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Conference Paper

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26th European Regional Conference of the International Telecommunications Society (ITS):
"What Next for European Telecommunications?", Madrid, Spain, 24th-27th June, 2015

Provided in Cooperation with:

International Telecommunications Society (ITS)

Suggested Citation: Gallardo, Fernando; Méndez, Mariano; Monjas, Manuel; Sánchez, Fernando (2015) : Real Options on New Generation Access Networks based on FTTH. An approach to the Spanish Case, 26th European Regional Conference of the International Telecommunications Society (ITS): "What Next for European Telecommunications?", Madrid, Spain, 24th-27th June, 2015, International Telecommunications Society (ITS), Calgary

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Real Options on New Generation Access Networks based on FTTH. An approach to the Spanish Case

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INTRODUCTION

The aim of this research was to identify and evaluate the real options for growth and of a regulatory nature in the investment projects of fixed-line fibre optic networks by an incumbent operator. This valuation exercise was undertaken for the Spanish market.

The work is divided into five sections. First, there is an introduction to the technology deployment option of fibre to the home (FTTH). Next, will be presented a description of the Spanish market in relation to the deployment of fixed-line fibre optic networks and the strategy of the incumbent operator. In the third section, there will be a discussion on the case of the basis of valuation for a fibre to the home (FTTH) investment project in the Spanish market. In the fourth section will be presented and assessed the real options associated with the project presented in the third section. We analyze real options of growth and the actual choice linked to regulatory decisions related to the establishment of a regulated price in the wholesale market. The paper ends by presenting the main conclusions.

1. FTTH AS A NEW GENERATION ACCESS NETWORK (NGA)

The new generation access networks (NGAs) are encompassed in a much broader concept of the New Generation Networks (NGNs). The fundamental aspects of an NGN are IP connectivity between any two points connected to the network and separation between the service platforms and network infrastructure. The growing need for bandwidth in order to be able to configure an increasing wealth of services makes it necessary to improve network access, which to a very great extent is formed by copper wire-based transmission media. Technological enhancements such as ADSL have significantly increased the copper wire bandwidth, but they still fall very short of the possibilities offered by optical fibre.

There are two general technical options when deploying an NGA. One is to completely replace the copper with optical fibre (i.e. Fibre to the Home, FTTH). The second possibility, FTTN (FTT Node), consists of replacing most of the line with fibre, but keeping some copper in the final stretch. In the case of Spain, the option that is being most seriously considered is FTTH, since the existing access telephone networks do not have street-installed cabinets. Their construction, apart from being costly, would also entail problems related to municipal permits.

On the other hand, the FTTH networks can have two types of architecture. The first one is point to point (PTP), which means that each client has their own fibre optics cable. In contrast, the Gigabit Passive Optical Network (GPON) architecture allows various clients to share the fibre. Telefónica (Spain) has chosen this second architecture, which means that the technological option is of the FTTH-GPON type. The fact that a fibre cable is shared by various clients does not technically allow for the unbundled leasing of the loop. It would only be possible to rent the bit stream.¹

2. THE SPANISH MARKET AND STRATEGIC POSITIONING OF THE INCUMBENT OPERATOR

Telefónica, with respect to the Spanish market, has made a strong commitment in recent years by deploying FTTH-type fixed networks. This commitment should be framed within a unique business strategy, that would develop further down the line, in aiming at achieving a sustainable competitive advantage over competitors and additionally boost presence in related businesses with content and digital services, such as pay-TV and applications related to the Internet of Things (IoT).

Just three years ago, according to data published by the European Commission (EC) in "Broadband Coverage in Europe 2011", Spain was a European Union (EU) country with lower figures of deployment of FTTH/FTTP, occupying the 20th position in the 28 countries (EU-28) that made up the European Union. From that year, the speed of deployment of FTTH within the Spanish territory has led this country and its incumbent operator to lead the deployment ratios and connecting of new Ultrawideband (UWB) customers in the European context. According to public data of Telefónica (2015), by the end of 2014 there was a total of 10.35 million households with the ability to connect to a FTTH network, compared to 1.58 million households that could achieve this in late 2011. In order to take into account the relevance of this growth, it is noteworthy that at the end of 2014 the total number of households with access to FTTH networks in the overall context of the European Union was 50.7 million (FTTH Council Europe, 2015), and that the second largest European operator in fibre optic deployment was the French company, Numericable, which already had in late 2014 a total of about 8 million households. Telefónica has also communicated to the market (Gilpérez, 2014) their aim of coverage of all households within 80% of Spain by the end of 2017, which in practice means that the FTTH network will be deployed in all populations of at least 10,000 inhabitants. This strategic option has significant differences with the other major European incumbent operators (BT, Orange, Deutsche Telekom and Telecom Italia), as the European incumbent operator is the only one which is counting on an abandonment of copper networks, along with their xDSL-type equipment, within a specific time horizon.

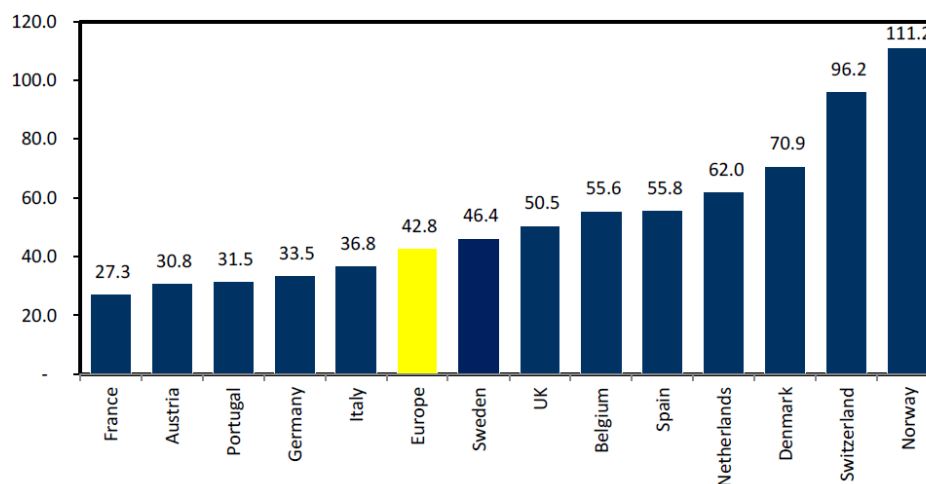
The essential objective in the analysis of the Spanish incumbent operator is to determine what distinctive strategic elements there are in the extensive deployment of an FTTH

¹ Hoerning et al. (2012) demonstrate that GPON is the cheapest technology, but it is inferior in terms of consumer surplus and total welfare.

network. We must begin by demonstrating that its investment strategy has been accompanied by a commercial strategy focused on offering converged services. Telefónica with their offering of 3P (fixed-line voice/GSM mobile voice/fixed and mobile broadband access, BA) and 4P (3P + Satellite IP) under the auspices of the product, Fusion, has prompted changes in the strategies of competing operators and generated a strong concentration of corporate activity in the sector. The result has been that the Spanish market currently has three major business groups with offers of convergent services. These three groups are: Telefónica itself, Vodafone (which acquired the largest cable operator in Spain, Ono, in July 2014 for 7,200 million Euros) and Orange (which acquired the main Local loop unbundling (LLU or LLUB) operator in Spain and second FTTH operator, Jazztel, for 3,400 million Euros in September 2014).

On the other hand, the shift towards convergence and extension of FTTH has added a distinguishing feature to the Spanish market: the fact that the market level of Average Revenue Per Unit (ARPU) is comparatively high compared to other markets, due to the premium price policy that is applied by the incumbent of the fixed and mobile markets. In this respect it can be seen that at the end of 2014, despite a sharp fall in the market as a result of convergence and bundling, the ARPU of the fixed-line incumbent operator surpassed many other comparable European operators (see Figure 1).

Figure 1: Average Income for Fixed Connection Incumbent Operators in Europe (2014, €/month)



Source: RBC Capital Markets (2015, p.8).

This high level of rates has led in recent years to intense competition in the market, which proliferated aggressive price offers launched by LLU operators. The strong price competition had also driven up the churn rate (movement from one provider to another) of the different services offered by the incumbent operator. For example, in the case of mobiles, there were recorded 5.6 million operator changes in one year through operator portability. With regard to the fixed-line services, there was a total of 1.8 million changes

in operator in the same year (CMT, 2012). The impact of the economic crisis in Spain was that users could seek cheaper alternatives and, consequently, Telefónica lost significant market shares.

