GDP)	Ln (HHI)	Ln (Urban)	SSE	R Sq.
OLS Pooling	3.775 (0.615)***	-0.143 (0.031)***	-0.316 (0.164)	0.18 (0.05)** *	0.042 (0.167)	-0.093 (0.001)**	17.889	0.36101
Within Fixed Estimateion (FE)	-	-0.079 (0.039)*	-0.312 (0.226)	-1.084 (0.493)*	0.28 (0.193)	0.332 (0.663)	2.9721	0.1345
Random GLS Swamy-Arora	3.775 (1.702)*	-0.143 (0.087).	-0.316 (0.454)	0.18 (0.138)	0.042 (0.463)	-0.093 (0.079)	17.889	0.36101
Random GLS Wallace Hussain	4.771 (7.487)	-0.118 (0.18)	-0.454 (1.117)	0.1 (0.63)	0.207 (1.028)	-0.091 (0.302)	18.629	0.33711

Note: All variables are expressed in natural algorithm (LN) except the "FTTP" variable.

***, **, * denote statistical significance at the 0.1%, 1% and 5% respectively

Finally, in scenario 3 (Sc3 Substitute Time Effects), time effects are removed and replaced by a logarithmic time covariate. Although a monotonic sequence appears in this case, projections can be easily obtained.

Table 4: Scenario 3 Analysis

Methodology	Intercept	Ln (Penetration)	FTTP	Ln (GDP)	Ln (HHI)	Ln(Urban)	Ln (Time)	SSE	R Sq.
OLS Pooling	3.764 (0.601) ***	-0.1 (0.0341)**	-0.304 (0.16).	0.19 (0.049) ***	0.137 (0.167)	-0.088 (0.028) **	-0.164 (0.06) **	16.954	0.39443
Within Fixed Estimation (FE)	-	-0,107 (0.038)**	-0,366 (0.229)	-1,518 (0.445) ***	0,22 (0.194)	0,454 (0.636)	-0,061 (0.057)	3.1994	0.64314
Random GLS Swamy-Arora	4,877 (1.276) ***	-0.106 (0.034)**	-0.436 (0.198) *	0.104 (0.109)	0.205 (0.182)	-0.091 (0.052).	-0.166 (0.047) ***	4.3115	0.62584
Random GLS Amemiya	8.01 (2.619) **	-0.01 (0.034)**	-0.474 (0.21)*	-0.245 (0.217)	0.221 (0.182)	-0.062 (0.107)	-0.146 (0.049) **	3.6533	0.61212
Random GLS Wallace Hussain	4.909 (1.293) ***	-0.106 (0.034)**	-0.438 (1.199) *	0.1 (0.109)	0.206 (1.189)	-0.091 (0.052).	-0.166 (0.047) ***	4.2865	0.62528

Note: All variables are expressed in natural algorithm (LN) except the “FTTP” variable.
 ***, **, * denote statistical significance at the 0.1%, 1% and 5% respectively ***

In the random effects model (Random GLS), the unobserved variables are assumed to be uncorrelated with (or, more strongly, statistically independent of) all the observed variables.

Table 5 Model 1 (Fixed Effects Sc1) and Model 2 (Random Effects Sc3)

Variables	Model 1 (based on Sc1)	Model 2 (based on Sc3)
Type	Fixed effects	Random effects
Intercept	-	8.910867 (2.601213)***
Ln(Penetration)	-0.126390 (0.028301)***	-0.107748 (0.033503)**
Ln(GDP)	-1.726119 (0.382088)***	-0.451066 (0.254588).
FTTP	-0.436240 (0.222730).	-0.475305 (0.209465)*
Ln(Time)	-	-0.120612 (0.048406)*
R-squared	0.63384	0.6098
SSE	3.2828	3.6042

***, **, * denote statistical significance at the 0.1%, 1% and 5% respectively

5.1 Forecasts

When forecasting the dependent variable for a sample of countries, only the significant independent variables will be adapted by using specific models. GDP, penetration, and coverage will be estimated.

GDP future estimates (2019-2021) will be adapted from International Monetary Fund (IMF) since the study’s dataset is until year 2018. In the projections starting in 2020, it is also taken into account the expected Covid-19's recession. Regarding the coverage, Pinheiro and Bates

(2000) methodology will be applied, with the mixed effects models that allow the differentiation, not only of the intercept but of all variables. Additionally, they could handle non-linear models that apply in our study, since coverage is not that different from penetration and they could be described by an S-function.