In this context, Telefónica decided to take a radical turn in 2012 in their business strategy. The new strategy (based on the deployment of FTTH and offering converged services) aimed at exploiting their unique competitive advantages, which are summarised in the following points:

- Possession of the largest customer base in the market, both in the fixed and mobile businesses, in a market which at that time was configured to solely mobile operators (i.e. Vodafone, Telstra and virtual mobile operators (OMVs)) or solely fixed-line operators (i.e. Ono, R, Euskaltel or Telecable and LLU operators such as Jazztel)
- Possession of a comparative advantage of scale and size with the consequent impact in terms of capacity and economies of scale in the creation of new networks
- Possession of a high expertise in the market with unique services having low penetration in Spain and high consumer interest, as is the case with pay-TV

Following this logic, the company began with the creation of the Fusion product, offered for the first time in the Spanish market the chance to enjoy something in a predictable manner and which was combined in a single bill for both fixed and mobile services with the same operator. In exchange, there was a reduction in price against individual prices for each service separately and the assumption of a contract commitment of 12 months with the operator. In this manner, there was time to prepare new offers that were difficult or impossible to replicate by competitors. It also prepared the ground for future upsellings (opening opportunities to purchase related products/services, i.e. opportunities for growth).

The context of this industrial logic plays a key role in FTTH networks, as the superior quality of service may be based on customer loyalty, while it becomes a platform from which to aspire to improve revenue from the cross-selling of services such as TV or sale of Ultrawideband (UWB) services based on speeds of 100 Mb/s for downstream and 10 Mb/s for upstream, with a premium price of around 12 Euros, versus traditional services based on speeds of 10 Mb/s for downstream and 1 Mbit/s for upstream. Here lies the real growth-associated option leading to investments in FTTH.

However, due to the regulatory situation in which there was already a wholesale offer of fibre up to 30Mb, the possibility of opening the network to third parties in products that could compete with the offer of the operator (50, 100 Mb), at least until 2016, was not foreseeable. This would force the other competitors to invest in deployment of ultra-fast networks, with the resulting impact on its cost structure by, in this manner, tougher price competition. Finally, despite the generalised pattern in FTTH competition, it probably regulated at some point that the price level of the wholesale offers should be significantly higher than copper (based on the amortised cost of a network) which,

doubtless, is an attraction for the incumbent, by enabling greater protection of global ARPU levels within the market. These considerations are the basis of the analysis of a real regulatory option which is presented below.

A strategy of massive deployment of fibre optics implies that the incumbent operator faces the simultaneous management of two fixed access networks (copper and FTTH). With no management synergies between both networks, there is an increase in the total cost of network management (energy consumption, maintenance, etc.). But, on the other hand, extensive deployment of FTTH provides the future option to the incumbent operator of choosing the decommissioning of the copper network in the geographical areas where fibre is to be deployed. This allows the incumbent operator to enjoy additional economies of scale derived from the management of a more efficient network, both in management (with many more possibilities of remote monitoring and management) and exploitation (because they have much lower levels of energy consumption and lower failure rate), and an FTTH network that has many inert and passive components that do not present the same problems as those fed into copper network equipment. They also allow a much more efficient management of the assets of the operator, including physical assets, such as the number of nodes or stations necessary to provide the service through FTTH, that is much smaller than the copper network.

3. APPROACH STAGE ON THE BASIS OF ASSESSMENT OF A FTTH INVESTMENT PROJECT IN THE SPANISH MARKET BY THE INCUMBENT OPERATOR

The adequate and complete methodological approach is to define and measure an optimal policy of FTTH network deployment by the incumbent operator within the Spanish territory. To do this one must analyse the profitability and risk of investments that have to be undertaken, taking into account not only the traditional methodology of discounted cash flow (DCF) based on the net present value (NPV), but also the actual relevant options. Two real options will be considered: the growth option and the wait-to-invest option. The approach should start with the consideration of a FTTH deployment throughout the Spanish territory through modular investments zones or areas. In each of the areas initial investment is made in order to establish whether home points (Points of Presence, PoPs) have access to the new network (i.e. past points). Once the core network is deployed, an additional investment is required for each client that wishes to connect (connected client). Since this is an investment of the incumbent operator, the deployment of the fibre optic network overlays the traditional copper, and both networks will coexist for a period of time.

Assume that the number of areas or necessary for the fLLU deployment of FTTH areas amounts to "n". Applying the endpoint of discounted cash flow (DCF), each area will have an NPV (NPV_i from $i=1$ to $i=n$). If the NPVs obtained are sorted in descending order, the incumbent operator will reject projects with less than zero NPV and accept those which present a positive NPV. In this work we will focus on the financial valuation of the

investment of a FTTH network in an urban area with 100,000 fixed connection points of existing copper networks. Let us assume that in this area there are no alternative fixed networks and that there is intra-network competition (i.e. the competitors of the incumbent network operators had rented the LLU contracts). We leave for further research work the valuation of the different areas that make up the Spanish market and the complete optimization of LLU deployment.

The basic assumptions we have established for the valuation of the investment are:

- Time horizon of ten years
- Residual value coincides with the initial capital expenditures (CAPEX) investment in anterior property points
- Cost of capital of 10%
- Amortization of investments over period of 10 years
- Tax rate of 10%

Cash flows that are considered relevant to the NPV calculation of the selected area are:

- Total Capex to ensure that all property points of the area undergo transition. The cost of this component is determined by orographic variables.
- Capex necessary to achieve customer connections in the area.
- Operating expenses for the operation and maintenance of the network.
- Revenue generated from the sale of services. Revenue is the result of multiplying the number of connected clients by the ARPU. Looking at the pricing model design, connected clients can be of three types: customers migrating from copper networks of the incumbent to the new FTTH network of the incumbent; customers stolen from the competition by being able to offer a service that initially cannot be replicated by competing operators; and customers who previously did not have a fixed access and that now require one, because of the substantial improvement of services of the FTTH² network. With respect to the ARPU, this can be generated in two ways: by hiring existing services (Internet access at high or OTT (Over-the-Top) speeds of existing services) or the possibility of hiring new OTT services in the future that are not initially available. This second component will be considered later in the next section in order to assess the real growth option. The factors that influence the number of customers and contracting of access services and pre-existing OTT are dependent on the socioeconomic variables of the area where the network is deployed.
- Net income upon disposal of property assets. Over a period of time the two networks (copper and FTTH) will cohabit. At some point, after 10 years in the case study that we are proposing, we will proceed with the decommissioning of the copper network. When this occurs property assets will be released that may be sold. Therefore, the cash flow from sales of these assets are considered relevant in the face of investment appraisal.

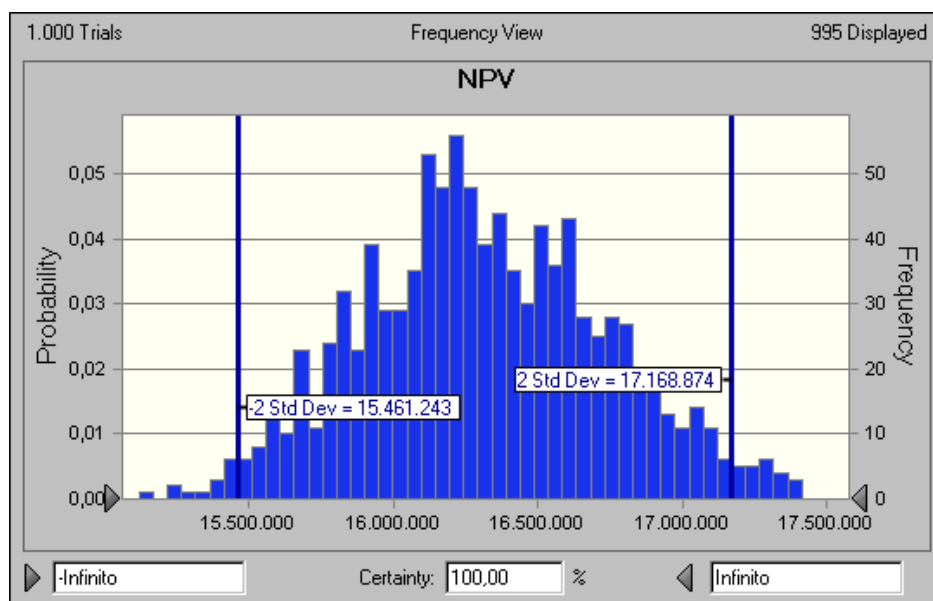
² The substitution effect of fixed-line mobile has been empirically tested in Europe in general (Barth and Heimeshoff, 2014) and in Spain in particular (Mariñoso Suarez and Garcia, 2013)

- Revenues from the rental of the network in the wholesale market. We believe that in a free market environment, the incumbent operator will lease part of the network to alternative operators at some negotiated price. In our model we consider that this will happen Within a year period 4. The uncertainty associated with the regulator set in the future
- Revenues from the rental of the network in the wholesale market. We believe that in a free market environment, the incumbent operator will lease part of the network to alternative operators at some negotiated price. In our model we consider that this will happen within period of 4 years. The uncertainty associated with the regulator which in the future will set a regulated wholesale price lower than desired by the incumbent operator generates a real option of a regulatory nature which will be discussed in section 5 of this paper.
- Residual value.

The model includes construction of part of the market forecast, market shares and income for the incumbent if they do not pursue investment in FTTH networks. The behaviour of these variables is modelled if the incumbent operator deployed the FTTH network and, for a 10 year period, the network of copper and FTTH converges. These two models help us to calculate the incremental cash flows that must be taken into account for the assessment of investment in FTTH. In Annex 1 of this work are the basic assumptions (coloured yellow) and incremental model flows considered for the baseline scenario.

As can be seen in the tables in Annex 1, the incoming operator mitigated its loss of market share by delivering the FTTH network, which significantly reduces the churn rate. Also, the new network can improve the ARPU through increased service quality and upselling. The NPV obtained for the base scenario amounts to 16,302,4999 Euros and its estimated distribution through the simulation model can be seen in Figure 2.

Figure 2 - Simulated distribution of NPV of the project



To reach this simulated distribution, a number of assumptions about the project are established. These assumptions and their simulation are discussed in detail in the next section.

3.1 ANALYSIS OF THE ASSUMPTIONS OF THE PROJECT AND CALCULATION OF ITS VOLATILITY

In order to simulate the evolution of incremental cash flows of the project we have established a number of hypotheses with respect to the possible evolution of the variables (Table 1).

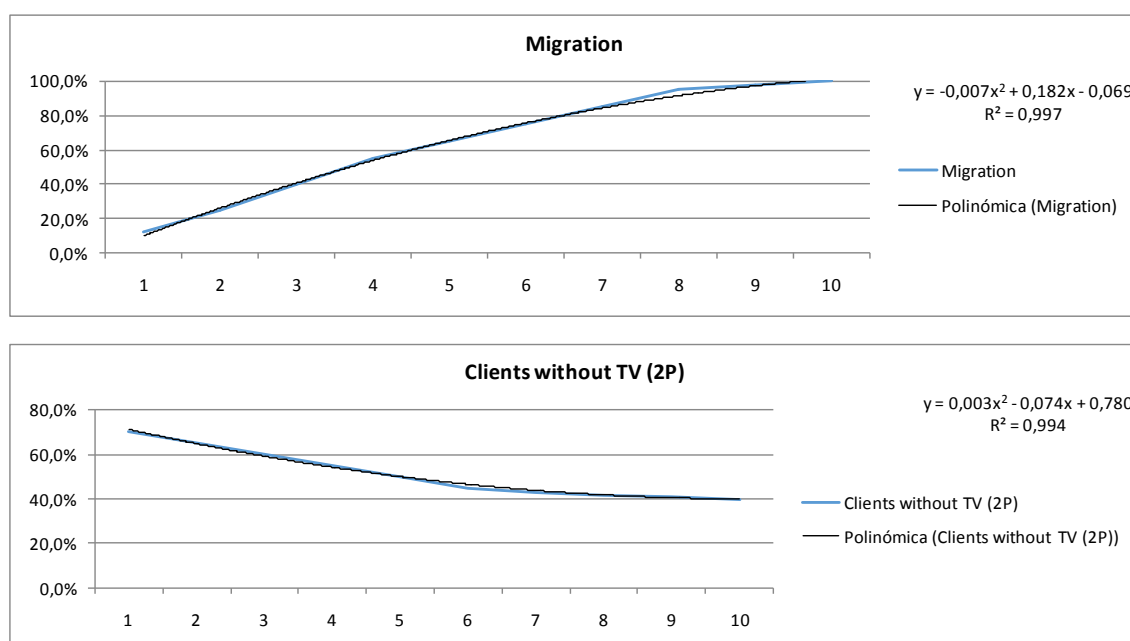
Table 1 – Assumptions for the model related to the competitive environment

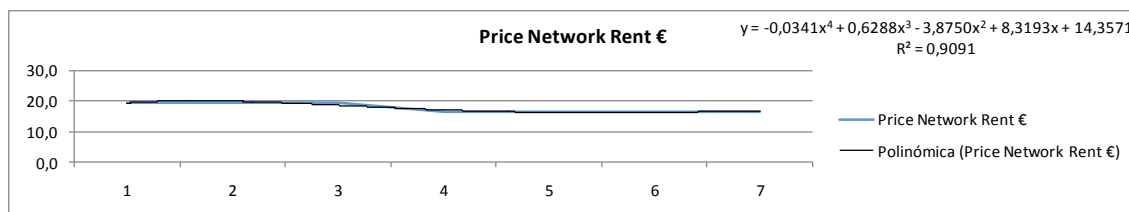
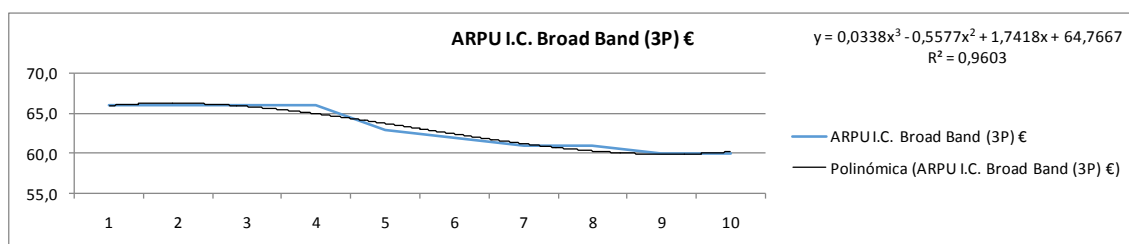
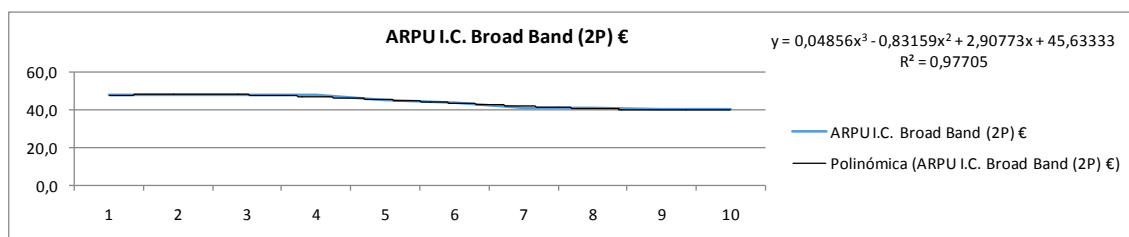
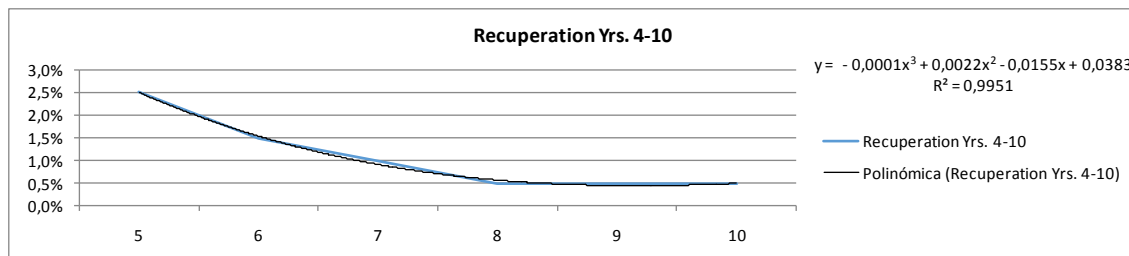
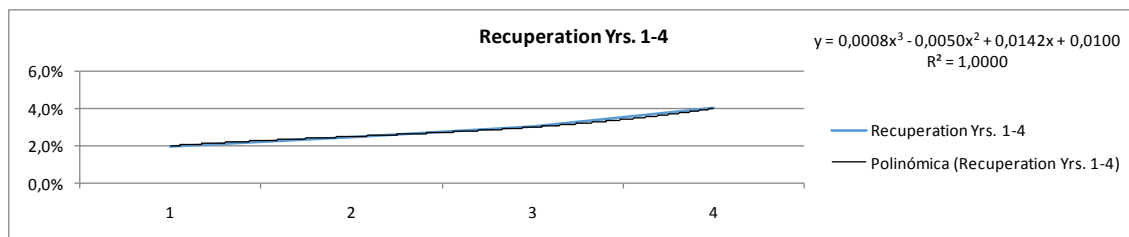
Year	1	2	3	4	5	6	7	8	9	10
Migration	12,5%	25,0%	40,0%	55,0%	65,0%	75,0%	85,0%	95,0%	98,0%	100,0%
Clients without TV (2P)	70,0%	65,0%	60,0%	55,0%	50,0%	45,0%	43,0%	42,0%	41,0%	40,0%
Recuperation	2,0%	2,5%	3,0%	4,0%	2,5%	1,5%	1,0%	0,5%	0,5%	0,5%
ARPU I.C. Broad Band (2P) €	48	48	48	48	45	44	41	41	40	40
ARPU I.C. Broad Band (3P) €	66	66	66	66	63	62	61	61	60	60
Price Network Rent €	0	0	0	19,5	19,5	19,5	16,5	16,5	16,5	16,5