By using the logistic function as described by Islam and Meade (2015), a more accurate forecast is achieved (Fig 1). Allowing the two coefficients b_i , c_i (equation 5) to differentiate, and keeping constant the Saturation coefficient across all countries, a robust projection for coverage is obtained. That is followed for compatibility reasons, since it cannot overcome the 100%, but also it cannot be very low. The assumption is that during time, all countries will take the necessary actions to approach the 100% broadband coverage either it is provided by Fiber to the Home, or other Internet access technology.

$$Coverage_i = \frac{Sat}{1 + \exp\left(-\frac{(t-b_i)}{c_i}\right)} \quad (5)$$

The regression results of Pinheiro and Bates (2000) methodology led to an 85.65% estimated saturation level across all countries that could have been higher based on the previous models, for example setting a 95 % saturation level.

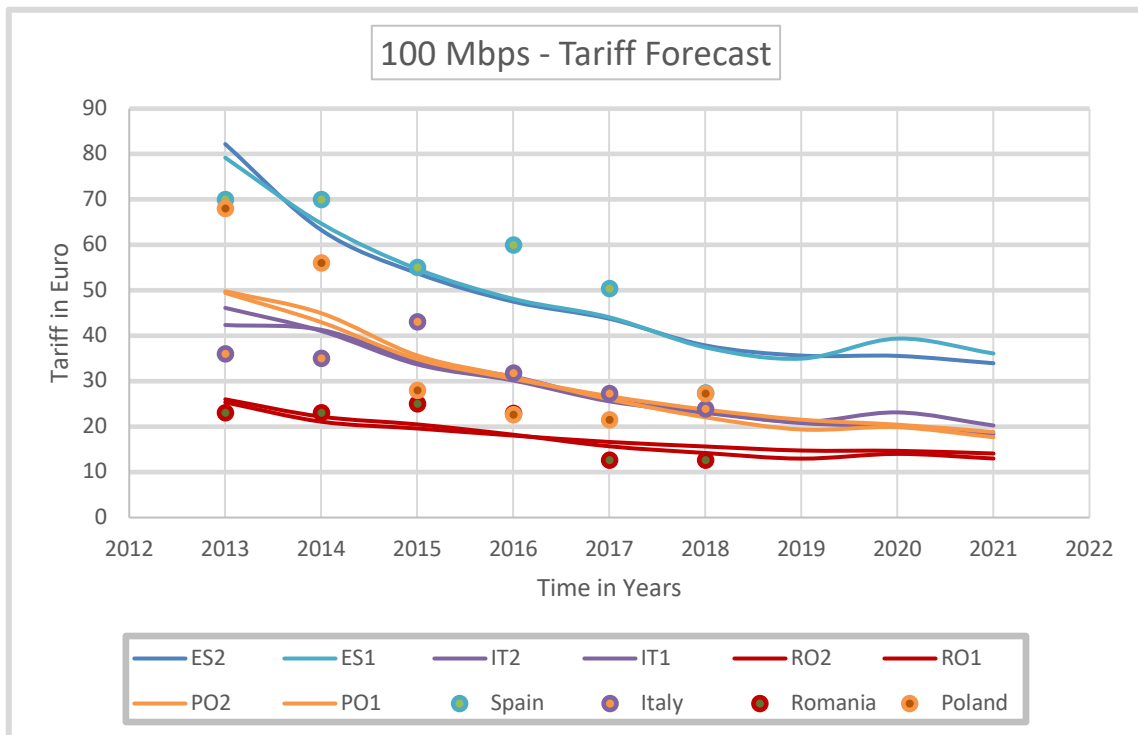


Fig. 1. Tariff Forecast for selected Countries.

The reason that there was no separate estimate followed per country is due to the small available dataset that increases the uncertainty among the countries. In that sense, with the panel data analysis, the one country helps the other to generate robust estimators. Regarding the FTTH service’s penetration, the study produces satisfying results in most countries based on the European Commission dataset. In countries that were no sufficient and acceptable

results produced as regression failed to capture the country's trends, the previous methodology followed with coverage is adapted.