These assumptions are based on professional experience. Given that, in all cases there is a clear pattern of growth or decline, a polynomial fit was performed for each case.

In the case of recovery, since until year 4 the slope is positive and negative from there onwards, we have combined two different settings, one for years 1-4 and another for years 5-10, which in combination reflect the expectations of the analyst. The graphic and its settings are shown in Figure 3.

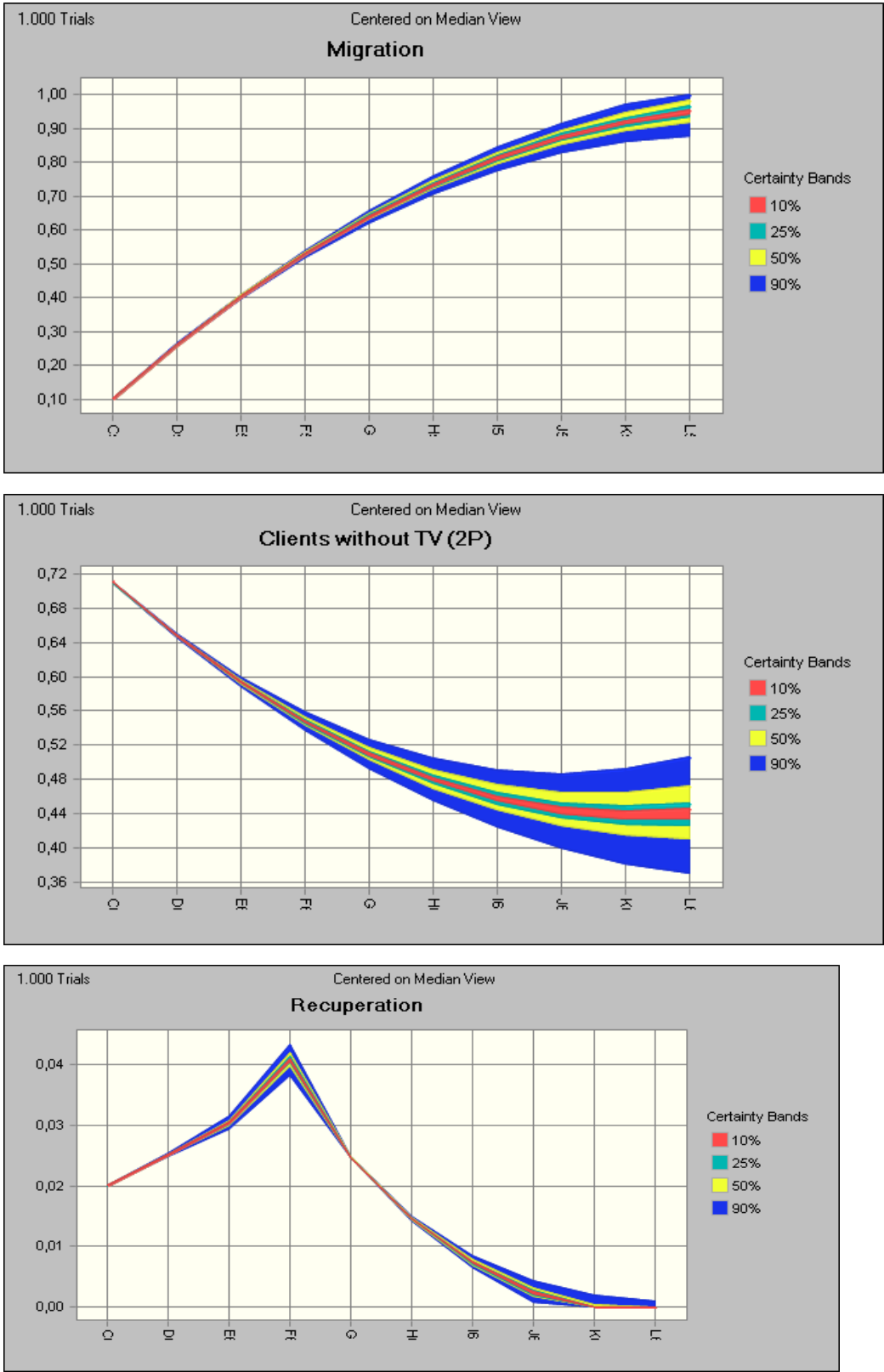
Figure 3 – Adjustments of the model variables related to the competitive environment

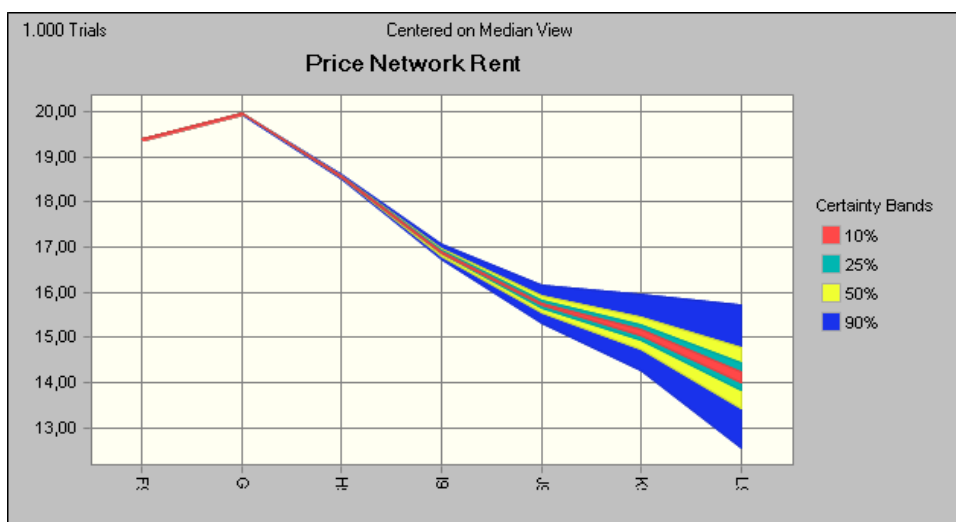
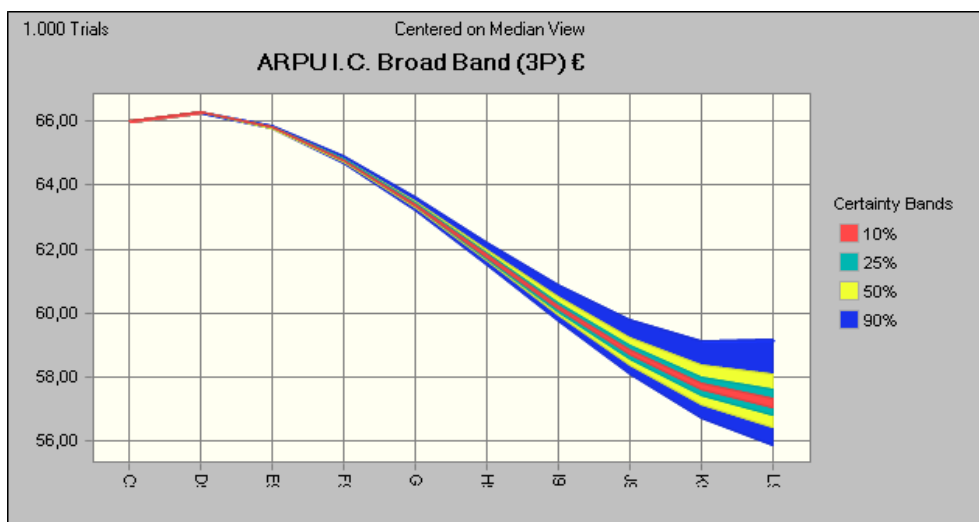
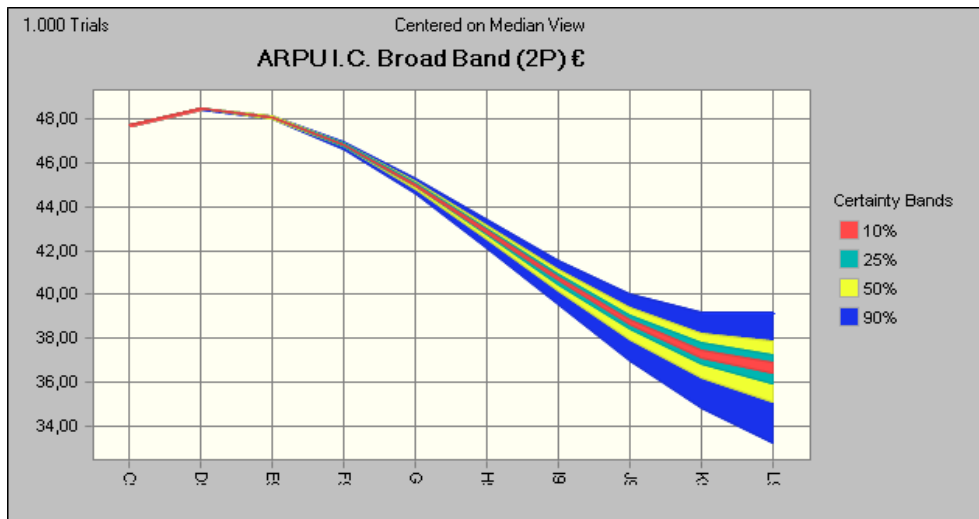




Once the settings have been determined, the first adjustment coefficient is used for each hypothesis, which adds uncertainty through a triangular distribution. The results can be viewed in the following graphs, the horizontal axis represents years 1-10 of the project:

Figure 4 Results of adjustments of the variables related to the competitive environment





As for the use of the methodology of real options through binomial expansion it is necessary to know the volatility of the underlying asset. In this case, the project will use the project itself for volatility. This method, developed by Copeland and Antikarov

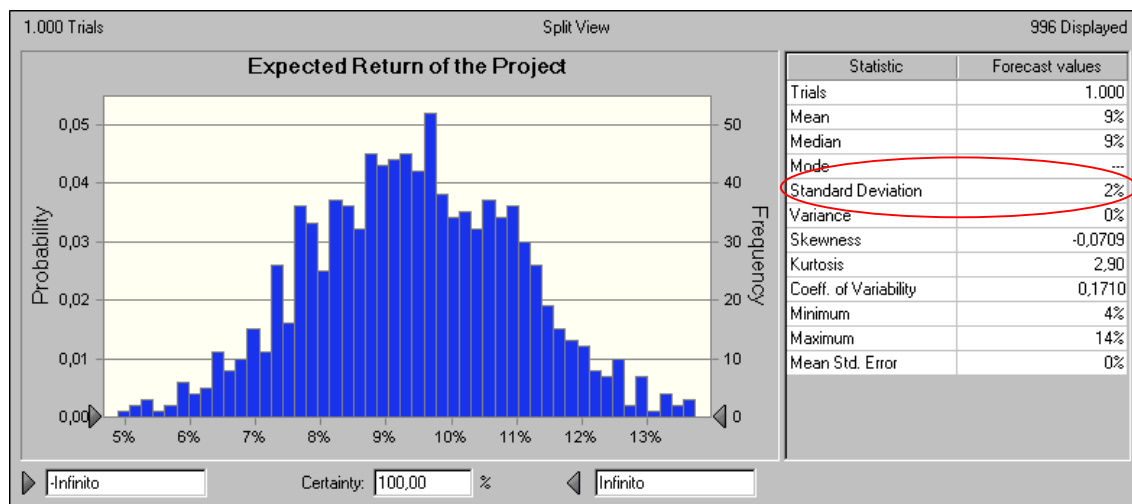
(2001), compares the performance of this project value between 0 and 1 by the following formula:

$$z = \log \left(\frac{PV_1 + CF_1}{PV_0} \right),$$

where log is the natural logarithm, PV1 is the present value of cash flows for period 1, CF1 is the cash flow in period 1 (the latter two include the value of the simulation), PV0 is the present value of the cash flows at time 0, assumed to be fixed in order to obtain the expected performance.

We perform the simulation of these returns, and once undertaken, the standard deviation is removed, assuming that the latter is the expected volatility of the project (Figure 5):

Figure 5 Expected volatility of the project



In our case the value of the obtained volatility is 2%. This value may seem low, but it is consistent with this project for several reasons. In principle, cash flows are incremental and are based on a technology shift for a very important customer base for the incumbent company. However, with respect to the forecasts and assumptions discussed above, these are quite restrictive in terms of possible project outcomes.

4. DEFINITION AND VALUATION OF REAL OPTIONS OF THE PROJECT

Classical methods of valuation of investments (such as NPV, used for assessment of the baseline scenario in section 3) have some limitations when evaluating projects that are subject to uncertainty (Dixit et al, 1995; Amram et al 2000).

To correct this deficiency, the theory of real options valuation (ROV) provides an evaluation framework that considers the impact on the project value of certain decisions that can be completed during its execution (enlargement, reduction, wait-to-invest, abandonment, etc.).

There are three conditions for the application of this method (Copeland et al., 1998): existence of uncertainty, flexibility of the project, and the possibility of assessment in various periods. Since the late 20th Century, the literature on the evaluation of projects in various sectors through real options has been very large.

In the field of telecommunications, common real options (CRO) (Tahon et al., 2014) are related to expansion projects, exchange of products and services, expansion of business lines, delayed investments and abandonment of projects. The use of real options for evaluating investments in the Telecom sector has many contributions from such researchers as Alleman et al. (1999); Basili et al. (2003); Tanguturi et al. (2006); Mastroeni et al. (2010) and Rokkas et al. (2010).

In our valuation model we contemplate two real options. On the one hand, there is the consequence of the creation of new infrastructure which will, in the near future, offering new services related to the Internet of Things (IoT), offering emerging products and services such as security, remote assistance and video surveillance. This option, we define and assess as the real growth option (RGO).

On the other hand, given the regulatory uncertainty in the sector regarding the rental of the network and the price of this action, there opens the possibility of waiting a few years to have the necessary information in order to evaluate the project. In this case, we speak of an option to defer (OTD) linked to a regulatory decision.