Additionally, Islam Meade and Fiebig (2002) introduce a forecasting methodology with limited data, adapting pooling techniques, transforming Gompertz into a linear function and then selecting the best tool among several, such as fixed effects, random effects and others. The reason that Islam Meade and Fiebig (2002) selected the Gompertz instead of other S-shapes, is that it converts the saturation factor transforms into a constant one for the fixed and random effects. That is not possible with the Logistic function, allowing the countries' differentiation on that factor instead of other parameters related to diffusion speed and time to reach the 50% saturation level. In the case of penetration, the independent method is selected on priority, otherwise, the other two methods are investigated.

6. Conclusions and Discussion

Most European governments have developed specific national broadband plans to foster the deployment of next generation access networks, namely in Spain and Italy. In particular, they have adapted effective strategies adopted to achieve wide fibre coverage and encourage co-investment between competing operators. Most of the European operators, apply a pay-as-you-grow approach that leverages the fiber infrastructure already in use. Tariffs are closely related to penetration and coverage in operators' effort to attract new customers and switch from copper. Additionally, Fixed Wireless Access is emerging as an alternative technology to the fiber but it is still in early stages. The idea is to replace the last 50-200m optic fiber infrastructure with 5G wireless, thus addressing the digital divide problem.

According to the European FTTH Council, Spain is the European country with the highest penetration rate. Based on the Spanish regulator (CNMC), in the fixed broadband sector, the penetration of the fastest growing technology (FTTH) continues to grow; it stood at almost 55% of households at the end of 2018, while xDSL penetration fell by nine percentage points during the year. The keys to this success lie in Spain's fiber optic regulatory framework, the Digital Agenda for Europe and the efforts carried out by the CNMC. In Spain although FTTH customers' base grows, there is an ongoing tariff battle with all rival operators launching promotions of convergent packages at cheap prices. That is obvious, as during the study's period, tariffs fall almost 59%, which is almost double compared to Italy's 33%.

Fiber technology in 2020, accounts for nearly half of fixed access connections in Italy, according to the latest edition of the Communications Observatory of Italy's telecommunications sector regulator (AgCom). Copper remains the dominant Internet access technology. In 2019, the European Commission adopted a Cohesion Policy project worth more than 573 million of EU funds to support the deployment of fast broadband in Italy. That is part of the "Italian Digital Plan – Ultra-broadband", the national strategy for Next Generation Access network. It aims to ensure connection speeds of at least 100 megabits per second (Mbps) for 85% of Italian households and all public buildings – in particular schools and hospitals – and of at least 30 Mbps for all by 2020.

Telecom Italia plans via partnerships to create a single nationwide fiber network. Similarly, T-Mobile in Poland, plans expand its fibre-to-the-home (FTTH) footprint via its new

partnership deals in 2020, launching fibre-based services using the infrastructure of rival firm Orange Polska.

Romania records 2.4% economic growth in first quarter of 2020, in a combination with the operators' urging investment to their own fiber network. That is the solution for lower costs, as they will for example, no longer rely on the competitor's network to provide service to their customers. However, Romanian FTTH tariffs remain the cheapest across EU in 2018 at 12,57 euros per month, following a tariffs' fall between 2013 and 2018 of 43%.

Although this study revealed some interesting findings, there is a need to focus more on the model's structure. By integrating both penetration and coverage in the model multicollinearity issues might arise, as high correlation was detected. When applying further econometric methods it could be investigated if that affects the model's stability, when adding both variables to the model.

This is among the few research studies that investigates the FTTH tariffs with panel data analysis, however it would be also useful to continue to that direction, adding more years to the model's forecasting. Also, future study aims to compare the model's accuracy and robustness with other similar models and methods from the literature. As more data will be available in the years following 2018 from European Commission and GDP per capita projections from IMF, the study should be able to capture more trends per country and add also socioeconomic factors. Finally, fixed broadband countries' categorization, revealing and validating techno-economic similarities and FTTH tariff patterns among the countries' parameters could be also considered in the future work based on Assumptions-Rogers (2003) and Aravantinos-Varoutas (2017) research.

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Appendix A

Table A1 lists the countries that have been included in the study.

Table A1
Countries included in the dataset

Croatia	Ireland	Romania
Cyprus	Italy	Slovakia
Czechia	Latvia	Slovenia
Denmark	Lithuania	Spain
Estonia	Luxembourg	Sweden
Finland	Malta	United Kingdom
France	Netherlands	
Germany	Poland	
Greece	Portugal	