We can define the Real Regulatory Options (RROs) (Monjas et al., 2013) as those directly derived from the decision-maker of a public administration with respect to one or more relevant factors in the value of an investment project (tariffs, subsidies, prices, revaluation indexes, etc.). For these options to be considered as regulatory, they must meet all the requirements of traditional real options (they would be considered uncertain if relying on the discretion of the regulator, application flexibility and ability to run in multiple periods). The impacts of regulation on the assessment of projects in the telecommunications sector have been widely discussed, both from a cost perspective (Alleman, 1999; Hausman, 2002) and from its effects on income (Basili et al., 2003; Bourreau et al., 2012). Regarding its conceptualisation as a mechanism for assessing regulatory decisions, the evidence demonstrated by the literature addresses three fields. Thus, Alleman et al. (2002) demonstrate how regulatory restrictions affect the value of cash flows in the provision of bandwidth and fixed-line telephony by operators, using a two-period and by modelling using real options and the value of delaying an investment when there is regulatory obligation to provide these services to any subscriber. Such restrictions prevent the operators from deciding when to invest in a project and to which potential market they should direct their investment. Meanwhile, Pindyck (2007) focuses specifically on the effects of network neutrality (promoted by the Telecommunications Act of 1996) on the irreversibility of recovery of the costs of investment in networks, when the regulator forces the sharing of a network. These stranded costs to the promoter of the investment discourage investment in a new network. In this regard, there must a valuation of real options with respect to the difference between investing in the current situation or employing a time delay for the

investment. The main contribution of Pindyck is in understanding network-access prices, which must include the value of these options in order to compensate the owner-operators, because of the (asymmetric) risk they are incurring in maintaining the resultant large and immobilised investments. From a commercial optic, it may be debatable whether there would be a regulatory obligation on network sharing.

For these options are to be considered "regulatory" must meet all the requirements for "traditional" real options (be uncertain to rely on the discretion of the regulator, application flexibility and be able to run on multiple periods). Finally, Charamlopoulos et al. (2011) presented different regulatory scenarios, altering the time of the decision to invest in new networks or expand such investments. These real options are valued using binomial trees for four policy scenarios (permanent regulation of the obligation to cede a network, regulatory holidays, temporary regulation of the obligation to share networks, and regulation in the absence of investments in a network).

Then, we proceed to identify two real options associated with our investment project.

4.1 The Real Growth Option

As aforementioned, within the coming years the incumbent company will be faced with the possibility of extending the range of services through the new FTTH network. In our case, we assume that the decision will be made within a period of four years. These new services have two implications for the project.

On the one hand, from the point of view of investment, we undertake new investment with respect to the transition points in order to adapt the network to new technologies. In our case, we assume the hypothesis that the company has to invest an additional 25 Euros for each new transition point.

On the other hand, to make it accessible to all customers acquired up until the 4th year, the company has to make an investment for each and every one of them, totalling 11,987, and they must decide whether this investment makes 423,731 Euros in order to cover all of the previous network.

From that moment onwards, all new connections will include this new service, with increasing CAPEX for each period:

	0	1	2	3	4	5	6	7	8	9	10
CAPEX (Punto Pasado) despues	240	235	230	226	221	217	213	208	204	200	196
CAPEX (Punto Pasado) antes	240	235	230	226	221	242	237	232	228	223	219

From the point of view of revenue, we assume that this new service will increase the ARPU by an average of 25%:

	0	1	2	3	4	5	6	7	8	9	10
ARPU 2p Antes	0	48	48	48	47	45	43	41	39	37	36
ARPU 3p Antes	0	66	66	66	65	63	62	60	59	58	57
ARPU 2p Despues	0	48	48	48	59	56	54	51	48	46	46
ARPU 3p Despues	0	66	66	66	81	79	77	75	74	72	72

In light of this new information, we compare the present value of expected cash flows to the 4thYear with expected cash flows included in the addition of new services:

Total at 4 th year after new service	33,077,145
Total at 4 th year before new service	24,730,103
% flow increase	33.75%

We noted an increase of 33.75% in the incremental flows. In order to assess the growth option, we assume that if we invest 423 731 Euros we can achieve an increase of 33.75% in the value of the project.

Since this approach assumes that all customers acquiring the new service have to adjust this figure by the percentage of customers they realistically hope to adopt, or the probability of customer adoption in our case, we assume that in the mid-range scenario this would be 40%.

From here, we undertake three stages of development of the binomial tree (for a detailed application of the methodology recommended by Mendez and Lamothe, 2013).

In the first stage, the possible values of the expected cash flows of the project for the next four years are projected in the binomial tree using a volatility of 2% as was previously calculated:

Year	0	1	2	3	4
	26.302.499	26.833.845	27.375.925	27.928.955	28.493.157
		25.781.675	26.302.499	26.833.845	27.375.925
			25.271.164	25.781.675	26.302.499
				24.770.761	25.271.164
					24.280.267

In a second stage, we find the present value of the project value of the current risk-free rate in Spain, estimated at 2% return on a 10-year bond.

Year	0	1	2	3	4
	26.302.499	26.307.691	26.312.884	26.318.078	26.323.273
		25.276.152	25.281.141	25.286.131	25.291.123
			24.289.853	24.294.648	24.299.444
				23.342.041	23.346.649
					22.431.214

In the third step, we find the value of the option via the following formula:
In the 4th year:

$$Max((S^*(1+g)-K)*P;0),$$

where S is the expected value of the project for each scenario in the 4th year increased by 33.75%; a value that we would expect to increase by adding new products; K is the investment in the network with respect to all existing customers, a total of 423,731 Euros; P is the expected probability of adoption of the new service, estimated at 40%.

In 3 years up to the present time, the following equation is used to calculate the value of the option:

$$V_u * P_u + V_d * P_d,$$

where V_u is the value of the project in the optimistic scenario multiplied by the risk-neutral probability that this occurs, P_u and P_d are the pessimistic values, also multiplied by the risk-neutral probability of this producing P_d .

				Investment	423.731
				Increase in Expected CF	33,75%
				Probability of Adoption	40%
Year	0	1	2	3	4
	13.902.614	13.905.391	13.908.170	13.910.949	13.913.728
		13.353.507	13.356.177	13.358.847	13.361.517
			12.825.828	12.828.393	12.830.958
				12.318.738	12.321.203
					11.831.436

In this case, we see that the value of the growth option is at 13.9 million Euros, which would add value to the NPV of the project since it includes the flexibility to adapt the project to the future technological environment.

4.2 The option of deferring as Real Regulatory Option (RRO).

4.2.1 Identification and Valuation

The regulation of the access to next generation networking (NGN) is a key aspect in assessing the viability of investment projects based on the migration of FTTH networks. Thus far, we have developed a pricing model within which the investment decision in such networks is conditioned by the availability of technology, capital, and potential demand from a specific structure of competition. However, we have not made reference to the impact of the regulatory framework on the value of the project.

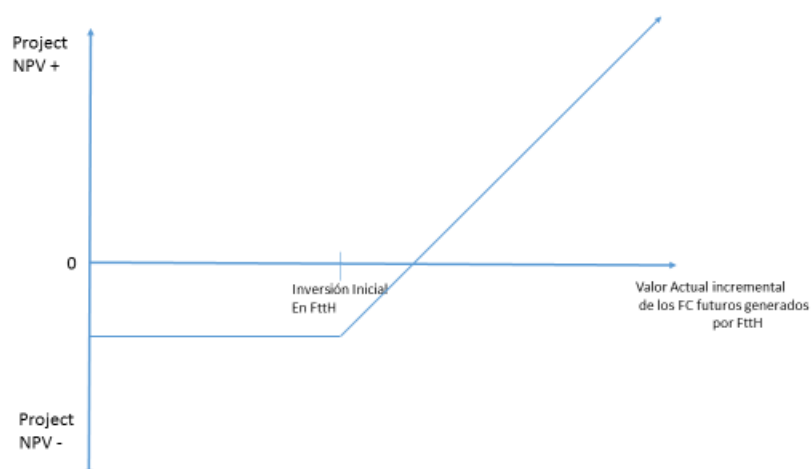
In our case, the regulation affects an additional source of uncertainty. We refer to the link with the possibility of renting the network to other competitors who have the ability to commercially capitalise on those subscribers captured by the owner operator of the fibre, or were incorporated from the commercial portfolio of the competitor. On this point, it is relevant to the valuation of the investment in fibre, the price of renting it to others, and the question of regulation. In this regard, according to the regulations of rental fees, fibre access to the customer's home, the companies that own the infrastructure, may differ (or not) in their investment expansion of this technology.

The eventual regulatory obligation to rent at a fixed price means that, in the specific case of fibre, the owner operator is required to lease at that price, to any alternative operator that has customers to whom they sell their service offerings. Clearly, the operator lessee (tenant) has not had to invest in the development of this fibre, and is limited to the payment of a fixed cost for its rental. In brief, the freezing of a percentage of CAPEX by the owner of the network for business development, would not be recoverable in the rental prices of the same fibre.

In this context, the option for the owner of the network to delay investments in FTTH will depend on the relationship between the income they can get from their exploitation (also considering the possible renting of it) and the costs of investment in such infrastructure. To the extent that revenues are subject to uncertainty and rental fees depend on an administrative decision, it is clear that the option of waiting-to-invest may have some value for the owner companies.

The option of waiting-to-invest (Delay Option) generates value when an investment project presents, at the time of evaluation, negative net present values. However, it can become profitable if its start-up time is delayed. Hence, it is essential that the project developer has the capacity to decide on when to launch an investment project. In the framework of the theory of options, as applied to our example case study, the graph of standby option configures a call option (financial contract between two parties), the strike price (E) matches the value of the initial investment in the project (in our case, the cost to the owner operator of investing in FTTH) and the price of the underlying (S) shows the net present value of future cash flows generated by the project (i.e. the incremental flows arising from the extension of FTTH to new clients (see Figure 1). If the expected value of future cash flows exceeds the fixed investment in the project, if we choose to postpone, the execution of the option switches to the expected value-added.

FIGURE 1 The wait-to-invest option.



We
can
raise,

therefore, the wait-to-invest option as an opportunity cost, as it will have value only in

the event of activation (i.e. delaying the investment), thus generating an actual value of the cash flow which is greater than the actual value if the investment is made immediately. This difference gives us the value of the delay option. Analytically, the intrinsic value of the wait-to-invest option (D_0) is between:

$$D_0 = \text{Máx} [S_1 - E_1 ; 0],$$

where S_1 is the current value of the cash flows of the project at the future time of maturity of the option, and E_1 is the cost of the investment.

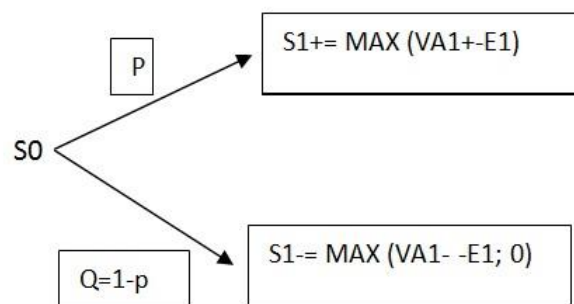
The current value of the cash flows of the project at the time of maturity (S_1) will be influenced by the existence of regulatory restrictions on the rental price of the fibre. We can distinguish two scenarios for NPV at the time of maturity:

a) Optimistic scenario ($S_1 +$).

B) Pessimistic Scenario ($S_1 -$).

These two scenarios allow us to know the option of deferring with different possibilities of occurrence via a binomial tree, which we assign to each scenario, (Figure 2).

Figure 2 – Binomial tree



These nodes, for the first period, can range from recurring later periods, according to the likelihood of expansion (contraction) of Net Present Value (NPV).

The total value of the project, once the option to defer included, is given by the following expression:

$$S_0 = [(S_1+ \times p) + ((1-p) \times S_1-)] / (1+R_f)^n,$$

where R_f is the discount rate.

The value of the option to defer is given by the difference between the total actual value (S_0) obtained and the net present value in the case of implementing the option of immediate exercise (investment).

$$\text{Wait-to-invest option} = S_0 - VA_0$$

4.2.2 Assumptions of the model. Modeling uncertainties

In what follows, we will introduce our valuation model, a number of alternative scenarios based on the existence (or not) of a regulatory restriction on the rental price of fibre to alternative operators, analysing their impact on the NPV of the project. Then, we will discuss the value of the option for the incumbent operator to defer.

We contemplate two monthly wholesale rental prices (Regulated and Free) for the 4th year of the project, in addition to its being included in the baseline scenario; those prices would be 15 and 20 Euros, respectively. We also assume two scenarios (optimistic and pessimistic) in the evolution of VAN of the project with probabilities of 0.4 (Up) and 0.6 (Down). The interaction of both assumptions generates a binomial tree that configures different possible NPV scenarios for both, the regulated prices and for the free prices. The incumbent operator should decide to invest in the 4th year of FTTH or defer investment, depending on the value adopted by the option.

As noted above, the option of waiting-to-invest is actually a call option on the present value of expected cash flows of the project (S), the exercise price (E), and the cost of investment on the date of expiration of the option. Thus, if the owner operator immediately decided to tackle the project of investment in FTTH the option of waiting-to-invest would be waived.

Furthermore due to each passing year and the effect of annual inflation, assuming the investment required to increase the fixed rate is the target of the European Central Bank (ECB) (2%), this implies a cumulative increase of 8.2% over the period of 4 years. Finally, given the high risks that are inherent in the project (i.e. entry of new competitors, technological changes, etc.) we have assumed a volatility of 50%, and risk-free rate of 2%.

Nodes for the binomial probabilities, with respect to the bullish and bearish scenarios, and considering a volatility of 50%, would be obtained from parameters u (1.65) and d (0.61). From them, we can model the evolution of the NPVs until the 4th year, taking as a starting point the NPV of the base-line scenario. The current NPV for the fourth year is given below.

Years	0	4
	26,302,499	179,549,952
		66,052,736
		24,299,444
		8,939,266
		3.288.572

On the other hand, the cost of the investment, because of expected inflation, passes from 10,000,000 Euros in the first year of the project to 10,817,415 Euros in the 4th year. With these data, the value of the option to invest in the 4th year, is calculated according to the formula:

$$\text{MAX}(S-E; 0),$$

where S represents the NPV in the 4th year for each stage and the cost of investing in that year. If the difference is positive, the investment should be made in the 4th year (and, therefore, not delay it); otherwise, investment should not be deferred.

The values of these differences for the five nodes of the 4th year would be:

Node 1	168,725,632
Node 2	55,228,415
Node 3	13,475,423
Node 4	0
Node 5	0

As can be seen for three of the five cases (those which accumulate a higher level of probability), the option to invest in the 4th year is profitable and it is, therefore, advisable to not postpone the investment.

5. CONCLUSIONS

This paper presented a project involving the modelling of an investment in FTTH from the perspective of an incumbent operator and an area in which there is, initially, only the incumbent copper network itself. The modelling incorporates potential options of growth and options linked to regulatory decisions expected of the wholesale price of renting the network fibre.

With respect to the previous body of literature, our research develops two innovations. Firstly, within the field of real options we combined different scenarios of regulated prices, services and competition, with different possibilities for the start of the investment, while respecting the principle of network neutrality and considering the existence of an obligation to rent the network by the incumbent operator. Secondly, we studied the effects on investments in the development of fibre with respect to the Spanish case, contributing to a literature which is traditionally devoted to the Anglo-Saxon reality.

The primary conclusion is that the fibre network greatly boosts the competitive position of the incumbent operator, because it allows to (i) reduce the loss rate measured by the churn rate, (ii) improve ARPU, (iii) attract customers who are not connected to fixed-line networks, and (iv) taking immediate and future upselling opportunities (real options for

growth) for new services linked to the Internet of Things (IoT). However, there is no evidence of the existence of options for waiting-to-invest or delaying the project beyond the specified period for its implementation. We have observed that improving the competitive position we described compensates for the expected value (EV) option. However, a regulatory decision to set prices well below the threshold referred to in the case study, could activate this option, reaffirming the importance of the decisions that the National Regulatory Authority can make in this regard.

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Annex - Basic assumptions for configuration of the baseline scenario

	0	1	2	3	4	5	6	7	8	9	10
DIMENSIÓN DEL MERCADO FTTH											
Conexiones posibles	85.000	85.000	85.000	85.000	85.000	85.000	85.000	85.000	85.000	85.000	85.000
Ratio conex. Posibles	85,0%	85,0%	85,0%	85,0%	85,0%	85,0%	85,0%	85,0%	85,0%	85,0%	85,0%
Conexiones inabilitadas	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
Ratio conex. inabilitadas	15,0%	15,0%	15,0%	15,0%	15,0%	15,0%	15,0%	15,0%	15,0%	15,0%	15,0%
EVOLUCIÓN DEL MERCADO TOTAL											
MERCADO TOTAL CUANDO HAY SOLO COBRE	76.500	76.500	76.500	76.500	76.500	76.500	76.500	76.500	76.500	76.500	76.500
MERCADO TOTAL CUANDO HAY FTTH + COBRE											
COBRE	76.500	77.076	77.207	77.351	77.798	77.559	77.414	77.380	77.289	77.340	54.441
INCUMBENTE	76.500	74.063	71.543	68.446	60.482	53.005	44.965	39.162	33.067	28.082	0
ALTERNATIVAS	57.375	53.776	50.062	45.741	41.315	37.789	34.198	30.606	27.024	24.880	0
FTTH	19.125	20.288	21.481	22.705	19.168	15.216	10.767	8.556	6.044	3.202	0
INCUMBENTE	0	3.012	5.664	8.905	17.316	24.554	32.449	38.218	44.221	49.258	54.441
ALTERNATIVAS	0	3.012	5.664	8.905	12.354	14.155	15.959	17.830	19.579	19.932	20.126
	0	0	0	0	4.962	10.399	16.490	20.388	24.642	29.326	34.316
DESGLOSE MERCADO TOTAL POR OPERADORAS											
INCUMBENTE	76.500	77.076	77.207	77.351	77.798	77.559	77.414	77.380	77.289	77.340	54.441
COBRE	57.375	56.788	55.726	54.646	53.669	51.944	50.157	48.436	46.603	44.812	20.126
FTTH	57.375	53.776	50.062	45.741	41.315	37.789	34.198	30.606	27.024	24.880	0
ALTERNATIVAS	0	3.012	5.664	8.905	12.354	14.155	15.959	17.830	19.579	19.932	20.126
COBRE	19.125	20.288	21.481	22.705	24.130	25.615	27.257	28.944	30.686	32.528	34.316
FTTH	19.125	20.288	21.481	22.705	19.168	15.216	10.767	8.556	6.044	3.202	0
	0	0	0	0	4.962	10.399	16.490	20.388	24.642	29.326	34.316
cuota incumbente conexiones	75%	74%	72%	71%	69%	67%	65%	63%	60%	58%	37%
diferencial con solo cobre	0,00%	0,20%	0,26%	0,33%	0,30%	0,12%	-0,02%	-0,13%	-0,20%	-0,20%	-18,90%
DISTRIBUCIÓN DEL MERCADO DE COBRE POR OPERADORAS (CUANDO HAY FTTH)											
CLIENTES SIN BANDA ANCHA (Solo voz, 1P)	76.500	74.063	71.543	68.446	60.482	53.005	44.965	39.162	33.067	28.082	0
OPERADORA INCUMBENTE	38.250	36.720	35.190	33.660	32.130	30.600	29.070	27.540	26.010	24.480	0
OPERADORAS ALTERNATIVAS	38.250	36.720	35.190	33.660	32.130	30.600	29.070	27.540	26.010	24.480	
CLIENTES DE BANDA ANCHA											
CLIENTES B.A. OPERADORA INCUMBENTE	38.250	37.343	36.353	34.786	28.352	22.405	15.895	11.622	7.057	3.602	0
CLIENTES B.A. SIN TV (2P) OP. INCUMBENTE	19.125	17.056	14.872	12.081	9.185	7.189	5.128	3.066	1.014	400	0
CLIENTES B.A. CON TV (3P) OP. INCUMBENTE	15.300	13.693	12.244	10.671	9.338	8.730	8.257	7.451	6.507	6.165	5.936
CLIENTES B.A. OPERADORAS ALTERNATIVAS	3.825	3.362	2.627	1.409	-153	-1.541	-3.128	-4.385	-5.494	-5.764	-5.936
	19.125	20.288	21.481	22.705	19.168	15.216	10.767	8.556	6.044	3.202	0

DISTRIBUCIÓN DEL MERCADO DEFTTH POR OPERADORAS										
0	1	2	3	4	5	6	7	8	9	10
OPERADORA INCUMBENTE OPERADORAS ALTERNATIVAS	3.012	5.664	8.905	17.316	24.554	32.449	38.218	44.221	49.258	77.391
	3.012	5.664	8.905	17.316	24.554	32.449	38.218	44.221	49.258	77.391
	0	0	0	4.962	10.399	16.490	20.388	24.642	29.326	34.316
	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
OPERADORA INCUMBENTE OPERADORAS ALTERNATIVAS	3.012	5.664	8.905	17.316	24.554	32.449	38.218	44.221	49.258	54.441
	3.012	5.664	8.905	17.316	24.554	32.449	38.218	44.221	49.258	54.441
	2.109	3.682	5.343	6.795	7.078	7.181	7.667	8.223	8.172	8.050
	904	1.982	3.562	5.559	7.078	8.777	10.163	11.356	11.760	12.075
	2.437	4.957	8.054	11.226	13.351	15.385	17.375	19.258	19.602	19.787
	12.5%	25.0%	40.0%	55.0%	65.0%	75.0%	85.0%	95.0%	98.0%	100.0%
	1.706	3.222	4.832	6.174	6.676	6.923	7.471	8.088	8.037	7.915
	731	1.735	3.222	5.052	6.676	8.462	9.904	11.170	11.565	11.872
	170	170	170	170	170	170	170	170	170	170
	170	170	170	170	170	170	170	170	170	170
CLIENTES SIN TV (2P) CLIENTES SIN TV (3P) CLIENTES NUEVOS	119	111	102	94	85	77	73	71	70	68
	70.0%	65.0%	60.0%	55.0%	50.0%	45.0%	43.0%	42.0%	41.0%	40.0%
	51	60	68	77	85	94	97	99	100	102
	406	537	681	958	634	404	285	151	160	169
	2.0%	2.5%	3.0%	4.0%	2.5%	1.5%	1.0%	0.5%	0.5%	0.5%
	284	349	409	527	317	182	123	63	66	68
	70.0%	65.0%	60.0%	55.0%	50.0%	45.0%	43.0%	42.0%	41.0%	40.0%
	122	188	272	431	317	222	163	88	94	101
	10.708.488	11.319.752	12.051.814	13.913.718	15.483.957	17.162.391	18.364.476	19.590.195	20.598.071	26.114.899
	1.000.000	1.070.849	1.131.975	1.205.181	1.391.372	1.548.396	1.716.239	1.836.448	1.959.019	2.059.807
INGRESOS DE CLIENTES Ingresos de clientes solo voz (1P) ARPU CI. Sin B.A.	1.930.270	3.690.812	5.898.722	8.316.714	9.172.541	10.322.187	11.211.424	12.358.416	13.389.574	15.587.738
	1.930.270	3.690.812	5.898.722	8.316.714	9.172.541	10.322.187	11.211.424	12.358.416	13.389.574	15.587.738
	1.214.552	2.120.688	3.077.594	3.913.748	3.821.892	3.791.824	3.772.088	4.045.854	3.922.568	3.864.104
	48.0	48.0	48.0	48.0	45.0	44.0	41.0	41.0	40.0	40.0
	715.718	1.570.125	2.821.128	4.402.966	5.350.649	6.530.363	7.439.336	8.312.562	8.467.006	8.694.234
	66.0	66.0	66.0	66.0	63.0	62.0	61.0	61.0	60.0	60.0
	1.930.270	3.690.812	5.898.722	8.316.714	9.172.541	10.322.187	11.211.424	12.358.416	13.389.574	15.587.738
	1.930.270	3.690.812	5.898.722	8.316.714	9.172.541	10.322.187	11.211.424	12.358.416	13.389.574	15.587.738
	1.214.552	2.120.688	3.077.594	3.913.748	3.821.892	3.791.824	3.772.088	4.045.854	3.922.568	3.864.104
	48.0	48.0	48.0	48.0	45.0	44.0	41.0	41.0	40.0	40.0
INGRESOS MERCADO MAYORISTA Líneas aliadas a las operadoras alternativas Precio de alquiler bucle totalmente desagregado	0	0	0	1.161.099	2.433.343	3.858.640	4.036.911	4.879.138	5.806.643	6.794.523
	0	0	0	4.962	10.399	16.490	20.388	24.642	29.326	34.316
				19.5	19.5	19.5	16.5	16.5	16.5	16.5
	144.589	271.883	427.444	831.166	1.178.595	1.557.541	1.934.479	2.122.625	2.364.395	2.613.183
	3.012	5.664	8.905	17.316	24.554	32.449	38.218	44.221	49.258	54.441
	4	4	4	4	4	4	4	4	4	4
GASTOS DE MANTENIMIENTO Conexiones Coste mant. Por cliente										

